June 6, 2005

Mr. Kent Hamlin
Director, Accreditation
Institute of Nuclear Power Operations
700 Galleria Parkway, N.W., Room 130
Atlanta, GA 30339-5957

Dear Mr. Hamlin:

On April 5, 2005, the Nuclear Regulatory Commission (NRC) staff held a public meeting with representatives from the Institute of Nuclear Power Operations (INPO), Nuclear Energy Institute (NEI), NEI-sponsored Focus Group on Operator Licensing, and several U.S. power reactor facilities at the NEI offices in Washington, D.C., to discuss plant-referenced simulator issues. On May 19, 2005, the staff issued a summary of that meeting (ADAMS Accession #ML051240349).

In accordance with Action Item 4 of the meeting summary, please find attached the NRC-developed approach to scenario-based testing (SBT) for review and comment in preparation for the joint NRC/industry simulator SBT performance demonstration in August 2005. As noted during the meeting, the NRC staff validated this approach at one of its Technical Training Center simulators to independently determine its feasibility and suitability for meeting the Commission's simulator rule pursuant to 10 CFR 55.4 and 55.46. Enclosure 1 is the NRC-developed SBT Summary; Enclosure 2 is the scenario description and required operator actions (typical NUREG-1021, Appendix D (Attachment 1)); and, Enclosure 3 is the NRC-developed SBT with an example assertions/certification statement.

The staff looks forward to reviewing and comparing the industry's proposed approach to SBT (Action Item 7 of the meeting summary) to that developed by the NRC. In order to adequately prepare for the joint simulator SBT demonstration in August 2005, we request that Action Item 7 be concluded by June 30, 2005, and that you include an update on the status of Action Item 5 and 6 in your response.

The staff sincerely appreciates the manner in which the industry is working with us to resolve concerns over simulator SBT and other issues.

Please contact me at (301) 415-2942 or e-mail dct@nrc.gov if you have any questions or need further information.

Sincerely,

***/RA/***

David C. Trimble, Section Chief
Operator Licensing and Human Performance
Reactor Operations Branch
Division of Inspection Program Management
Office of Nuclear Reactor Regulation

Enclosures: As stated

Please contact me at (301) 415-2942 or e-mail dct@nrc.gov if you have any questions or need further information.

Sincerely,

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Enclosures: As stated

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# NRC-DEVELOPED SBT SUMMARY

## PURPOSE

To independently determine first hand the feasibility, suitability, and acceptability of simulator scenario-based testing (also known as SBT) as envisioned by NRC staff for meeting the Commission's simulator rule pursuant to 10 CFR 55.4 and 55.46 respectively.

## BACKGROUND

On April 5, 2005, the staff held a public meeting with representatives from the Institute of Nuclear Power Operations (INPO), Nuclear Energy Institute (NEI), NEI-sponsored Focus Group on Operator Licensing Issues, and representatives from several U.S. power reactor facility licensees at NEI headquarters office in Washington, D.C., to discuss plant-referenced simulator issues. The issue regarding SBT was discussed at length. The staff explained that it had developed and conducted a PWR simulator SBT performance test at the NRC's Technical Training Center (TTC) as an independent check on feasibility and to better understand the industry's difficulty with the SBT issue. The group was informed that the staff would share its SBT testing experience with industry and agreed to work with industry representatives to help resolve concerns with SBTs.

On March 24, 2005, at the NRC's Technical Training Center (TTC) in Chattanooga, TN, the staff demonstrated a SBT for performance testing purposes on the Trojan Pressurized Water Reactor Full-Scope Simulator. The staff was able to validate the feasibility of an SBT approach in which expected simulator performance is identified in advance of the test.

The staff's concern with facility licensees SBTs stems, for the most part, from inadequacies in SBTs identified during IP-71111.11 inspections that have been documented in inspection reports as Unresolved Items (URIs). Specifically, licensees SBTs emphasize the expected performance of the operator(s) rather than performance of the simulator compared to the actual or predicted plant performance.

## STAFF SBT DEVELOPMENT

Prior to developing the SBT, the staff reviewed the testing criteria of the ANSI/ANS-3.5-1998 standard and the regulatory requirements of 10 CFR 55.4 and 55.46. To meet the definition in 10 CFR 55.4, performance testing must assess simulator performance against actual or expected plant performance. This SBT approach illustrates substantive and meaningful simulator performance testing for malfunctions as well as integrated expected plant response. The simulator performance expectations were limited to first order effects and focused on key parameters, automatic actions, and alarms. In general, the level of staff effort to develop its SBT was approximately 10 hours. The simulator "validation or run" time was approximately 10 - 20 minutes for each malfunction and 15 - 30 minutes for integrated plant responses. Simulator SBT setup time (initial condition, parameter plot/trend, manual manipulations, etc.) was not counted toward SBT testing time.

TESTING CRITERIA

Simulator performance during the SBT malfunction(s) and transients was assessed against the criteria of Section 4.1.4 of the ANSI/ANS-3.5-1998 standard, which are:

(1) The simulator allows the use of applicable reference Unit procedures.

(2) Any observable change in simulated parameters corresponds in direction to those expected from actual or best estimate response of the reference unit to the malfunction.

(3) The simulator shall not fail to cause an alarm or automatic action if the reference unit would have caused an alarm or automatic action under identical circumstances.

(4) The simulator shall not cause an alarm or automatic action if the reference unit would not cause an alarm or automatic action under identical circumstances.

The staff believes that simulator performance must meet these standards in order to support the training objective of SBTs in the ANS-3.5 standard. In other words, not meeting these criteria would likely result in negative training.

Additionally, as described in ANSI/ANS-3.5-1998 Appendix A, “Simulator Documentation,” the SBT documentation of simulator performance criteria and simulator testing included the following basic information: (1) the initial conditions; (2) the perturbations made to induce the transient, such as malfunctions, remote functions, or operator actions; (3) the responses of pertinent simulator parameters; (4) an evaluation and validation of test results; and (5) the update of related documentation.

SBT TEST INSTRUCTIONS

Conduct SBT performance testing to verify the simulator’s performance as compared to actual or predicted reference plant performance. Identify any software and hardware discrepancies and discrepancies from the scenario validation and or from the performance testing. Assign discrepancies which affect or impact operator actions priority over others that do not. Record the test results as specified. Attached supporting pertinent performance information such as key parameter(s) trends/plots, completed procedure data sheets, etc.)

CONCLUSIONS FROM TEST

Two approaches to SBT testing were used in the conduct of this feasibility study. In the first approach, expected plant/simulator performance of key parameters, automatic actions, and alarms were identified ahead of time. The SBT was then conducted and simulator performance was assessed against the predetermined performance expectations. In the second approach, the SBT was conducted first without having first identified performance expectations. The results were then assessed in a manner similar to post trip reviews to see if simulator performance for key parameters, automatic actions, and alarms was consistent with what subject matter expert(s) would have expected.

The consensus among the NRC staff conducting the feasibility study was that the first approach of determining expected plant performance ahead of the conduct of the SBT was the more effective approach. The chief infirmity of the second approach was that evaluators found that they were less likely to question simulator performance using this approach (i.e, having seen how the simulator performed there was an enhanced bias toward accepting that performance as correct and, conversely, less questioning of that performance).

DISCLAIMER

The staff's SBT was conducted to test feasibility of an approach to testing and is not intended to be used exclusively or verbatim.

TYPICAL NUREG-1021, APPENDIX D
OPERATING TEST SIMULATOR SCENARIO

**Appendix D** **Example - Initial Dynamic Simulator Scenario** **Attachment 1**

**Facility**: TROJAN **Reactor Type**: PWR **Scenario No.**:1 **Operating Test #** 1 **Page** 1 **of** X

**Examiners:** _____ **Applicants/Operators**: _____

_____ _____

_____ _____

**Initial Plant Condition**: IC-XX, 100 % Power, MOC, Technical Specifications Mode: 5

**Shift Change**: Component Cooling Water pump (CCW) pump A out of service (OOS);
A severe thunder storm warning is in effect.

| Event No. | Malf No. | Event Type* | Event Description |
|---|---|---|---|
| 1 | SG-A (0-70 GPM) | C (RO)<br>N (BOP)<br>R (RO) | 70 gpm SG A tube leak (ramped over 5 minutes with subsequent loss of CCP-A and failure of CCP-B to start; requires reactor power reduction) |
| 2 | RCS | I (RO) | Pressurizer level transmitter L-459 fails low |
| 3 | SG-A (70-450 GPM) | M (ALL) | 450 gpm SG A tube rupture (ramped over 3 minutes) |

* (N) Normal, (R) Reactivity, (I) Instrument,(C) Component, (M) Major

Note: This scenarios/events are individual examples: they are not intended to represent complete scenario/event sets on an operating test.

For each planned event, enter on Form ES-D-2 (or equivalent) a description of the event and detailed actions required by the applicable plant procedures (e.g., normal, abnormal, emergency, and administrative, including the technical specification and emergency plan) for each operating position (i.e., SRO for senior reactor operator, RO for reactor operator, BOP for balance of plant) in a manner similar to the first event on the next page.

**Operating Test:** 1 **Scenario No.**:1 **Event No.** 1 **Page** 1 **of** __

**Event Description**: 70 gpm SG A tube leak (ramped over 5 minutes) with subsequent loss of CCP-A and failure of CCP-B to start; requires reactor power reduction

| Time | Position | Expected Operator Actions |
|---|---|---|
| 00:00 | Crew | Shift crew turn-over & brief on status of plant, plans for the shift, etc. |
| ____ | RO/BOP | Recognize indications of a tube leak on SG A:<br>- air ejector offgas radiation monitor off normal<br>- SG A blowdown radiation monitor off normal<br>- CVCS charging / letdown (mismatch) off normal<br>- VCT inventory changes off normal |
| ____ | SRO | Direct RO/BOP actions in accordance with (IAW) AOP-XX, [Title, Step X.x through X.x]:<br>- monitor & control VCT level<br>- monitor & control Pressurizer level & pressure<br>- verify leakage > or < technical specifications limits<br>- announce high radiation levels in turbine building<br>- verify SG A RCS tube leak via sampling & analysis<br>- verify release calculations via health physics<br>- commence unit power reduction & shutdown<br>- notify NRC & state authorities<br>- minimize secondary contamination<br>- classify event IAW EPIPs (as Unusual Event) |
| ____ | RO/BOP | Execute AOP-XX actions IAW SRO directions |

| | | |
|---|---|---|
| ____ | RO/BOP | Recognize Operating CCP tripped & alarmed:<br>- initiates & takes actions ARP-17007-1-ALB-C6, CHARGING PUMP OVERLOAD TRIP,<br>(1) Check panel to determine which CCP pump(s) tripped<br>(2) Check for correct charging & seal flow<br>- initiates & takes actions IAW AOP-18007-C, CHEMICAL AND VOLUME CONTROL SYSTEM MALFUNCTION, Section C, Loss of Charging Flow, Steps B1.thru B7.<br>(1) Verify at least one charging pump running / RNO<br>(2) Verify PRZR level trending to program band / RNO<br>(3) Check RCP seal injection valves open<br>(4) Check normal charging valves open<br>(5) Isolate letdown & initiate CVCS EXCESS LETDOWN<br>(6) Locate & isolate any charging system leakage<br>(7) Maintain PRZR level & seal flow until normal charging is restored / RNO (Commence unit shutdown IAW UOPs [Title, etc.]<br>- acknowledge & take manual actions IAW pertinent Alarm Response Procedures (ARPs) [List title of ARPs] |
| ____ | SRO | Direct RO/BOP IAW AOP–18007-C (same as above) except RNO Step B7, “Commence unit shutdown by initiating appropriate UOPs:<br>- start standby CCP & re-establish charging<br>- if unable to start standby CCP, then isolate letdown<br>- initiate repairs |
| ____ | SRO | Supervise/coordinate reactor power reduction IAW UOPs:<br>- review / brief crew on precautions IAW unit power reduction /normal shutdown procedure(s) [UOP-XX, title, etc.]<br>- verify delta- I maintained in limits<br>- verify load reduction rate |
| ____ | RO | Coordinate with BOP to commence power reduction: (reactor)<br>- complies with all procedure precautions & limitations<br>- calculate/estimate boration required for reactor shutdown IAW [title]<br>- borate & or insert control rods to maintain T-avg within program & delta-I limits |
| ____ | BOP | Coordinate with RO to commence power reduction: (Main turbine/generator unloading and removal from service)<br>- complies with all procedure precautions & limitations<br>- notifies load dispatcher of pending unit unloading |

NRC TECHNICAL TRAINING CENTER
SIMULATOR SCENARIO-BASED TEST (SBT) DEMONSTRATION

**Attachment X Example - Plant-referenced Simulator Scenario Based Test Form XX-X-X**

**Simulation Facility**: PWR **Scenario No.**: 1 **Event No.** 1 **Page** 1 **of** __

**Initial Plant Condition**: 100 % Power, BOC, No out of service equipment

**Event Description**: 70 gpm tube leak on "A" SG (ramped over 5 minutes) with running CCP trip and failure of standby pump to start; requires power reduction.

**Instructions**: Validate/confirm the following expected plant response (including pertinent alarms & automatic actions), and use of applicable procedures. Circle test results as Satisfactory (S) or Unsatisfactory (U). All unsatisfactory test results require a simulator fidelity discrepancy report (DR) for corrective action. Unsatisfactory test results which directly impact operator action(s) must be corrected before test maybe declared satisfactory.

**References**: P&IDs:#1301, Main Steam System
#1201, Reactor Coolant System
#1208, Chemical & Volume Control System

**Plant Procedures**: Use of applicable Alarm Response Procedures (ARPs), Abnormal Operating Procedures (AOPs), Emergency Operating Procedures (EOPs), System Operating Procedures (SOPs)

AOP-18007-C, Chemical & Volume Control System Malfunction, Rev 4
AOP-18009-C, Steam Generator Tube Leak, Rev 4
EOP-19020-C, E-2 Faulted Steam Generator Isolation
ARP-17000-C, (Listed in or noted in test)

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| Results | Item | SBT Performance Test |
|---|---|---|
| S/U | 0 | **Malf # XXX-A, SG A TUBE LEAK**, actuates at 70 gpm (ramped over 5 minutes) (SG A Narrow Range level trend attached) |
| | | **Steam Generator A** |
| N/A | 1 | SG A level indicates perturbation (Note: N/A if level control in "auto" and maintaining set point) |
| S/U | 2 | SG A steam flow becomes greater than feed water flow with constant SG A level |

S/U 3 SG A Feed flow/steam flow mismatch indicated (due to small RCS system leak flow input relative to large feed-water system flow input)

S/U 4 Alarm [#__], STM GEN A FLOW MISMATCH, remains off (alarm not expected)

S/U 5 Alarm [#__], STM GEN A HI/LO DEVIATION, actuates (Cause # 2, RCS leak), if at +/- 5% of referenced to level program, no automatic actions

S/U 6 Alarm [#__], STM GEN A HI-HI LEVEL ALERT, remains off (alarm not expected, actual level remains less than 78% during tube leak)

S/U 7 Main Condenser Air Ejector & Steam Packing Exhauster Effluent Monitor radiation level increases (RM-X) as RCS system leak rate increases

S/U 8 Alarm [#__], HIGH RADIATION ALARM, actuates (when any HIGH alarm on one or more RM Channels - (i.e., ejector/exhauster effluent radiation monitor exceeding HI trip set point at __ MR/Hr with in turns automatically diverts air ejector discharge to filtration)

**Chemical Volume & Control System**

S/U 9 Volume Control Tank level (LI-X) is maintained by CVCS automatic makeup mode: VCT inventory rate of loss increases with magnitude of RCS leak increase; as evidenced by more frequent operation of automatic makeup (i.e., makeup starts at ≤ 30%\ ___ and terminates ≥ 50%___ VCT level)

Note: If CVCS in Manual Makeup, then VCT level rate change reflects magnitude of RCS leak magnitude)

S/U 10 Volume Control Tank pressure (PI-X) tracks/follows VCT level inventory change

S/U 11 Alarm [#__], VCT HI / LO LEVEL, actuates at 20%__ decreasing level

S/U 12 Holdup Tank (HUT) Divert Valve 1-LV-XXXA remains closed

S/U 13 Alarm [#__], VCT HI LO PRESS, actuates when < 10__ psig

S/U 14 Automatic action - VCT pressure control valve, 1-PV-X auto closes at <10__ psig decreasing

S/U 15 Alarm [#__], TOTAL MAKEUP FLOW DEVIATION, actuates on +/- 8__ gpm deviation from set point - no auto actions

**Pressurizer**

S/U 16 Pressurizer level (LI/LR-X) reflects loss of RCS inventory with increasing rise in VCT makeup frequency

S/U 17 Pressurizer pressure (PI-X) tracks/follows level inventory change

S/U 18 Alarm [#__], PRZR LO LEVEL DEVIATION, actuates (at 5%__ below level program) with no automatic actions

S/U 19 Alarm [#__], PRZR LO LEVEL / HTR CNTL OFF / LTDN SECURED, actuates when <17%__ with the following automatic actions:

S/U 20 (a) All pressurizer heaters turn off; and (b) Letdown Isolation occurs

S/U 21 Alarm [#__], PRZR CONTROL / HI LEVEL DEVIATION, remains off (actuates at 5%__ above level program) with no automatic actions

S/U 22 Alarm [#__], RC LOOP $^{a}$T/AUCT $^{a}$T HI-LO DEV, actuates (unbalanced steam/feed flow in SG A) if +/-2 degF___ deviation from program set point with no subsequent automatic actions:

S/U 23 No Reactor auto trip occurs (interlock not met - if low flow in 1 RCP loop with >48% rated MWTH nor low flow in 2 out of 4 RCP loops > 10% rated MWTH)

S/U 24 Alarm [#__], RC LOOP Tavg /AUCT Tavg HI-LO DEV, actuates (unbalanced steam/feed flow in SG A) if +/-2 degF deviation from program set point

S/U 25 No Reactor auto trip occurs (interlock not met - if low flow in 1 RCP loop with >48% rated MWTH nor low flow in 2 out of 4 RCP loops > 10% rated MWTH)

S/U 26 Alarm [#__], Tavg / Tref DEVIATION, actuates if +/-3 degF deviation from program set point with no auto actions

S/U 27 Applicable Safety Related Display Console & Plant Process Computer point(s) responds to event: (Attach applicable displays/PPC points to substantiate response & evaluation)

S/U 28 Key parameters evaluated: SG A level, SJEA Rad Level; RCS Tavg; Steam/Feed Flow (Attach as applicable recorder, trend / parameter plots)

S/U Malfunction #____, validated & test completed with no performance exceptions

| | | |
|---|---|---|
| S/U | 0 | Malf # XXX, **CCP-A TRIP**, actuates |
| | | **Centrifugal Charging Pump A** |
| S/U | 1 | Centrifugal Charging Pump A trips and locks-out: motor amps reflect overload & trip (i.e., rapid surge current increase followed by immediate drop to 0__ amperes |
| S/U | 2 | Alarm [#__], CHARGING PUMP OVERLOAD TRIP, actuates (from CCP-A motor lockout relay actuation on ≥ ____ amperers) with no automatic actions |
| S/U | 3 | Centrifugal Charging Pump B does not auto start (Manual start is disabled): motor amps remain at 0__ amperes |
| S/U | 4 | Positive Displacement Charging Pump remains running |
| S/U | 5 | Alarm [#__], PD PUMP COOLANT LO LEVEL, remains off |
| S/U | 6 | Alarm [#__], LTDN HX OUT HI TEMP, actuates (at ≥ 127.5 DegF___) with subsequent automatic actions (caused when Letdown flow > Charging flow), then: |
| S/U | 7 | (a) Auxiliary Component Cooling Water (ACCW) valve TV-XXX opens |
| S/U | 8 | (b) Letdown flow diverts to VCT ≥ 132.5 degF__ |
| S/U | 9 | Alarm [#__], CHARGING LINE HI / LO FLOW, actuates (at ≤ 25 gpm___) with no automatic actions |
| S/U | 10 | Total Charging Flow decreases to 0__ gpm on FI-X |
| S/U | 11 | Regenerative Heat Exchanger Letdown outlet temperature increases on TR-X |
| S/U | 12 | Alarm [#__], REGEN HX LTDN HI TEMP, actuates (at ≥ 400 DegF) with no automatic actions |
| S/U | 13 | Alarm [#__], RCP SEAL WATER INJ LO FLOW, remains off unless (at ≤ 7 gpm and PDCP speed at 0 rpm) with no automatic actions |
| S/U | 14 | Applicable Safety Related Display Console & Plant Process Computer point(s) responds to event: (Attach applicable displays/PPC points to substantiate response & evaluate) |
| S/U | 15 | Key parameters evaluated:(Attach as applicable recorder, trend / parameter plots) |
| | | SG A level; VCT level & pressure, Charging flow; Letdown flow; Pressurizer level; RCS Tavg; etc. |
| S/U | | Malfunction #____, validated & test completed with no performance exceptions |

**Attachment X Example - Plant-referenced Simulator Scenario Based Test Form XX-X-X**

**Simulation Facility**: PWR **Scenario No.**: 1 **Event No.** 2 **Page** 1 **of** __

**Initial Plant Condition**: 100 % Power, BOC, Pressurizer LT-459 selected for service

**Event Description**: Pressurizer level instrument L-459 fails low.

**Instructions**: Validate/confirm the following expected plant response (including pertinent alarms & automatic actions), and use of applicable procedures. Circle test results as Satisfactory (S) or Unsatisfactory (U). All unsatisfactory test results require a simulator fidelity discrepancy report (DR) for corrective action. Unsatisfactory test results which directly impact operator action(s) must be corrected before test maybe declared satisfactory.

**References**: P&IDs:#1201, Reactor Coolant System - Instrumentation

**Plant Procedures**: Use of applicable Alarm Response Procedures (ARPs), Abnormal Operating Procedures (AOPs), Emergency Operating Procedures (EOPs), System Operating Procedures (SOPs)

AOP-18001-C, Primary Systems Instrumentation Malfunction, Rev 4
ARP-17000-C, (Listed in or noted in test)

| Results | Item | SBT Performance Test |
|---|---|---|
| S/U | 0 | **Malf # XXX, PRESSURIZER LEVEL TRANSMITTER L-459 FAILS LOW**, actuates (no ramp) (Pressurizer level trend attached) |
| | | **Pressurizer Level Indication** |
| S/U | 1 | Pressurizer level indicator LI-459 goes to 0%___ |
| S/U | 2 | Pressurizer level indicator LI-460 indicates actual level at _____% |
| S/U | 3 | Pressurizer level recorder LR-459 goes to 0%___ |
| S/U | 4 | Pressurizer pressure (PI-461) does not tracks/follows malfunctioning level instrument |
| S/U | 5 | PDP speed increases or FCV-121 opens to increase pressurizer level |
| * | * | Note: Select functioning pressurizer level transmitter LT-460 before high level 2/3 level trip signal causes a reactor trip. |

S/U 6 Alarm [#__], PRZR LO LEVEL DEVIATION, actuates (at 5%__ below level program) with no automatic actions

Note: Manual control & adjustment required by operator to correct level transient / selection of standby pressurizer level instrumentation (i.e., LI-460)

S/U 7 Alarm [#__], PRZR LO LEVEL / HTR CNTL OFF / LTDN SECURED, actuates when <17%__ with the following automatic actions:

S/U 8 (a) All pressurizer heaters turn off; and (b) Letdown Isolation occurs

S/U 9 Alarm [#__], PRZR CONTROL / HI LEVEL DEVIATION, remains off (actuates at 5%__ above level program) with no automatic actions

S/U 10 Alarm [#__], PRZR HI LEVEL ALERT, remains off (actuates when >70%)

S/U 11 Alarm [#__], PRZR HI LEVEL CHANNEL ALERT, remains off (actuates when >92%)

S/U 12 Alarm [#__], PRZR LO PRESS ALERT, remains off (actuates when <1960 psig)

S/U 13 Alarm [#__], PRZR HI PRESS, remains off (actuates when >2310 psig)

S/U 14 Alarm [#__], PRZR HI PRESS CHANNEL ALERT, remains off (actuates when >2385 psig)

S/U 15 Applicable Safety Related Display Console & Plant Process Computer point(s) responds to event: (Attach applicable displays/PPC points to substantiate response & evaluate)

S/U 16 Key parameters evaluated: Pressurizer level & pressure, (Attach as applicable recorder trend / parameter plots)

S/U Malfunction #____, validated & test completed with no performance exceptions

**Attachment X Example - Plant-referenced Simulator Scenario Based Test Form XX-X-X**

**Simulation Facility**: PWR **Scenario No.**: 1 **Event No.** 3 **Page** 1 **of** __

**Initial Plant Condition**: 100 % Power, BOC, No out of service equipment

**Event Description**: 450 gpm tube rupture on "A" SG (ramped over 3 minutes)

**Instructions**: Validate/confirm the following expected plant response (including pertinent alarms & automatic actions), and use of applicable procedures. Circle test results as Satisfactory (S) or Unsatisfactory (U). All unsatisfactory test results require a simulator fidelity discrepancy report (DR) for corrective action. Unsatisfactory test results which directly impact operator action(s) must be corrected before test maybe declared satisfactory.

**References**: P&IDs:#1301, Main Steam System
#1201, Reactor Coolant System
#1208, Chemical & Volume Control System

**Plant Procedures**: Use of applicable Alarm Response Procedures (ARPs), Abnormal Operating Procedures (AOPs), Emergency Operating Procedures (EOPs), System Operating Procedures (SOPs)

AOP-18007-C, Chemical & Volume Control System Malfunction, Rev 4
AOP-18009-C, Steam Generator Tube Leak, Rev 4
EOP-19020-C, E-2 Faulted Steam Generator Isolation
ARP-17000-C, (Listed or noted in test)

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| Results | Item | SBT Performance Test |
|---|---|---|
| S/U | 0 | **Malf # XX-A, SG A TUBE RUPTURE**, actuates at 450 gpm (ramped over 3 minutes) (SG A Narrow Range/Wide Range level trend attached) |
| | | **Steam Generator A** |
| N/A | 1 | SG A level indicates pronounced perturbation, initially being maintained by SG A level control (in "auto" and maintaining set point ), followed by SG A level increase once SG A inventory can no longer be controlled |
| S/U | 2 | SG A steam flow becomes greater than feed water flow with constant SG A level until Main Steam Line A is isolated (Operator action required) |
| S/U | 3 | SG A feed water flow becomes less with rising SG A level from RCS tube rupture leakage into SG A, (Operator action required to isolate feed water) |

S/U 4 SG A Feed flow/steam flow mismatch increases (due to larger RCS system leakage flow input relative to large feed-water system flow input)

S/U 5 SG A pressure held in check with steam dumps until Main Steam Line A isolation occurs, at which time SG A pressure increases to Atomospheric Relief Valve(s) set point of XXX__ Psig which terminates SG A pressure increases

S/U 6 Alarm [#__], STM GEN A FLOW MISMATCH, actuates

S/U 7 Alarm [#__], STM GEN A HI/LO DEVIATION, actuates at + 5% of referenced to level program, no automatic actions

S/U 8 Alarm [#__], STM GEN A HI-HI LEVEL ALERT, remains off (alarm not expected, actual level remains less than 78% during tube rupture until leak)

S/U 9 Main Condenser Air Ejector & Steam Packing Exhauster Effluent Monitor radiation level increases (RM-X) as RCS system leakage rate increases

S/U 10 Alarm [#__], HIGH RADIATION ALARM, actuates (when any HIGH alarm on one or more RM Channels - (i.e., ejector/exhauster effluent radiation monitor exceeding HI trip set point at __ MR/Hr with in turns automatically diverts air ejector discharge to filtration)

**Chemical Volume & Control System**

S/U 11 Volume Control Tank level (LI-X) is not maintained by CVCS automatic makeup mode: VCT inventory rate of loss increases with magnitude of RCS leakage increase; as evidenced by more & more frequent operation of automatic makeup (i.e., makeup starts at ≤ 30%\ ___ and terminates ≥ 50%___ VCT level)

Note: If CVCS in Manual Makeup, then VCT level rate change reflects magnitude of RCS leak magnitude)

S/U 12 Volume Control Tank pressure (PI-X) tracks/follows VCT level inventory change

S/U 13 Alarm [#__], VCT HI / LO LEVEL, actuates at 20%__ decreasing level

S/U 14 Holdup Tank (HUT) Divert Valve 1-LV-XXXA remains closed

S/U 15 Alarm [#__], VCT HI LO PRESS, actuates when < 10__ psig

S/U 16 Automatic action - VCT pressure control valve, 1-PV-X auto closes at <10__ psig decreasing

S/U 17 Alarm [#__], TOTAL MAKEUP FLOW DEVIATION, actuates on +/- 8__ gpm deviation from set point - no auto actions

**Pressurizer**

S/U 18 Pressurizer level (LI/LR-X) reflects increased loss of RCS inventory with increasing rise in VCT makeup frequency

S/U 19 Pressurizer pressure (PI-X) tracks/follows level inventory change

S/U 20 Alarm [#__], PRZR LO LEVEL DEVIATION, actuates (at 5%__ below level program) with no automatic actions

S/U 21 Alarm [#__], PRZR LO LEVEL / HTR CNTL OFF / LTDN SECURED, actuates when <17%__ with the following automatic actions:

S/U 22 (a) All pressurizer heaters turn off; and (b) Letdown Isolation occurs

S/U 23 Alarm [#__], PRZR CONTROL / HI LEVEL DEVIATION, remains off (actuates at 5%__ above level program) with no automatic actions

S/U 24 Alarm [#__], PRZR HI PRESS CHANNEL ALERT, remains off (>2385 psig)

S/U 25 Alarm [#__], PRZR HI PRESS, remains off (>2310 psig)

S/U 26 Alarm [#__], PRZR CONTROL LO PRESS AND HEATERS ON, actuates at <2210 psig___ with automatic action below:

S/U 26 Pressurizer Backup Heaters energize

S/U 27 Alarm [#__], PRZR LO PRESS ALERT, actuates at <1960 psig___ with no automatic actions

S/U 28 Alarm [#__], PRZR LO PRESS SI ALERT, actuates at <1870 psig___ with no automatic actions

S/U 29 Alarm [#__], RC LOOP $^{a}$T/AUCT $^{a}$T HI-LO DEV, actuates (unbalanced steam/feed flow in SG A) if +/-2 degF___ deviation from program set point)

S/U 30 Alarm [#__], RC LOOP Tavg /AUCT Tavg HI-LO DEV, actuates (unbalanced steam/feed flow in SG A) if +/-2 degF deviation from program set point)

S/U 31 Alarm [#__], Tavg / Tref DEVIATION, actuates if +/-3 degF deviation from program set point

N/A 32 Operator action required when pressurizer pressure <1870 psig (e.g., EOP-1900-C, E-0, REACTOR TRIP OR SAFETY INJECTION) which requires a reactor trip and safety injection, if one has not occurred:

Note: Reactor trip response validation limited to E-0 expected response only.

N/A 33 Operator action required when directed by EOP E-0, Step 24 (Check if SG tubes are intact - RNO (Go to EOP-19030-C, E-3, STEAM GENERATOR TUBE RUPTURE) which requires identification of and isolation of affected SG:

Note: Steam Generator A response limited to E-3 expected response only.

S/U 34 Applicable Safety Related Display Console & Plant Process Computer point(s) responds to event: (Attach applicable displays/PPC points to substantiate response & evaluate)

S/U 35 Key parameters evaluated: SG A level, SJEA Rad Level; RCS Tavg; Steam/Feed Flow (Attach as applicable recorder trend / parameter plots)

S/U Malfunction #____, validated & test completed with no performance exceptions

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**SIMULATOR VALIDATION OF EOP EXPECTED PLANT RESPONSES**

S/U 0 E-0, REACTOR TRIP OR SAFETY INJECTION

S/U 1 Each control rod bottom light lit

S/U 2 Alarm [#___], ROD AT BOTTOM, actuates

S/U 3 Alarm [#___], TWO OR MORE RODS AT BOTTOM, actuates

S/U 4 Reactor trip and bypass breakers - OPEN

S/U 5 Neutron flux - LOWERING - decreases to 0

S/U 6 Main turbine trips - all turbine stop valves - SHUT

S/U 7 AC Emergency Busses remain energized (1AA02 & 1BA03)

S/U 8 Safety Injection auto initiates on Pressurizer pressure <1870 psig

S/U 9 Feed Water auto Isolates:
(1) MFIVs (Main Feedwater Isolation Valves) - SHUT
(2) MFRVs (Main Feedwater Regulation Valves) - SHUT
(3) BFIVs (Bypass Feedwater Isolation Valves) - SHUT
(4) BFRVs (Bypass Feedwater Regulation Valves) - SHUT

S/U 10 Engineered Safety Features Actuation System (ESFAS) actuates: automatic actions are: (Acceptable to only identify procedure EOP foldouts, attachments, etc. used to confirm automatic actions used for confirmations)

S/U 10 Containment Phase A - ACTUATES (List valves which auto close, etc.)

S/U 11 Motor Driven Auxiliary Feedwater (MDAFW) pumps - RUNNING (auto start); AFW flow > 570 GPM___

S/U 12 SG Blowdown isolates: SG blowdown isolation & sample valves - SHUT

S/U 13 Turbine Driven AFW - RUNNING (if LO-LO LEVEL in two or more SGs, and station BLACKOUT)

S/U 14 ECCS pumps - RUNNING:

(1) CCPs - RUNNING - RNO (remain off due to earlier malfunction active)
(2) SI pumps - RUNNING
(3) RHR Pumps - RUNNING

S/U 15 CCW pumps remain on - TWO RUNNING EACH TRAIN

S/U 16 NSCW pumps remain on - TWO RUNNING EACH TRAIN

S/U 17 Containment Cooling Units - Fans operating in low speed -RUNNING

S/U 18 NSCW cooler isolation valves remain open - OPEN

S/U 19 Containment Ventilation Isolates - dampers & valves SHUT

S/U 20 Main steam line pressure remains >585 psig

S/U 21 Containment pressure remains <14.5 psig

S/U 22 Steam Line depressurization rate commensurate with turbine unloading rate

S/U 23 Main Steam Line Isolation & Bypass Valves - SHUT

S/U 24 Containment Spray - NOT REQUIRED (pressure remains <21.5 psig)

S/U 25 Both Emergency Diesel Generators auto start - RUNNING

S/U 26 ECCS Valve Alignment - PROPER INJECTION LINEUP: (Confirm Attachments B, C & D)

S/U 27 RCS Average Temperature - STABLE AT OR TRENDING TO 557 degF

S/U 28 Pressurizer Power Operated Relief Valves (PORVs) remain closed -SHUT

S/U 29 Pressurizer Normal Spray Valves remain closed - SHUT

S/U 30 Reactor Coolant Pumps remain running (Operator action to stop all RCPs when RCS PRESSURE LESS THAN 1375 psig)

S/U 31 ACCW pump(s) remain running - RUNNING

S/U 32 NO SG PRESSURE LOWERING IN A UNCONTROLLED MANNER

S/U 33 NO SG COMPLETELY DEPRESSURIZED

S/U 34 SG Tubes are intact RNO - (No, operator action required, transition to EOP-19030-C, STEAM GENERATOR TUBE RUPTURE):
(1) Main Steam Line A radiation - NORMAL - RNO
(2) Main Steam Line B radiation - NORMAL
(3) Main Steam Line C radiation - NORMAL
(4) Main Steam Line D radiation - NORMAL
(5) Condenser air ejector radiation - NORMAL - RNO
(6) SG blowdown radiation - NORMAL - RNO

S/U 35 RCS is intact inside Containment

(1) Containment radiation - NORMAL
(2) Containment pressure - NORMAL
(3) Containment emergency recirculation sump levels - NORMAL

S/U 36 Alarm [#__], XXXXX, ..... actuates/ remains off (identify pertinent alarms /automatic actions directly associated with EOP plant response)

Note: May attach as supplement to this item

S/U 37 Applicable Safety Related Display Console & Plant Process Computer point(s) responds to event: (Attach applicable displays/PPC points to substantiate response & evaluate)

S/U 38 Key parameters evaluated:(Attach as applicable recorder trend / parameter plots)

Rod positions; SG A level; VCT level & pressure, Charging flow; Letdown flow; Pressurizer level; RCS Tavg; etc.

S/U E-0 ____, validated & test completed with no performance exceptions

**SIMULATOR VALIDATION OF EOP EXPECTED PLANT RESPONSES**

S/U 0 **E-3, STEAM GENERATOR TUBE RUPTURE**

Note: Entry from: (a) EOP E-0, Step 24___

**Reactor Coolant Pumps**

S/U 1 RCS PRESSURE LESS THAN 1375 PSIG

S/U 2 Alarm [#___], PRZR LO PRESS / P7 REACTOR TRIP, actuates <1960 psig___)
Automatic actions:
(1) Reactor auto trip
(2) Turbine auto trip
(3) Feedwater Isolation if Tavg < 564 degF
(4) Steam Dump Armed

S/U 3 Operator actions: Stop all RCPs
(a) All RCPs stop

**SG A**

S/U 4 SG A Rupture confirmation:

(1) High radiation from SG A main steam line
(2) Rise in SG A narrow/wide range level

S/U 5 Operation actions: Isolate flow from Ruptured SG A (Adjust SG A Atmospheric Relief Valve (ARV) controller set point to 1160 psig)

S/U 6 Ruptured SG A ARVs - remain SHUT

S/U 7 Operator actions: Shut steam supply valve____ from SG A to TDAFW pump:

S/U 8 SG A blowdown isolation valve\ ___ remains SHUT

S/U 9 Operator actions: Shut ruptured SG A steamline isolation & bypass valves:

(1) SG A MSL A isolation valve - SHUT
(2) SG A MSL A isolation bypass valve - SHUT

S/U 10 Operator actions: Check rupture SG A level > 5%___

S/U 11 SG A level increases above 5% (as long as RCS pressure > SG A pressure)

S/U 12 Operator actions: Stop feed water flow to ruptured SG A when SG A level > 5%

S/U 13 Continue with E-3 as long as necessary to validate SG A pressure & level response to RCS into SG A and vice versa (differential pressure drives direction of flow)

S/U 14 Alarm [#__], XXXXX, ..... actuates/ remains off (identify pertinent alarms /automatic actions directly associated with EOP plant response)

Note: May attach as supplement to this item

S/U 15 Applicable Safety Related Display Console & Plant Process Computer point(s) responds to event: (Attach applicable displays/PPC points to substantiate response & evaluate)

S/U 16 Key parameters evaluated:(Attach as applicable recorder trend / parameter plots)

SG A level & pressure, Pressurizer level & pressure; etc.

S/U E-3 ____, validated & test completed with no performance exceptions

**Simulator Software & Hardware discrepancies/ discrepancies identified from testing:**

DR#, XXXX, (Description & details, etc. - Use objective characterizations such as: Contrary to test Step x, alarm X failed to actuate at setpoint. The alarm actuated at Y.)

**POST-TRIP DYNAMIC/STATIC TREND/PLOT PARAMETER LIST** (Check ANSI/ANS-3.5)

Point ID Parameter (*parameters to be plotted simultaneously verses time with resolution of 1 second or less is required by ANSI/ANS-3.5)

_____*RCS WR Thot - LOOP 1
_____*RCS WR Tcold - LOOP 1
_____*SG A NR Level
_____*SG A WR Level
_____*SG A Pressure
_____*SG A Steam Flow
_____*SG A Feed Flow
_____ AFW Flow to SG A
_____ RCS WR Thot - LOOP 2
_____ RCS WR Tcold - LOOP 2
_____ SG B NR Level
_____ SG B WR Level
_____ SG B Pressure
_____ SG B Steam Flow
_____ SG B Feed Flow
_____ AFW Flow to SG B
_____ Turbine Impulse Pressure
_____ Main Generator Megawatts
_____*Power Range Flux
_____*Intermediate Range Flux
_____*Source Range Flux
_____ RCS WR Pressure
_____*RCS Loop Flow - Loop 1
_____*RCS Loop Flow - Loop 2
_____*RCS Loop Flow - Loop 3
_____*RCS Loop Flow - Loop 4
_____ Containment radiation
_____*Containment pressure
_____*Containment temperature
_____*Pressurizer pressure
_____*Pressurizer level
_____*Narrow range pressurizer pressure

EXAMPLE - INTEGRITY OF SIMULATOR SBT (ASSERTIONS)

SBT NAME: Operating Test No. _____, [Title]

PURPOSE

As required by 10 CFR 55.46 (d)(1), the purpose of this simulator performance test, known as a Scenario-Based-Test (SBT) is to provide documented test results which demonstrate expected plant response to operator input and to normal, transient, and accident conditions to which the simulator has been designed to respond.

TEST RESULTS SUMMARIES

Initial Conditions (ICs) - Simulator initial conditions established for this performance test were derived from real time operation of the simulator from established ICs. (e.g., protected base line)

Malfunctions and Transients - Simulator performance for the identified key parameters, automatic actions, and alarms during scenario malfunctions and transients utilized in this performance test met the criteria of ANSI/ANS-3.5-1998, Section 4.1.4 under simulated identical plant conditions or met them with the following exceptions. (Provide technical narrative for exceptions).

Simulator Operating Limits - No simulator operating limits were exceeded during the conduct of this performance test.

Modeling and Hardware Discrepancies - Modeling and hardware discrepancies and discrepancies identified during the conduct of this performance test are available for NRC review, prior to or concurrent with preparations for each operating test or requalification program inspection.

Learning and Examination Objectives - Established operator learning and examination objectives for this performance test were met.

I, _____ (Print Name) certify that the above assertions are true.

Signed: _____(Signature & Date)