NEI
White Paper
Revision 0

Nuclear Power Plant-Referenced Simulator Scenario Based Testing Methodology

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1.0 PURPOSE

The purpose of this white paper is to provide an equitable and consistent approach and methodology for the conduct and documentation of simulator Scenario Based Testing (SBT) as described in paragraph 4.4.3.2 of ANSI/ANS-3.5-1998, "Nuclear Power Plant Simulators for Use in Operator Training and Examination". This white paper also supports pending requirements for SBT in a proposed version of ANSI/ANS-3.5 currently undergoing revision.

2.0 PROBLEM STATEMENT

Paragraph 4.4.3.2 of ANSI/ANS-3.5-1998 outlines the concept of scenario based testing but does not describe in detail a process by which this method of simulator performance testing is conducted, evaluated and documented. On December 11, 2007 the NRC and NEI's Licensed Operator Focus Group (LOFG) reached a significant agreement in principle on a methodology for performing, evaluating and documenting scenario based testing to ensure consistent application of the SBT process. This agreement was based on the NRC's observation of a demonstration of the SBT process at Robinson Nuclear Plant's plant-referenced simulator in July of 2006 in which the concept of instructor validation of simulator scenarios to be used for training and evaluation, and oversight of simulator performance during the validation process, worked hand-in-hand. This methodology will here after be referred to as the "SBT Methodology".

Key to the SBT Methodology is parallel testing and evaluation of simulator performance while instructors validate simulator training and evaluation scenarios. As instructors validate satisfactory completion of training or evaluation objectives, procedure steps and scenario content, they are also ensuring satisfactory simulator performance in parallel, not series, making the process an "online" method of evaluating simulator performance. Also critical is the assembly of the SBT package – the collection of a marked-up scenario, appropriate procedures, monitored parameters, an alarm summary and an affirmation checklist – that serves as the proof of the robust nature of this method of performance testing. The SBT Methodology alleviates the need for post-scenario evaluation of simulator performance without creating an additional burden for instructors who are essentially required to ensure that simulator performance is satisfactory anyway. Most importantly, the instructor validation process and this SBT Methodology identifies and corrects more problems than any other form of performance testing, making this one of the most effective means to maintain simulator fidelity.

Until the 12/11/07 NRC-LOFG agreement on the SBT Methodology and the development of this white paper, there has been no defined and standardized process to conduct SBT. At this meeting the NRC agreed in principle with four recommendations (refer to references 4.5, 4.6 and 4.7):

1. Accept and endorse the SBT testing methodology.
2. Accept and endorse the SBT documentation methodology.
3. Bound the required scenarios to undergo SBT as NRC-required examination scenarios (i.e., NRC initial license examination scenarios and annual re-qualification examination scenarios) and scenarios utilized for license candidate reactivity manipulation credit.
4. The requirement to demonstrate that testing of the malfunctions listed in section 3.1.4 of ANSI/ANS 3.5-1998 has been performed at least once in the lifetime of the simulator; this documentation will include the completed test results, and these test results will be retained for the life of the simulator.

This white paper therefore serves as the means for the industry to recognize a recommended and standard process for the conduct, performance and documentation of SBT.

3.0 EVALUATION

3.1 Scenario Based Testing (SBT) takes advantage of the sound, fundamental practices of preparing for simulator training and examination through instructor scenario validation. SBT is a parallel activity to scenario validation, not one that functions in series. Through the course of scenario validation, instructors should constantly monitor simulator parameter response to ensure that pre-determined objectives can be achieved without deviation from the scenario or plant procedures and without violation of physical laws. During scenario validation, an affirmation of simulator performance is documented through completion of a checklist such as that provided in Attachment 1, thus completing the SBT process. It is not intended that SBT be a post-scenario evaluation of collected data (e.g. alarm pages, charts, trends), but rather a real-time evaluation process as each required scenario is being validated.

3.2 As a minimum, the following scenario types must undergo SBT:

3.2.1 NRC Initial License Examination scenarios.

3.2.2 Licensed Operator Requalification annual examination scenarios.

3.2.3 Scenarios used for taking credit for reactivity manipulations for license candidate experience requirements.

3.2.4 It is encouraged that other scenarios, such as those used for licensed operator continuing training and examination and initial licensed operator periodic and audit exams, be considered for SBT prior to use as well.

3.3 Scenario based testing is conducted by a crew of SRO certified instructors and/or licensed operators, plus a lead instructor orchestrating the SBT process. A “crew” for this purpose would be a minimum of one individual in the SRO position and two individuals in RO positions.

3.4 Prior to the start of SBT, a pre-defined set of key parameters should be loaded for recording simulator performance. A combination of selected key parameters such as those found in the steady state and transient test lists of Appendix B of ANSI/ANS-3.5-1998 is recommended. The number of key parameters monitored is dependent on reactor type (PWR or BWR), but should be sufficient for adequate documentation of simulator performance.

3.5 Scenarios should be run in real time, to the extent necessary, to ensure the completion of the objectives and termination point. It is acceptable to “freeze” the simulator to evaluate simulator parameters and performance,

such as after each major event and/or malfunction. "Backtrack" must not be used in order to preserve the integrity of monitored parameter trending.

3.6 Execution of each procedure, as described in the scenario guide, should be achieved during scenario based testing.

3.7 Plant parameters, alarms, and automatic actions should be monitored to ensure expected response. The simulator shall not cause unexpected, or prevent expected automatic actions and alarms. Verification of alarms should be limited only to those pertinent to primary (often referred to as "first-principles" or "first order") response from each malfunction/event, those important to operator response and scenario objective completion, and those necessary for satisfactory procedure execution. While attention should always be paid to all simulator indications and alarms, it is unnecessary to perform item-by-item evaluation of secondary and tertiary alarms and indications that would be received after major transients, such as a reactor scram/trip, loss-of-coolant accident and/or loss-of-offsite power event, for example.

3.8 Observable change in key parameters should be verified to correspond in trend and direction to those expected.

3.9 Simulator response shall not violate the physical laws of nature.

3.10 The simulator shall be capable of being used to satisfy predetermined training or evaluation objectives or tasks without exceptions, significant performance discrepancies, or deviation from the approved scenario sequence.

3.11 Include appropriate instructor interface and cueing in each scenario.

3.12 Throughout the course of performing SBT, the validating crew and lead instructor should articulate what response, trends, parameter/setpoint values, and primary alarms they expect, see and have received throughout each event of the scenario. The lead instructor responsible for performing SBT should pay close attention to the crew's articulation of cues and feedback to verify proper simulator response and scenario content. This is not to imply that the validating crew must know the content of the scenario in advance, however it is acceptable if they do.

3.13 Key procedure actions should be either documented in the scenario or verified using copies of actual procedures. Lead instructor and crewmember notations of setpoints, trends, actions, "response not obtained" steps (most Pressurized Water Reactors) and Emergency Operating Procedure (EOP) flowchart actions (Pressurized Water Reactors and Boiling Water Reactors), in both the scenario and the procedures used is necessary as a means of showing engagement in the SBT process. The lead instructor is responsible for ensuring this occurs and that the scenario and procedure markups are retained as part of the SBT data package.

3.14 An affirmation checklist, similar to Attachment 1 will be completed for each scenario that requires performance of SBT, to document completion of scenario based testing. The information in Attachment 1 denotes minimum required information for the affirmation checklist.

3.15 The marked-up scenario, appropriate procedure pages, a print-out of the monitored parameter file, an annunciator summary and the affirmation checklist in Attachment 1 constitute the SBT data package. This package will be assembled and retained in accordance with site requirements for four (4) years or until the scenario undergoes SBT again, whichever occurs first.

3.16 Electronic retention of appropriate data noted in 3.15 above such as monitored parameter files and annunciator summaries is acceptable but must meet the same four (4) year retention time requirement and must be readily retrievable.

3.17 With regard to retaining flow-chart based procedures for the data package, several methods are acceptable. One method would be to include enough detail in the scenario to follow what an operator would execute through a flow chart (major yes/no and if/then decisions, support procedure steps, etc.) such that retaining copies of the flowchart would be unnecessary. Another method would be to use paper copies of flowcharts that could then be retained in the data package. Finally, digital photographs of the actual marked-up flowcharts could be taken, printed and retained in the data package. No one method is preferred over another; the key is to be able to show adequate and verifiable procedure execution, operator actions and simulator performance through the use of plant procedures without deviation or exception.

3.18 Facilities are encouraged to develop and populate a scenario validation database. The database would contain an entry for each scenario that would show the scenario's title and revision, the date it was validated and/or underwent SBT and any deficiencies identified. Typically, the lead instructor would populate the database at the conclusion of each validation/SBT event.

3.19 Discrepancies should be documented using the site process for identifying and correcting simulator deficiencies. If the scenario validation database noted in step 3.18 above is used, note the deficiency there as well.

3.20 Procedure revision requests should be submitted using the appropriate site process where procedure changes are appropriate as identified during SBT.

4.0 REFERENCES

4.1 10CFR55.45, Operating Tests

4.2 10CFR55.46, Simulation Facilities

4.3 NRC Regulatory Guide 1.149 Revision 3, Nuclear Power Plant Simulation Facilities for use in Operator Training and License Examinations

4.4 ANSI/ANS-3.5-1998, Nuclear Power Plant Simulators for use in Operator Training and Examination

4.5 Letter to Nancy L. Salgado (NRC) from Jack W. Roe (NEI), Simulator Scenario Based Testing Methodology, dated November 20, 2007, Adams document ML0733370662

4.6 Letter to Jack W. Roe, NEI) from Frederick D. Brown (NRC), Simulator Scenario Based Testing Methodology, dated January 3, 2008, Adams document ML073460199

4.7 Memorandum to Frederick D. Brown (NRC) from Nancy L. Salgado (NRC), Summary of December 11, 2007, Meeting With Industry Focus Group on Operator Licensing Issues, dated January 3, 2008, Adams document ML073511714

Attachment 1

NUCLEAR POWER PLANT-REFERENCED SIMULATOR SCENARIO BASED TESTING METHODOLOGY CHECKLIST

Scenario Number: _____Rev:_____ IC:____ Date Validated:_____

Checklist Instructions	Initials
1. Load the pre-prepared simulator monitored parameter file *(sites may load the actual file name and any instructions here)*.	
2. Verify that the scenario has clearly stated objectives and/or training/evaluation tasks	
3. Ensure the scenario and its contents include: a. The point in the scenario where each event is initiated b. The malfunctions that are entered to initiate each event c. The symptoms/cues that will be visible to the crew for diagnosing each event d. The expected major crew actions for each event. List general procedural flow path, immediate actions, and any procedural steps that are "by exception" e. Applicable Technical Specification Limiting Conditions for Operation (LCO) conditions f. Emergency Plan Actuation Level (EAL) declaration thresholds as appropriate	
4. In real time, as necessary, verify that the sequence and timing of events, including critical instructor interface and cueing, are reasonable and allows the use of applicable procedure to satisfy the credited tasks and scenario objectives	
5. Verify that the simulator response is realistic and observable change in parameters corresponds in trend and direction to those expected	
6. Verify that the critical alarms and automatic actions function as expected and print simulator annunciator summary	
7. Print monitored parameter data and if desired, electronically archive *(sites may include actual instructions to complete this action here).*	
8. Enter scenario information in the scenario validation database *(if used).*	
9. Assemble relevant marked up procedure pages (abnormal and emergency procedures, startup/shutdown procedures, system operating procedures, alarm response procedures), exercise guides, annunciator summary, and the monitored parameter file.	
10. Scenario tested and simulator response reviewed by: *(list lead instructor and crew members)*	

Comments/Discrepancies: _____

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Date Validated & Signature: _____