NEI 09-09 [Rev 0]

NUCLEAR POWER PLANT-REFERENCED SIMULATOR SCENARIO BASED TESTING METHODOLOGY

April 2009

NEI 09-09 [Rev 0]

Nuclear Energy Institute

Nuclear Power Plant-Referenced Simulator Scenario Based Testing Methodology

April 2009

ACKNOWLEDGEMENTS

NEI acknowledges the assistance of the following individuals during the development of this White Paper:

- Jack Roe, NEI; Director – Security and Operations Support
- Russell Smith, NEI; NEI Licensed Operator Focus Group (LOFG) Project Manager/Facilitator
- Gregg Ludlam, Exelon Corporation – Document author and Industry Chairman, NEI LOFG
- Chuck Sizemore, FP&L – Corporate Training and Industry Vice Chairman, NEI LOFG
- Kerry Wright, FP&L Corporation – Seabrook Station and NEI LOFG member
- Chuck Hess, PPL Corporation – Susquehanna Steam Electric Station and NEI LOFG member
- J.R. Steely, Duke Energy – Oconee Station and NEI LOFG member
- Michael Peterson, Exel Energy Corporation – Corporate Training and NEI LOFG member
- Tom Mayfield, Entergy Corporation – Corporate Training and NEI LOFG member
- Dilip Sunthankar, Progress Energy – Robinson Nuclear Plant
- Lee Sanders, Tennessee Valley Authority – Sequoyah Nuclear Plant
- Chuck Tyner, Exelon Corporation – Three Mile Island
- Mac McDade, Progress Energy – Shearon Harris Nuclear Plant

NOTICE

TABLE OF CONTENTS

ATTACHMENTS

GUIDELINE FOR THE MANAGEMENT OF MATERIALS ISSUES

1 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 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. Proper conduct of the SBT Methodology is intended to alleviate the need for post-scenario evaluation of simulator performance since the performance of the simulator is being evaluated (i.e.: compared to actual or predicted reference plant performance) during the parallel conduct of SBT and scenario validation. Conducting SBT as an integral part of simulator scenario validation and training/evaluation preparation provides the opportunity to identify and correct more simulator issues than most other means of simulator testing while providing instructors the opportunity to improve simulator training and evaluation in an integral fashion.

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 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 to satisfy the reactivity control manipulation requirement for license candidates in 10 CFR 55.31(a)(5).

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. Key parameters are the parameters necessary for a full understanding or explanation of the expected plant response to which the simulator has been designed to respond. 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 must be sufficient for adequate documentation of simulator performance for any given scenario and combination of scenario events.

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, as long as the simulator continues to support the SBT in a continuous manner, without any mathematical model or initial condition changes. "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. Test personnel as a minimum (1) must verify parameters, alarms, and automatic actions directly related to a scenario event, a malfunction, and/or an operator input, and (2) are not expected to verify non-relevant alarms and automatic actions, unless they are unexpected. Verification of alarms should be limited only to those pertinent to primary (often referred to as "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 The response of the simulator resulting from operator action, no operator action, improper operator action, automatic reference unit controls, and inherent operating characteristics shall be realistic and shall not violate the physical laws of nature, such as conservation of mass, momentum, and energy, within the limits of the verification, validation, and performance testing criteria of the standard.

3.10 The simulator shall be capable of being used to satisfy predetermined training or evaluation objectives 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 printout of the monitored parameter file, an annunciator summary and the affirmation checklist in Attachment 1 constitute the SBT Test Results Package. This package will be assembled and retained in accordance with site requirements for four (4) years or until superceded with updated test results (i.e.: the scenario undergoes SBT again), whichever occurs first.

3.16 Electronic retention of the SBT Test Results Package 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 in accordance with site simulator configuration management procedures. If the scenario validation database noted in step 3.18 above is used, note the discrepancies 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 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 ML073240964

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

4.8 Letter to Jack W. Roe, (NEI) from Frederick D. Brown (NRC), Simulator Scenario Based Testing Methodology White Paper, dated December 30, 2008, Adams document ML083290481

ATTACHMENT 1
Nuclear Power Plant-Referenced Simulator
Scenario based testing methodology checklist

Scenario Number: _____ **Revision:** _____ **IC:** _____ **Date Validated:** _____

Item	Simulator Performance	Initials
1	Simulator performance supported scenario objectives.	
2	Simulator initial conditions (IC) agreed with reference plant with respect to reactor status, plant configuration, and system operation.	
3	Simulator operated in real time during conduct of SBT. *Note: Use of "freeze" allowed when evaluating specific performance.*	
4	Simulator demonstrated expected plant response to operator input and to normal, transient, and accident conditions to which the simulator has been designed to respond.	
5	Simulator permitted use of the reference plant's procedures so that the scenario was completed without procedural exceptions, simulator performance exceptions, or deviation from the scenario sequence.	
6	Simulator did not fail to cause an expected alarm or automatic action and did not cause an unexpected alarm or automatic action. *Note: Attach simulator alarm summary (versus time) to SBT Test Results record.*	
7	Observable change in simulated parameters corresponded in trend and direction to those expected from actual or best estimate response of the reference plant. *Note: Attach predetermined Monitored Parameter List (versus time) to SBT Test Results record.*	
8	Reference plant design limitations were not exceeded.	
9	Each scenario malfunction demonstrated expected plant response to its initiating cause.	
10	SBT conducted in a manner sufficient (i.e., meets requirements of ANSI/ANS-3.5-1998) to ensure that simulator fidelity has been demonstrated and met for this scenario. *Note: Attach relevant "as-run" marked-up plant procedures and or procedure portions/pages utilized to support assertion.*	
11	Modeling and hardware discrepancies identified during the conduct of SBT are documented and entered in accordance with the site simulator configuration management procedures. *Note: Discrepancies that directly affect operator response (or action) or expected plant response must be resolved before the SBT test results can be judged as satisfactory.*	
12	Simulator SBT performance test results: ___ SATISFACTORY / ___ UNSATISFACTORY *Note: Attach list of SBT test personnel (include name, job title, and level of effort).*	*Date (mm/dd/yyyy) and Signature*
	Technical comments attached:	