SAFETY EVALUATION BY THE OFFICE OF NEW REACTORS

RELATED TO THE REQUEST FOR A COMMISSION APPROVED SIMULATOR FOR

VIRGIL C. SUMMER NUCLEAR STATION UNITS 2 AND 3

SOUTH CAROLINA ELECTRIC AND GAS COMPANY

SOUTH CAROLINA PUBLIC SERVICE AUTHORITY

DOCKET NOS. 52-027 AND 52-028

1.0 INTRODUCTION

By letter dated April 21, 2016[1] pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) 55.46(b) as supplemented by letters dated May 25 and July 12, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML16146A717 and ML16194A247), South Carolina Electric & Gas Company (SCE&G, facility licensee)[2] submitted a new request for a Commission-Approved Simulation Facility (CAS) for VCSNS Units 2 and 3. SCE&G stated that its request corresponds closely with a request for a CAS submitted by Southern Nuclear Operating Company (SNC) on September 18, 2015 (ADAMS Accession No. ML15265A107) and addressed the NRC Requests for Additional Information associated with the SNC submittal. A plant-referenced simulator models the systems of the reference plant (i.e., the specific nuclear power plant from which a simulation facility's control room configuration, system control arrangement, and design data are derived) with which the operator interfaces in the control room, including operating consoles, and permits use of the reference plant's procedures. However, VCSNS Units 2 and 3, which are Westinghouse Electric Company's (Westinghouse) AP1000 nuclear power plants, are currently under construction, and SCE&G has not yet developed the simulation facility into a plant-referenced simulator. Therefore, SCE&G made the request to allow SCE&G to administer operating tests pending completion of a plant-referenced simulator.

Previously, by letters dated January 16, 2015 (ADAMS Accession No. ML15016A339), as supplemented on March 30, 2015 (ADAMS Accession No. ML15089A425), April 28, 2015 (ADAMS Accession No. ML15118A802), and June 25, 2015 (ADAMS Accession No. ML15182A208) SCE&G submitted a request for approval to use a CAS for VCSNS Units 2 and 3, other than a plant-referenced simulator, in the administration of operating tests for

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[1] Letter NND-16-0109 with enclosures from R. A. Jones, Vice President, New Nuclear Operations, SCE&G to NRC, Subject: South Carolina Electric & Gas Company, Virgil C. Summer Nuclear Station Units 2 and 3, Request for a CAS, April 21, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16112A256).

[2] Virgil C. Summer Nuclear Station Units 2 and 3 are owned by the South Carolina Electric & Gas Company and South Carolina Public Service Authority (Santee Cooper). The VCSNS owners authorized SCE&G, Inc. to exercise responsibility and control over the physical construction, operation, and maintenance of the facility, and SCE&G is considered to be the facility licensee for purposes of this safety evaluation.

operators and senior operators under 10 CFR 55.45(b)(1). By letter dated July 2, 2015, (ADAMS Accession No. ML15182A097), the staff informed SCE&G that the agency was suspending its review of SCE&G's request based on the staff's determination that certain items, which were delineated in the enclosure to the July 2, 2015 letter, needed to be addressed through corrective action, or required additional explanation, before the staff could complete its detailed safety review. The NRC stated that when SCE&G had resolved the technical issues and corrective action items outlined in the enclosure, then SCE&G could request that the staff resume its safety review. By letter dated November 13, 2015 (ADAMS Accession No. ML15320A178), SCE&G stated that it had evaluated the unresolved items summarized by the NRC in the July 2, 2015, letter and has prepared proposed resolutions to the technical issues and corrective action items identified. This November 13, 2015, letter included a request for the staff to resume its review of the SCE&G CAS submittal. However, by letter dated December 16, 2015 (ADAMS Accession No. ML15350A202), SCE&G withdrew the request for a CAS, stating that SCE&G intends to resubmit the request when existing open items have been addressed.

This safety evaluation addresses the April 21, 2016, CAS request (hereafter called the CAS request letter), and explains the staff's conclusion that there is reasonable assurance for the following:

- The simulation facility for VCSNS Units 2 and 3 can be used to administer operating tests that require an applicant to demonstrate an understanding of and the ability to perform the actions necessary to accomplish a representative sample of the 13 items in 10 CFR 55.45(a) and that the simulation facility's response will model that of the reference plant during the operating tests.

- The simulation facility for VCSNS Units 2 and 3 can perform a sufficient number of operating tests for any one of the 13 items in 10 CFR 55.45(a) so that a licensing exam is not predictable.

- Any open simulator discrepancies will not negatively affect a licensing exam.

As part of an application for an operator or senior operator license, the applicant is required by 10 CFR 55.31(a)(5) to "[p]rovide evidence that the applicant, as a trainee, has successfully manipulated the controls of either the facility for which a license is sought or a plant-referenced simulator that meets the requirements of 10 CFR 55.46(c)." Accordingly, this safety evaluation also addresses the use of the VCSNS Units 2 and 3 simulation facility in providing evidence of such training. However, this evaluation does not address an exemption from 10 CFR 55.31(a)(5); without such exemption, the applicant would be unable to meet the requirements of the Commission's regulations until there is a "plant-referenced simulator that meets the requirements of 10 CFR 55.46(c)" available. Nonetheless, as explained in Section 3.4 of this safety evaluation, the Commission finds the simulation facility for VCSNS Units 2 and 3 satisfies the criteria in the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.149, Revision 3, "Nuclear Power Plant Simulation Facilities for Use in Operator Training and License Examinations," (October 2001) to be suitable for control manipulations. RG 1.149 describes methods acceptable to the staff for complying with those portions of the Commission's regulations associated with approval or acceptance of a nuclear power plant simulation facility for use in operator and senior operator training and operating tests and for meeting applicant experience requirements.

As explained below, the Commission also finds that the simulation facility for VCSNS Units 2 and 3 and its proposed use are suitable for the conduct of operating tests for the facility

licensee's reference plant under 10 CFR 55.45(a). Therefore, pursuant to 10 CFR 55.46(b)(2), the Commission approves the simulation facility for VCSNS Units 2 and 3 for administration of operating tests. The approval to administer tests on this CAS will expire as unneeded when SCE&G has available a plant-referenced simulator meeting the requirements of 10 CFR 55.46(c).

2.0 REGULATORY EVALUATION

2.1 Description of Simulation Facility

The CAS request letter, Enclosure 2, "Description of the Components of the Simulation Facility Intended to be Used for Each Part of the Operating Test – 10 CFR 55.46(b)(1)(i)," states:

> The VCS simulation facility is comp[o]sed of two AP1000 full scope simulators, designated "2A" and "2B." Both simulators are referenced to VCS Unit 2 and are intended to be maintained functionally identical. The simulators are licensed[3] to conform to the requirements of ANSI/ANS-3.5-1998, "Nuclear Power Plant Simulation Facilities for Use in Operator Training and License Examination," as endorsed by Revision 3 of NRC Regulatory Guide 1.149, "Nuclear Power Plant Simulation Facilities for Use in Operator Training and License Examinations."

2.2 Controlling Regulations

Per 10 CFR 55.33, to be licensed, an applicant must, among other things, pass the requisite operating test in accordance 10 CFR 55.45. The operating tests administered to applicants for operator and senior operator licenses in accordance with 10 CFR 55.45(b)(1) are generally similar in scope. The content will be identified, in part, from learning objectives derived from a systematic analysis of licensed operator or senior operator duties performed by each facility licensee and contained in its training program and from information in the Final Safety Analysis Report (FSAR), system description manuals and operating procedures, facility license and license amendments, Licensee Event Reports, and other materials requested from the facility licensee by the Commission. The operating test, to the extent applicable, requires the applicant to demonstrate an understanding of and the ability to perform the actions necessary to accomplish a representative sample from among the 13 items in 10 CFR 55.45(a)(1)-(13).

Pursuant to 10 CFR 55.45(b):

> *Implementation--Administration*. The operating test will be administered in a plant walkthrough and in either--
> (1) A simulation facility that the Commission has approved for use after application has been made by the facility licensee under § 55.46(b);
> (2) A plant-referenced simulator (§ 55.46(c)); or
> (3) The plant, if approved for use in the administration of the operating test by the Commission under § 55.46(b).

The Commission's regulations in 10 CFR 55.46 address the use of a simulation facility for the administration of the operating test and plant-referenced simulators to meet experience

[3] Simulators are not specifically licensed. In this quote, ANS-3.5-1998 is being referred to as part of the licensing basis for the combined license issued to SCE&G for VCS 2 and 3 nuclear plants.

requirements for applicants for operator and senior operator licenses. 10 CFR 55.46(b) sets forth the following process:

> *Commission-approved simulation facilities and Commission approval of use of the plant in the administration of the operating test.* (1) Facility licensees that propose to use a simulation facility, other than a plant-referenced simulator, or the plant in the administration of the operating test under §§ 55.45(b)(1) or 55.45(b)(3), shall request approval from the Commission. This request must include:
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> (i) A description of the components of the simulation facility intended to be used, or the way the plant would be used for each part of the operating test, unless previously approved; and
> (ii) A description of the performance tests for the simulation facility as part of the request, and the results of these tests; and
> (iii) A description of the procedures for maintaining examination and test integrity consistent with the requirements of § 55.49.
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> (2) The Commission will approve a simulation facility or use of the plant for administration of operating tests if it finds that the simulation facility and its proposed use, or the proposed use of the plant, are suitable for the conduct of operating tests for the facility licensee's reference plant under § 55.45(a).

2.3 Guidance Documents and Industry Standards

ANSI/ANS-3.5-1998 (W2008)[4], "Nuclear Power Plant Simulators for Use in Operator Training and License Examination" establishes the functional requirements for full-scope nuclear power plant control room simulators used for operator training and examination. ANSI/ANS-3.5-1998 also establishes criteria for the degree of simulation, performance, and functional capability of the simulated control room instrumentation and controls.

RG 1.149, describes methods acceptable to the NRC staff for complying with those portions of the NRC's regulations associated with approval or acceptance of a simulation facility for use in reactor operator and senior operator training and NRC's license examinations. Section C.1 of RG 1.149, Revision 3, endorses ANSI/ANS-3.5-1998, stating that, with certain clarifications listed in Sections C.1.1 to C.1.6, the standard:

> sets forth provisions acceptable to the NRC staff for addressing minimum design, testing, performance, and configuration criteria

[4] W=Withdrawn. The standard was approved April 15, 1998 and withdrawn April 12, 2008. Being withdrawn means that ANSI/ANS-3.5-1998 (W2008) is no longer being maintained as an American National Standard, and might contain outdated material or may have been superseded by another standard. In this case, the standard is replaced by ANSI/ANS-3.5-2009 (approved September 4, 2009).

> for a plant-referenced simulator; for integrating simulator design and performance with an accredited training program; for comparing a simulator to its reference plant; for upgrading simulators to reflect changes to reference plant response or control room configuration; and for improving simulator fidelity. ANSI/ANS-3.5-1998 provides methods acceptable to the NRC staff for a facility licensee to demonstrate that, through meeting the criteria of ANSI/ANS-3.5-1998, the plant-referenced simulator will possess a sufficient degree of completeness and accuracy to meet the requirements of 10 CFR Part 55, "Operators' Licenses," for use in reactor operator and senior operator training and NRC license examinations.

In April of 2011, the NRC published RG 1.149, Revision 4, "Nuclear Power Plant Simulation Facilities for use in Operator Training, License Examinations, and Applicant Experience Requirements" to describe updated methods for approval of a nuclear power plant simulation facility for use in operator and senior operator training and license examination operating tests and for meeting applicant experience requirements. Revision 4 also documents the NRC's acceptance and endorsement of ANSI/ANS-3.5-2009. Concerning continued usage of previous editions of ANSI/ANS-3.5-2009, RG 1.149, Revision 4, Section C.4 states:

> Acceptability of Licensee's Simulation Facility
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> Licensees that maintain simulation facilities certified under previous editions of ANSI/ANS-3.5 (1998, 1993, and 1985) endorsed by the NRC are encouraged to, but are not required to, revise the software and testing documentation to maintain the simulation facility in accordance with ANSI/ANS-3.5-2009. The NRC expects that a simulation facility will be maintained in accordance with a single version of the standard, preferably ANSI/ANS-3.5-2009.

Although the NRC has preference for the updated[5] ANSI/ANS-3.5-2009 standard, use of the update is not mandatory; the standards applied to a particular plant depend on the plant's existing license. As previously stated, the simulators are licensed to conform to the requirements of ANSI/ANS-3.5-1998 as endorsed by Revision 3 of RG 1.149. The staff used the 1998 standard, as endorsed by Revision 3 to RG 1.149, when assessing the licensee's request. However, the staff confirmed that no intervening developments (e.g., rulemaking) precluded continued usage of the older standards when reviewing current requests.

Operator licensing examinations must meet the requirements of 10 CFR 55 Subpart E, "Written Examinations and Operating Tests." 10 CFR 55.40 requires the Commission and power reactor facility licensees use the criteria in NUREG-1021, "Operator Licensing Examination Standards for Power Reactors," to prepare and evaluate the operating tests required by 10 CFR 55.45. NUREG-1021 provides specific direction on operator licensing examination standards. NUREG-1021 provides that a facility licensee must provide the written examination, operating

[5] The update, ANSI/ANS-3.5-2009, provides enhanced readability, and provides users with improvements and clarifications in simulator scenario-based performance testing, some new sections addressing simulator core performance testing and post-event simulator testing, and other new important guidance concerning accurate simulation for use in operator training and examination.

test, and a certification that its simulators can run the scenarios included in the operating test to the NRC for review and approval prior to the administration of licensing examinations. NUREG-1021 also provides that the NRC staff must confirm that the simulator can run the scenarios included in the operating test without malfunction or deviation prior to the administration of the licensing examination.

NUREG-1021 divides the operating test into two major parts, which are simulator scenarios and job performance measures (JPMs). Simulator scenarios expose the applicants to normal, abnormal, and emergency conditions during all modes of operation. JPMs are used to determine the competence of the applicants in performing tasks identified in the facility's job task analysis. Both of these elements are used to evaluate the applicant's understanding of and ability to perform the actions necessary to accomplish a representative sample of the 13 items listed in 10 CFR 55.45(a). Applicants for operator and senior operator licenses must also meet the application requirements in 10 CFR 55.31(a)(5), which require evidence that applicants performed control manipulations on plant-referenced simulators that have been approved under 10 CFR 55.46(c), or the plant itself.

Together, ANSI/ANS-3.5-1998 and NUREG-1021 provide for the integration of the simulation facility with the licensing examination to ensure that the operating test provides for an equitable and consistent administration of examinations to all applicants. Satisfactory completion of the performance tests prescribed by ANSI/ANS-3.5-1998 demonstrate that the simulation facility is sufficient in both scope and fidelity with its reference plant. The method of administering, preparing, and evaluating licensing examinations described in NUREG-1021 ensures the equitable and consistent administration of licensing examinations and confirms that a simulation facility can function without malfunction or deviation for the particular scenarios to be included in a specific operating test.

2.4 Explanation of Terminology

When a simulation facility is used to license operators and senior operators, it must replicate the reference plant configuration and performance with sufficient scope and fidelity for the purposes for which it is used with respect to operating tests under 10 CFR 55.45 and performance of control manipulations that affect reactivity, evidence of which is required as part of the application for an operator's license, as provided in 10 CFR 55.31(a)(5). This allows the staff examiners to evaluate the applicant's understanding of and ability to perform the actions necessary to accomplish a representative sample of the 13 items listed in 10 CFR 55.45(a)(1)-(13), which are necessary to safely operate the reactor as part of the operating crew during normal, abnormal, and emergency conditions.

To ensure a common understanding of the terms, concepts, and conditions applicable to this safety evaluation, the staff provides the following explanations.

- Plant-referenced simulators as compared to CAS:

  SCE&G requested that the Commission approve the VCSNS Units 2 and 3 simulation facility, in its current configuration, as a CAS to be used to conduct operator licensing examinations until the simulators are accepted as plant-referenced simulators. The simulation facility for VCSNS Units 2 and 3 does not yet meet the NRC's requirements for plant-referenced simulators because the design activities required by the AP1000 design certification to establish the human factors engineering (HFE) design for the main control room are in progress, but have not yet been completed. The definition of a plant-

referenced simulator as stated in 10 CFR 55.4 means a simulator modeling the systems of the reference plant with which the operator interfaces in the control room, including operating consoles, and which permits use of the reference plant procedures. While the current configuration of the simulation facility for VCSNS Units 2 and 3 models core physics, thermodynamic and heat transfer characteristics associated with integrated system operations, containment functions, and electrical and instrumentation and control system functionality, the actual control room console and operating station designs are incomplete.

However, a proposed control room console and operating station design has been established and tested in the integrated system validation (ISV) test. The ISV identified human engineering discrepancies (HEDs), which have been documented and are currently in the resolution process. For example, in the CAS request letter, the facility licensee described that the ISV identified some aspects of the AP1000 Alarm Presentation System that did not conform to HFE guidelines. Specifically, the number of alarms present in the control room during abnormal plant conditions resulted in a higher level of workload than is desired for the AP1000. Therefore, Westinghouse provided an update for the simulation facilities for VCSNS Units 2 and 3 to reduce the workload associated with managing alarms. The current configuration of the simulation facility for VCSNS Units 2 and 3 models the configuration that was tested in the ISV with modifications that were made to resolve the significant issues identified by the ISV, and this configuration is consistent with the system and component designs, as well as the HFE guidelines, described in the AP1000 design control document (DCD).

As explained later in this evaluation, the HEDs that have been identified are either resolved or have been determined not to prevent the simulation facility for VCSNS Units 2 and 3 from demonstrating sufficient fidelity with the reference plant for the purpose of administering operating tests in accordance with 10 CFR 55.45(a), and accordingly the simulation facility for VCSNS Units 2 and 3 is suitable both for use in operating tests and for performance of control manipulations required by 10 CFR 55.31(a)(5).

- Simulator performance discrepancies as compared to HEDs

  Discrepancies fall into two categories, which are simulator performance deficiencies and HEDs. Simulator performance discrepancies were identified by factory and site acceptance testing. Simulator performance discrepancies are specific to simulator functionality and its ability to replicate the reference plant performance. Simulator discrepancies typically measure how the simulator configuration differs from the reference plant configuration as documented in the DCD. Examples include a component or indication not operating as it would in the reference plant, incorrect labeling of control room indications, an automatic calculation not working properly, the simulator incorrectly modeling core physics, and inconsistent indications.

  HEDs were identified by the ISV and are associated with HFE design effectiveness. HFE design discrepancies include some simulator performance discrepancies, but they are primarily focused on providing a control room design that minimizes the potential for human error. Human error is not as predictable as errors in the performance of electrical and mechanical systems. Westinghouse applied general HFE design principles that conform to Revision 2 of NUREG-0711, “Human Factors Engineering Program Review Model” (February 2004) and Revision 2 of NUREG-0700, “Human-System Interface

Design Review Guidelines" (May 2002) to develop the AP1000 control room HFE design and tested the design with the ISV to validate that the HFE design supports the safe operation of the plant. The identification of HEDs during the ISV depends on the opinion of, and the performance of, the test personnel who perform the ISV test scenarios in the simulation facility. All HEDs will be assessed to determine if improvements can be made to the HFE design. Some HEDs will be left "as-is" because proposed solutions would introduce more significant HFE-related challenges than the current configuration. Others will be addressed by modifying procedures or the training program or by control room HFE design changes. It is important to remember that HEDs are a subjective measure of human performance and judgement is being applied as to what provides the best solution to support long term operating crew performance. Similarly, judgement is being applied by the staff as to how significant these HEDs are in impacting simulator performance during license exams. However, as discussed further in Section 3.2 of this evaluation, none of the HEDs that have been identified prevent the simulation facility from demonstrating fidelity with the reference plant during operating tests that contain a representative sample of the 13 items in 10 CFR 55.45(a), and accordingly, the simulation facility for VCSNS Units 2 and 3 is suitable both for use in operating tests and for performance of control manipulations required by 10 CFR 55.31(a)(5).

- Simulator performance testing

  The performance test scenarios referred to in this evaluation did not only test single component functionality. The scenarios contain multiple operating conditions that include the normal, abnormal, and emergency events applicable to the facility that demonstrate component performance as well as individual system performance and integrated system performance. To demonstrate simulator performance for comparison to the reference plant, the simulator must have accurate reactor physics models and thermal hydraulic models. The sophistication of these models is what allows simulator testing to identify system design problems such as components incorrectly sized, stroke times too long or too short, and control systems not calibrated correctly. Similarly, it is the sophistication of these models that provides for such things as accurate reactor physics models that support control manipulations and the translation of energy from the core and reactor coolant system into the containment providing for accurate modelling of the containment response in a loss of coolant accident. Large numbers of operating tests (at least on the order of thousands) can be supported by the current configuration of the simulation facility for VCSNS Units 2 and 3. The capability of a simulation facility to run all of the transient tests and malfunction tests listed in ANSI/ANS-3.5-1998 as well as the test scenarios required to perform the ISV is a significant demonstration of simulation capability.

- Simulation facilities and operator licensing examinations

  The simulation facility is a tool used to support the operating test required by 10 CFR 55.45. A simulation facility may also be used to perform the control manipulations required by 10 CFR 55.31(a)(5). As such it must meet minimum standards specified in 10 CFR Part 55. The most fundamental requirement is that the simulation facility must replicate the reference plant performance in scope and fidelity. In practice, a simulation facility runs scenarios, which are sequences of events selected from the range of normal, abnormal and emergency operating conditions that could occur in the plant. Scenarios are used to verify that the simulator replicates the

reference plant performance as documented in the DCD. Scenarios are also used to support the operating test administered to applicants for operator and senior operator licenses, as well as control manipulations.

As noted above, large numbers of scenarios can be supported by the current configuration of the simulation facility for VCSNS Units 2 and 3. Some of the possible scenarios are or may be affected by open discrepancies.

In making its findings on the simulation facility and its proposed use, the Commission is assessing how the information in the request (i.e., the information about the components and performance tests of the simulation facility, and the procedures for test integrity) shows that the simulation facility meets the intent of ANSI/ANS-3.5-1998. The showing must be sufficient to support the Commission's suitability findings to be used in licensing examinations. In making its findings, the staff compared SCE&G's CAS request letter with the VCSNS Units 2 and 3 Updated FSAR and also with the criteria in ANSI/ANS-3.5-1998 as endorsed in RG 1.149, Revision 3.

Additionally, with respect to the performance of control manipulations required by 10 CFR 55.31(a)(5), this evaluation assesses whether the simulation facility for VCSNS Units 2 and 3 replicates the AP1000 DCD predicted core model and whether sufficient fidelity has been demonstrated such that significant control manipulations required by 10 CFR 55.31(a)(5) can be completed without procedural exceptions, simulator performance exceptions, or deviation from approved training scenario sequence.

3.0 TECHNICAL EVALUATION

3.1 Simulation Facility Components

10 CFR 55.46(b)(1) states in part:

> Facility licensees that propose to use a simulation facility, other than a plant-referenced simulator, in the administration of the operating test under §§ 55.45(b)(1) or 55.45(b)(3), shall request approval from the Commission. This request must include:
>
> (i) A description of the components of the simulation facility intended to be used … for each part of the operating test, unless previously approved[.]

Staff Evaluation

A simulation facility contains static and dynamic components within its design. These components are addressed in ANSI/ANS-3.5-1998, Section 3.2, "Scope of simulation." The static component is best illustrated by ANSI/ANS-3.5-1998, Section 3.2.1.1, "Scope of Panel Simulation," which states:

> The simulator shall include those operational panels, consoles, and operating stations required to provide the controls, instrumentation, alarms, and other human-system interfaces used by operators in the reference unit to conduct the normal evolutions of 3.1.3 and respond to the malfunctions of 3.1.4.

The dynamic component is best illustrated by ANSI/ANS-3.5-1998, Section 3.2.2.1, "Systems Controlled or Monitored from the Control Room," which states:

> The inclusion of systems of the reference unit in the scope of simulation shall be to the extent necessary to allow the operator to perform the evolutions described in 3.1.3 and respond to the malfunctions described in 3.1.4. These systems shall be complete to the extent that the operator can perform these control manipulations and observe simulated unit response as in the reference unit. The scope of simulation shall include system interactions with other simulated systems, so as to provide a total integrated unit response.

In both cases, the normal evolutions and malfunctions address a range of plant conditions that ensure the simulation facility addresses all 13 items from 55.45(a).

The facility licensee described the simulation facility for VCSNS Units 2 and 3 in the CAS request letter, Enclosure 2. Enclosure 2 listed the plant systems modeled by the simulation facility for VCSNS Units 2 and 3. The staff compared the systems listed in Enclosure 2 with those listed in the VCSNS Units 2 and 3 FSAR, Table 1.7-2, "AP1000 System Designators and System Diagrams." With the exception of the two items identified below, the staff finds the systems listed in Enclosure 2 to be a complete list of those systems that interface with the control room and include the facility's heat removal systems, auxiliary systems, emergency systems, radiation monitoring systems, and the controls for plant equipment that affect reactivity and power level, including the control console. The two exceptions to the reference plant configuration are not modeled in the simulation facility for VCSNS Units 2 and 3 for the following reasons:

- The communication system in the simulation facility for VCSNS Units 2 and 3 does not model the networking feature (i.e., a feature that allows for multiple people to talk on one line) that will be available in the control room, but it does provide a phone system that allows operators to simulate communication with personnel onsite and offsite, which are the same actions that applicants will be required to perform in the actual plant. Therefore, the staff finds this exception acceptable.

- The CAS request letter, Enclosure 9, "List of Open Discrepancies," simulator deficiency report number 1508-42, states that the simulation facility for VCSNS Units 2 and 3 does not have the radiation monitoring panel on the back wall as depicted in the reference design. However, all the indications on this panel can be viewed at the operator consoles in the simulation facility for VCSNS Units 2 and 3. Therefore, applicants using the simulation facility for VCSNS Units 2 and 3 still have a method of obtaining the information that they will need to take actions directed by procedures, which are the same actions that operators will be required to perform in the actual plant. Therefore, the staff finds this condition acceptable.

With respect to the static simulator modeling, the staff determined that all the systems and components needed to manage the AP1000 safety functions (e.g., reactivity control, heat removal, containment integrity, and radiation control) are included in the simulation facility for VCSNS Units 2 and 3.

In the CAS request letter, Enclosure 3, "Description of the Performance Tests for the Simulation Facility and Results of the Tests," the facility licensee listed all of the performance tests and malfunction tests prescribed by ANSI/ANS-3.5-1998 that it performed on the simulation facility for VCSNS Units 2 and 3. Because the facility licensee performed these tests, which include normal, abnormal, and emergency events applicable to the AP1000 design, this demonstrates that the simulation facility for VCSNS Units 2 and 3 includes the specific controls, alarms, and indications needed to operate the plant systems. This testing and how the test results demonstrate that the simulation facility for VCSNS Units 2 and 3 models the reference plant with sufficient scope and fidelity concerning these systems and components are described in more detail in the next section of this evaluation.

In conclusion, the staff finds that the simulation facility for VCSNS Units 2 and 3 includes the AP1000 plant systems needed to support operating tests with respect to each of the 13 items in 10 CFR 55.45(a) and that the descriptions submitted by the licensee of the simulation facility systems conform to 10 CFR 55.46(b)(1)(i).

3.2 Simulation Facility Performance Tests

10 CFR 55.46(b)(1) states in part:

> Facility licensees that propose to use a simulation facility, other than a plant-referenced simulator, … in the administration of the operating test under §§ 55.45(b)(1) or 55.45(b)(3), shall request approval from the Commission. This request must include:
>
> (ii) A description of the performance tests for the simulation facility as part of the request, and the results of these tests[.]

Staff Evaluation

This section explains the staff's conclusions on how simulator testing demonstrated the adequacy of the dynamic modeling of the simulation facility for VCSNS Units 2 and 3. In the CAS request letter, Enclosure 3, the facility licensee stated that it conducts simulator performance testing in accordance with ANSI/ANS-3.5-1998, as endorsed by RG 1.149, Revision 3.

ANSI/ANS-3.5-1998 describes two types of performance testing; which are simulator operability testing and scenario-based testing (SBT). The purpose of both types of performance testing is to ensure that the simulator is sufficient in scope and fidelity compared to the reference plant it models. In the CAS request letter, Enclosure 2, the facility licensee stated that because VCSNS Units 2 and 3 are under construction, the simulation facility for VCSNS Units 2 and 3 has been tested to verify that it conforms to the AP1000 design as documented in the AP1000 DCD, which is incorporated by reference in the VCSNS Units 2 and 3 FSAR.

In the CAS request letter, Enclosure 3, the facility licensee addressed how it performs simulator operability testing and SBT. This is described below for each of the two types of simulator performance testing for the VCSNS Units 2 and 3 simulation facility.

Simulator Operability Testing:

The facility licensee provided a list of simulator operability tests that it performed on the simulation facility for VCSNS Units 2 and 3.

Appendix B, "Guidelines for the Conduct of Simulator Operability Testing," to ANSI/ANS-3.5-1998 provides examples of tests, parameters to be recorded, and time resolution for demonstration of simulator operability in order to clarify the scope and intent of simulator operability testing specified by 4.4.3.1, "Simulator Operability Testing," of ANSI/ANS-3.5-1998. However, Appendix B to ANSI/ANS-3.5-1998 is not part of the standard; it is "for information purposes only." The tests include steady-state tests and transient tests.

ANSI/ANS-3.5-1998, Sections 4.1.3, "Steady-State and Normal Evolutions," and 4.1.4, "Malfunctions," contain the acceptance criteria for each of the tests. The staff compared the list of simulator operability tests that the facility licensee performed with ANSI/ANS-3.5-1998, Appendix B. The staff found that the facility licensee's list of steady-state and transient tests performed on the VCSNS Units 2 and 3 simulation facility conformed to the testing specified by ANSI/ANS-3.5-1998.

The facility licensee stated that all simulator operability tests performed on the VCSNS Units 2 and 3 simulation facility were completed satisfactorily.

In the CAS request letter, Enclosure 5, "Evaluation of AP1000 Simulation Facility Summary of Unresolved Items Issued by the NRC," the facility licensee stated that the enclosure documents noticeable differences between expected reference plant response and simulator response. The facility licensee refers to these differences as simulator discrepancies and documents these discrepancies with simulator discrepancy reports. In the CAS request letter, Enclosure 3, the facility licensee stated that the performance testing identified simulator discrepancies, which the facility licensee included in Enclosure 9.[6] These simulator discrepancies identify portions of the simulation facility for VCSNS Units 2 and 3 that do not have sufficient fidelity with the reference plant.

The facility licensee evaluated each of the 216 open simulator discrepancies to determine if any of the simulator discrepancies precluded the VCSNS Units 2 and 3 simulation facility from being used to administer operating tests containing a representative sample of the 13 items listed in 10 CFR 55.45(a). The facility licensee determined that 99 simulator discrepancies were applicable to the items listed in 10 CFR 55.45(a) and needed additional evaluation, and that the remaining 117 simulator discrepancies were not applicable to any of the 13 items listed in 10 CFR 55.45(a). In the CAS request letter, Enclosure 6, "Commission Approved Simulator Aggregate Study – Simulator Training," the facility licensee documented the results of its evaluation of the 99 discrepancies. The facility licensee evaluated each of the individual deficiencies and determined that none of the issues, by themselves, challenged the ability of the simulation facility for VCSNS Units 2 and 3 to address any of the 13 items in 10 CFR 55.45(a).

SCE&G's aggregate evaluation identified the groupings of simulator discrepancies that, because of insufficient fidelity with the reference plant, could limit the simulation facility for

[6] Note: Not all of the simulator discrepancies in Enclosure 9 were identified by performance testing; some discrepancies were identified during the performance of other activities on the simulators.

VCSNS Units 2 and 3 from being used to administer operating tests containing a representative sample of the 13 items listed in 10 CFR 55.45(a).

Based on the aggregate impact evaluation results, the facility licensee completed corrective actions to resolve the 47 discrepancies associated with the 13 items in 10 CFR 55.45(a) and then completed testing to determine that the corrective actions were effective. The corrective actions satisfactorily addressed simulator discrepancies that could, in aggregate potentially impact significant, cross cutting operating activities such as reactivity control, operator workload, and operator decision making.

SCE&G's aggregate impact evaluation concluded that the aggregate impact of the remaining discrepancies would not impact the suitability of the VCSNS Units 2 and 3 simulation facility for the performance of operating tests. The staff verified that testing completed by SCE&G used the ANSI/ANS-3.5-1998 scenarios appropriate for testing the resolution for the identified discrepancy.

Based on the SCE&G's corrective actions and the aggregate impact evaluation results, the staff dispositioned the 99 simulator deficiencies identified by the ANS 3.5 performance testing as follows:

- 47 of the 99 discrepancies determined to impact 10 CFR 55.45(a) items were fixed,

- 20 of the 99 discrepancies, upon more detailed evaluation, did not affect any of the 13 items in 10 CFR 55.45(a). The discrepancies were associated with computer administrative functions such as printing special reports that are not used during operator licensing exams. The discrepancies were identified because these computer administrative functions are an aid to the simulator booth operator (i.e., the operator of the simulation facility) and support training activities.

The facility licensee determined that none of the remaining discrepancies, by themselves or in aggregate, constituted a challenge to the ability of the simulation facility for VCSNS Units 2 and 3 to address any of the 13 items in 10 CFR 55.45(a). The staff also independently verified that the remaining open simulator discrepancies individually and in aggregate did not impact the suitability of the simulation facility for use in the performance of operating tests. The staff concludes that these discrepancies are not of sufficient scope to impact the ability of the simulation facility for VCSNS Units 2 and 3 to replicate the reference plant in scenarios based on 10 CFR 55.45 requirements because the simulation facility for VCSNS Units 2 and 3 is capable of running a large number of scenarios (as demonstrated by the ability of the VCSNS Units 2 and 3 simulation facility to perform all of the simulator testing scenarios in ANSI/ANS-3.5-1998 and the test scenarios for the ISV) in support of any of the 13 items in 10 CFR 55.45(a). Therefore, the remaining simulator performance discrepancies do not preclude approval of the simulation facility for VCSNS Units 2 and 3 as a CAS for use in operating tests. Similarly, the remaining discrepancies do not prevent the simulation facility for VCSNS Units 2 and 3 from replicating the reference plant with sufficient scope and fidelity to support its use by applicants for control manipulations required by 10 CFR 55.31(a)(5).

The remaining simulator performance testing discrepancies could have a limited impact on certain test scenarios. The staff concludes this is not of concern because the simulation facility for VCSNS Units 2 and 3 is capable of running a large number of scenarios (as demonstrated by the testing scenarios) in support of any of the 13 items in 10 CFR 55.45(a).

SCE&G completed a training needs assessment in accordance with ANSI/ANS-3.5-1998 for each discrepancy and concluded the discrepancies did not impact operator actions or detract from training. Furthermore, NUREG-1021 states that a facility licensee must provide the written examination, operating test, and documentation that demonstrates that its' simulators can run the scenarios included in the operating test, to the NRC for review and approval prior to the administration of operator licensing examinations. NUREG-1021 also provides that the NRC staff must, prior to the administration of the licensing examination, confirm that the simulator can run the scenarios included in the operating test without malfunction or deviation. NUREG-1021, ES-301 Section D, which provides instructions for preparing initial operating tests, states that for each category of the operating test that:

> Every facet of the operating test, including the walk-through JPMs and simulator scenarios, should be planned, researched, validated, and documented to the maximum extent possible before the test is administered.

Scenario Based Testing:

Facility licensees validate the simulator scenarios that are part of the operating tests prior to their administration using the method of SBT, which is described in Section 4.4.3.2, "Simulator Scenario-Based Testing," of ANSI/ANS-3.5-1998. As described therein, "The intent of scenario-based testing is to ensure the simulator is capable of producing the expected reference unit response to satisfy predetermined learning or examination objectives." ANSI/ANS-3.5-1998 directs that SBT be performed for simulator scenarios developed to administer the operating tests, as well as for simulator scenarios used to meet the experience requirements in 10 CFR 55.31(a)(5) for applicants. If the results of the SBT indicate that there is not sufficient fidelity with the reference plant during the operating tests, then the scenario cannot be used, and the scenario must be revised to exclude the discrepancy.

As described in Enclosure 3 to its application, the simulation facility for VCSNS Units 2 and 3 is committed to the SBT methodology described in the ANSI/ANS-3.5-1998, and in Nuclear Energy Institute (NEI) 09-09, Revision 1, "Nuclear Power Plant-Referenced Simulator Scenario-Based Testing Methodology," (December 2009). As described by SCE&G, SBT is the parallel testing and evaluation of simulator performance while instructors validate NRC's initial license examination scenarios, licensed operator requalification annual examination scenarios, and scenarios used to satisfy the reactivity control manipulation requirements for license candidates in 10 CFR 55.31(a)(5). 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. SBT is conducted to ensure the simulator is capable of producing the expected "reference unit" response to satisfy predetermined learning or examination objectives by utilizing the existing training and examination scenario validation process.

The staff finds the facility licensee's method for performing SBT to be consistent with ANSI/ANS-3.5-1998 as approved in RG 1.149, Revision 3. This testing will ensure that simulator scenarios that are affected by any of the remaining discrepancies in the simulation facility for VCSNS Units 2 and 3 will not be used in a licensing examination or for simulator scenarios used to meet the experience requirements in 10 CFR 55.31(a)(5) for applicants. In addition, SBT also ensures that if there is any discrepancy not previously identified by the facility licensee and the staff that impacts the ability of the simulation facility for VCSNS Units 2 and 3 to replicate the reference plant for operating tests, adherence to the normal NUREG-1021

examination preparation process will allow the staff to screen the scenario out and prevent its use in an operator licensing examination.

ISV testing:

ISV testing is a confirmation of the control room design, not a test of simulator performance. Similar to an operator licensing examination, the ISV uses a simulator to test the control room design. The objective of the test, which is required by the AP1000 design certification, is to verify that the integrated system, which includes training, procedures, the human-system interface (including the operating consoles), and personnel elements (including the facility licensee's conduct of operations) will minimize human errors and support the safe operation of the plant. Westinghouse performed the test on the VCSNS Units 2 and 3 control room design and identified design problems and HEDs.

Design problems: Simulators are capable of showing system design problems such as improperly sized components and integration issues between systems. These problems are not control room design issues, but they are documented and fed back into the design modification process.

HEDs: An HED is an ISV finding. While design problems and simulator discrepancies are identified, the focus of the test is on identifying operator error, operator confusion, and operator efficiency improvements. The first two (operator error and operator confusion) are reactive. Corrective actions are focused on improving the operator interface with the control room design. The last (operator efficiency improvements) is proactive and accomplishes the same purpose. All involve subjective judgements made by the ISV test personnel on how human performance is being challenged and how human error can be minimized. For some HEDs, no action will be taken because proposed changes are not demonstrably better than the current configuration and may introduce other errors. Others will be addressed by changes in procedures and training or will result in control room design changes that are fed back into the control room design modification process. Control room design changes potentially impact operator performance and are addressed by the facility licensee's training program. Until then, the HEDs may result in increased work load, but the skills, knowledge and abilities needed to operate the plant remain the same.

To accomplish ISV testing, the simulation facility replicates an initial control room design. The initial control room design for VCSNS Units 2 and 3, together with the corrective actions described earlier and above, constitute the VCSNS Units 2 and 3 simulation facility that SCE&G requests approval of as a CAS, which is evaluated as described in this safety evaluation. The staff has determined that the facility licensee has demonstrated that its configuration of the simulation facility for VCSNS Units 2 and 3 successfully accomplishes simulator performance testing scenarios prescribed by ANSI/ANS-3.5-1998 and ISV test scenarios with sufficient scope and fidelity to the AP1000 to support its use in operator testing and control manipulations for VCSNS Units 2 and 3. These scenarios demonstrate the functionality of the simulation facility for VCSNS Units 2 and 3 under a broad range of operational conditions that address the 13 items in10 CFR 55.45(a).

Similar to the way SBT helps ensure simulator performance testing discrepancies do not challenge the ability of the VCSNS Units 2 and 3 simulation facility to replicate the reference plant with sufficient scope and fidelity, SBT also helps ensure that the design problems and HEDs identified by the ISV do not impact the scope and fidelity of the simulation facility.

Summary and Conclusions for Performance Testing:

In summary, the facility licensee performed the simulator operability testing prescribed by ANSI/ANS-3.5-1998, and documented where testing revealed aspects of the simulator that did not replicate the plant design. The facility licensee completed an aggregate review that effectively identified simulator discrepancies that could generically challenge the ability of the simulation facility for VCSNS Units 2 and 3 to replicate the reference plant with sufficient scope and fidelity. This is required in order to approve the simulation facility for use in operating tests under 10 CFR 55.45(a), or for control manipulations required by 10 CFR 55.31(a)(5). The facility licensee has taken corrective action to resolve all of the issues that caused these challenges. The simulator discrepancies that remain are limited in scope and have limited impact on the capability of the simulation facility for VCSNS Units 2 and 3 to replicate the reference plant with sufficient scope and fidelity for use in operating tests under 10 CFR 55.45(a) and control manipulations required by 10 CFR 55.31(a)(5). In addition, the required NUREG-1021 examination preparation process will allow the staff or facility licensee to screen out scenarios where simulator discrepancies could affect operator licensing examinations or control manipulations.

The initial configuration of the simulation facility for VCSNS Units 2 and 3, in combination with the facility licensee's corrective actions, have established sufficient scope and fidelity of the simulation facility for VCSNS Units 2 and 3 such that the AP1000 safety functions can be monitored and controlled through a broad range of normal, abnormal, and emergency operating conditions. For example, for reactivity control, test scenarios have demonstrated that the simulation facility for VCSNS Units 2 and 3 models the AP1000 DCD in terms of core physics, the plant thermal hydraulics (including the core, heat removal systems and containment response), the system performance (especially rod control but also systems that affect reactor coolant temperature and pressure), indications, controls and power supplies, and all of these components and systems are functioning as independent entities and in an integrated manner. The simulation facility for VCSNS Units 2 and 3 replicates the AP1000 DCD reference plant's expected performance with sufficient scope and fidelity concerning these components and systems to support operating tests, requalification training and testing, and control manipulations required in 10 CFR Part 55, and activities described in NUREG-1021, including JPMs that relate to reactivity control and control manipulations. Similarly, the simulation facility for VCSNS Units 2 and 3 replicates other AP1000 safety functions with sufficient scope and fidelity to support its approval as a CAS.

Therefore, based on the above, the staff concludes that the VCSNS Units 2 and 3 simulation facility demonstrates sufficient scope and fidelity with the AP1000 reference plant DCD to support approval of the VCSNS Units 2 and 3 simulation facility for the equitable and consistent administration of operator licensing examinations and control manipulations.

3.3 Procedures for Maintaining Examination and Test Integrity

10 CFR 55.46(b)(1) states in part:

> Facility licensees that propose to use a simulation facility, other than a plant-referenced simulator, … in the administration of the operating test under §§ 10 CFR 55.45(b)(1) or 10 CFR 55.45(b)(3), shall request approval from the Commission. This request must include:

(iii) A description of the procedures for maintaining examination and test integrity consistent with the requirements of § 55.49.

Staff Evaluation

In the CAS request letter, Enclosure 4, "Summary Description of the Procedures for Maintaining Examination and Test Integrity Consistent with the Requirements of 10 CFR 55.49," the facility licensee stated that its examination security procedure, VCS-TQP-0405, "Regulatory Exam Security " conforms to NUREG-1021, "Operator Licensing Examination Standards for Power Reactors," which provides guidance for complying with 10 CFR 55.49. The facility licensee stated that the procedure includes controlling physical access to examination material, encrypting electronic files that contain the simulator scenario events, and preventing the recording of simulator events while using the simulator to develop examination materials.

Through NRC staff's participation in the accreditation board for the facility licensee's Operations Training Program accreditation by the National Academy for Nuclear Training, the staff reviewed the facility licensee's examination security procedures. In a letter dated February 27, 2015 (ADAMS Accession No. ML15062A148), the Region II staff concluded, based on the review of the procedure, that the facility licensee's exam security procedures conformed to guidance in NUREG-1021 and were therefore adequate to ensure compliance with 10 CFR 55.49. Accordingly, the staff concludes that the facility licensee described an acceptable procedure for maintaining examination security and test integrity, and has complied with 10 CFR 55.46(b)(1)(iii).

3.4 Suitability of the Simulation Facility for VCSNS Units 2 and 3 for Control Manipulations

As described in Section 1.0, this safety evaluation also addresses the use of the simulation facility for VCSNS Units 2 and 3 by applicants for control manipulations which, per 10 CFR 55.31(a)(5), must be done on either the facility itself or on a plant-referenced simulator. The regulations in 10 CFR 55.46(c) and 10 CFR 55.46(d) list the requirements for a plant-referenced simulator that will be used for control manipulations. These requirements are listed below, in addition to the staff's evaluation of how the simulation facility for VCSNS Units 2 and 3 satisfies the requirements to be used for control manipulations.

Requirements listed in 10 CFR 55.46(c)(1) state,

> A plant-referenced simulator used for the administration of the operating test or to meet experience requirements in § 55.31(a)(5) must demonstrate expected plant response to operator input and to normal, transient, and accident conditions to which the simulator has been designed to respond. The plant-referenced simulator must be designed and implemented so that it:
>
> (i) Is sufficient in scope and fidelity to allow conduct of the evolutions listed in §§ 55.45(a)(1) through (13), and 55.59(c)(3)(i)(A) through (AA), as applicable to the design of the reference plant.
>
> (ii) Allows for the completion of control manipulations for operator license applicants.

Staff Evaluation

As discussed in Section 3.1 of this evaluation, the staff determined that the simulation facility for VCSNS Units 2 and 3 models the AP1000 plant systems and also contains the alarms, indications, and controls needed to operate the AP1000 plant systems, including those controls that affect reactivity. As discussed in Section 3.2 of this evaluation, the staff concludes that the simulation facility for VCSNS Units 2 and 3 is sufficient in scope and fidelity with the reference plant during operating tests that contain the 13 items in 10 CFR 55.45(a). Further, the staff reviewed the list of performance and malfunction tests that the facility licensee performed in accordance with ANSI/ANS-3.5-1998 and documented in the CAS request letter, Enclosure 3. The staff determined that the tests included evolutions listed in 10 CFR 55.59(c)(3)(i)(A)-(AA) that are applicable to the design of the AP1000 reference plant, including 10 CFR 55.59(c)(3)(i)(A)-(F) and (R), (T), (W), and (X), which are identified in 10 CFR 55.31(a)(5) as appropriate scenarios allowing applicants to perform control manipulations.

Accordingly, the staff concludes that the simulation facility for VCSNS Units 2 and 3 is sufficient in scope and fidelity to allow the conduct of the evolutions listed in 10 CFR 55.45(a)(1) through (13), and 55.59(c)(3)(i)(A) through (AA), and that it also allows for completion of the control manipulations for applicants.

Requirements in 10 CFR 55.46(c)(2) state,

> Facility licensees that propose to use a plant-referenced simulator to meet the control manipulation requirements in § 55.31(a)(5) must ensure that:
>
> (i) The plant-referenced simulator utilizes models relating to nuclear and thermal-hydraulic characteristics that replicate the most recent core load in the nuclear power reference plant for which a license is being sought; and
>
> (ii) Simulator fidelity has been demonstrated so that significant control manipulations are completed without procedural exceptions, simulator performance exceptions, or deviation from the approved training scenario sequence.

Staff Evaluation

As discussed in Section 3.2 of this evaluation, the staff concluded that the simulation facility for VCSNS Units 2 and 3 provides the necessary reactor physics, thermal hydraulic, and integrated system modeling of the reference plant necessary to perform license examinations. This includes the predicted core performance for the first core load, not the most recent core load, because VCSNS Units 2 and 3 are under construction and the core has not yet been loaded. This is acceptable because ANSI/ANS-3.5-1998, Section 5.1.1, “Utilization of Baseline Data,” lists sources of simulation facility baseline data, in order of preference, which may be used to ensure simulator fidelity with the reference plant. The most preferred source is data from the reference unit, which is not yet available and will not be available until after fuel load and the completion of plant startup testing. Therefore, the facility licensee must use the second preferred source, which is data generated through engineering analysis with a sound theoretical basis. This is the predicted reference plant core load as described in Revision 19 of the AP1000 DCD, Chapter 4,”Reactor.”

Also, as discussed in Section 3.2 of this evaluation, the staff concluded that the simulation facility for VCSNS Units 2 and 3 has demonstrated sufficient fidelity with the reference plant by conducting the performance testing required by ANSI/ANS-3.5-1998 and following the process described in ANSI/ANS-3.5-1998 for identifying, documenting, and correcting simulator discrepancies. Additionally, SBT, which the facility licensee performs for training scenarios that

allow applicants to perform the control manipulations required by 10 CFR 55.31(a)(5), will ensure that any simulator discrepancies are screened from the scenario, and SBT also validates that the simulation facility is capable of producing the expected reference unit response without significant performance discrepancies, or deviations from an approved scenario sequence or the applicable plant procedures.

Accordingly, the staff concludes that the VCSNS Units 2 and 3 simulation facility uses models relating to nuclear and thermal-hydraulic characteristics that replicate the predicted core load for the reference plant for which a license is being sought, and that simulator fidelity has been demonstrated so that significant control manipulations are completed without procedural exceptions, simulator performance exceptions, or deviation from the approved training scenario sequence.

10 CFR 55.46(d) addresses continued assurance of simulator fidelity and states:

> Facility licensees that maintain a simulation facility shall:
>
> (1) Conduct performance testing throughout the life of the simulation facility in a manner sufficient to ensure that paragraphs (c)(2)(ii), as applicable, and (d)(3) of this section are met. The results of performance tests must be retained for four years after the completion of each performance test or until superseded by updated test results;
>
> (2) Correct modeling and hardware discrepancies and discrepancies identified from scenario validation and from performance testing;
>
> (3) Make results of any uncorrected performance test failures that may exist at the time of the operating test or requalification program inspection available for NRC review, prior to or concurrent with preparations for each operating test or requalification program inspection; and
>
> (4) Maintain the provisions for license application, examination, and test integrity consistent with § 55.49.

Staff Evaluation

With respect to 10 CFR 55.46(d)(1), ANSI/ANS-3.5-1998 requires performance testing to be conducted on a periodic basis to demonstrate continued assurance of simulation facility fidelity. The facility licensee provided the results of its performance testing as part of the CAS request letter.

With respect to 10 CFR 55.46(d)(2), ANSI/ANS-3.5-1998 identifies criteria for determining whether discrepancies identified during testing must be corrected. The CAS request letter included a list of corrective actions taken to resolve discrepancies identified during performance testing. As described in Section 3.2 of this evaluation, the staff concluded that the simulation facility for VCSNS Units 2 and 3 demonstrates sufficient scope and fidelity with the AP1000 reference plant DCD to support approval of the simulation facility for VCSNS Units 2 and 3 for the equitable and consistent administration of operator licensing examinations and control manipulations.

With respect to 10 CFR 55.46(d)(3), the staff completed an inspection at VCSNS Units 2 and 3 in accordance with Inspection Procedure 41502, “Nuclear Power Plant Simulation Facilities”

(ADAMS Accession No. ML12233A564) on April 8, 2015. The inspection report is available at ADAMS Accession No. ML15142A657. As part of the inspection, the staff reviewed a sample of simulator performance test results. The staff reviewed a list of open and closed simulator discrepancies that the facility licensee identified to determine the types of issues that were being identified and included, and also compared the list of simulator discrepancies with a sample of simulator performance testing records to verify that the facility licensee correctly identified all simulator discrepancies that resulted from any testing as required by 10 CFR 55.45(d)(2). From their review of the testing records, the staff identified out-of-tolerance parameters that had not been identified by the licensee. The staff also reviewed the licensee's database of open simulator discrepancies to ensure that they were being tracked adequately. The staff observed that the facility licensee maintains a spreadsheet of all identified simulator discrepancies. This spreadsheet includes an identification number, the test or procedure in which it was identified, a brief status of the discrepancy, and the status of the training needs analysis, if required. The staff determined that the spreadsheet is an effective tool to track simulator discrepancies. However, the staff identified two cases where simulator discrepancies identified during testing had not been documented in the simulator corrective action program. The licensee entered these issues in their corrective action system. The staff reviewed the immediate corrective actions and extent-of-condition review and ultimately concluded in the inspection report that the facility licensee was taking acceptable actions to correct the identified deficiencies.

As part of the safety evaluation, the staff requested the facility licensee to describe the actions taken to ensure that:

- the correct set of initial conditions are established when conducting simulator performance testing in accordance with ANSI/ANS-3.5-1998, and

- when test results do not meet the acceptance criteria contained in ANSI/ANS-3.5-1998, tests are marked as "unsatisfactory" and corrective actions are taken.

The letter from Ms. April R. Rice (SCE&G) to the NRC dated July 12, 2016 (ADAMS Accession No. ML16194A247) described procedure changes and training that had been accomplished. The staff finds the corrective actions to be adequate to ensure future testing maintains the simulator fidelity. It found the facility licensee's program to assure continued simulator fidelity to comply with ANSI/ANS-3.5-1998 and to be adequate.

With respect to 10 CFR 55.46(d)(4), the facility licensee addressed how it satisfies the requirements in 10 CFR 55.49 in the CAS request letter. As described in Section 3.3 of this evaluation, the staff concludes that the facility licensee described an acceptable procedure for satisfying the requirements of 10 CFR 55.49.

Accordingly, the staff concludes that the simulation facilities for VCSNS Units 2 and 3 are suitable for the conduct of control manipulations required by 10 CFR 55.31(a).

4.0 SAFETY EVALUATION LIMITATIONS

The simulation facility for VCSNS Units 2 and 3 is approved for the conduct of operating tests until a plant-referenced simulator that meets all of the requirements in 10 CFR 55.45(c) and (d) is established, after which all operating tests will be performed on the plant-referenced simulator. In no case will use of the CAS be permitted beyond the finding made by the Commission in accordance with 10 CFR 52.103(g), which is required prior to the facility licensee loading fuel. Additionally, use of the simulator for any of these purposes necessarily remains

contingent on the simulation facility's continued demonstration of fidelity with the reference plant.

5.0 CONCLUSION

The staff concludes that the facility licensee has adequately addressed the regulatory requirements in 10 CFR 55.46(b), "Commission-approved Simulation Facility." This includes:

- Demonstration that the current control room simulator configuration for the simulation facility for VCSNS Units 2 and 3 includes the necessary components and systems needed to support operator exams.
- An adequate description of simulator tests and the test results.
- Acceptable control of the testing process, and the process for identification, correction and retesting of simulator discrepancies.
- Acceptable procedures for maintaining examination and test integrity consistent with the requirements of 10 CFR 55.49.

The staff concludes the facility licensee has effectively implemented the simulator qualification process outlined in ANSI/ANS-3.5-1998. Individual discrepancies were evaluated and corrective action taken for those that were determined to impact operator performance. In addition to the actions identified in ANSI/ANS-3.5-1998, the facility licensee initiated an evaluation of the discrepancies to identify conditions where similar, insignificant discrepancies might together have an aggregate impact. The facility licensee also initiated corrective actions for those areas where an aggregate impact was identified. The staff reviewed the methodology the facility licensee used, the results and the retest procedures and found these areas to be acceptable. The staff also performed an independent evaluation of the factory and site acceptance testing discrepancies from both an individual and aggregate perspective. The staff's results confirm the facility licensee's results.

The staff reviewed the test scenarios the facility licensee used for both simulator operability and ISV testing and found them to conform to regulatory guidance. The staff determined that the combination of scenarios used represents a diverse set of scenarios addressing or supporting all 13 items in 10 CFR 55.45(a). The aggregate impact evaluations completed by the facility licensee demonstrate that there are no individual or collective discrepancies that would prevent the simulation facility for VCSNS Units 2 and 3 from addressing any of the 13 items in 10 CFR 55.45(a) or from being used for scenarios that allow applicants to perform the control manipulations required by 10 CFR 55.31(a)(5). The diversity of tests performed between the ISV and the simulator operability tests also demonstrates that sufficient numbers of scenarios can be generated for any one of the 13 items in 10 CFR 55.45(a) such that there should be no predictability in the content of operator licensing examinations.

Additionally, ANSI/ANS-3.5-1998 and NUREG-1021 provide a screening process for exam scenarios that allow the facility licensee and the staff to screen out scenarios that could contain simulator discrepancies or HEDs and prevent them from being used in an operating test scenario. ANSI/ANS-3.5-1998 provides for the same screening process using SBT performed in accordance with NEI 09-09, for simulator scenarios used for control manipulations. This process is an additional measure that ensures the simulation facility and the operator exam scenarios are properly integrated in a manner that provides for the equitable and consistent administration of the examination.

The staff finds the proposed use of the simulation facility for VCSNS Units 2 and 3, which is to administer operating tests that are part of the licensing examination, is acceptable because the facility licensee and the staff examiners use the method for preparing and evaluating these examinations that is prescribed by NUREG-1021.

Additionally, the staff finds that the simulation facility for VCSNS Units 2 and 3 replicates the AP1000 DCD in terms of the predicted core model, and sufficient fidelity has been demonstrated such that significant control manipulations required by 10 CFR 55.31(a)(5) can be completed without procedural exceptions, simulator performance exceptions, or deviation from the approved training scenario sequences.

For the above reasons, the staff finds that the simulation facility for VCSNS Units 2 and 3 and its proposed use are suitable for the conduct of operating tests for the facility licensee's reference plant under 10 CFR 55.45(a).

6.0 REFERENCES

1. 10 CFR 55, "Operators' Licenses."
2. ANSI/ANS-3.5-1998 (W2008), "Nuclear Power Plant Simulators for Use in Operator Training and Examination," American Nuclear Society, La Grange Park, IL, April 15, 1998 (withdrawn April 12, 2008).
3. ANSI/ANS-3.5-2009, "Nuclear Power Plant Simulators for use in Operator Training and Examination," American Nuclear Society, La Grange Park, IL, September 4, 2009.
4. Regulatory Guide 1.149, "Nuclear Power Plant Simulation Facilities for Use in Operator Training and License Examinations," Revision 3, October 2001.
5. Regulatory Guide 1.149, "Nuclear Power Plant Simulation Facilities for Use in Operator Training and License Examinations," Revision 4, April 2011.
6. NUREG-1021, "Operator Licensing Examination Standards for Power Reactors," Revision 10, December 2014.
7. NUREG-0700, "Human-System Interface Design Review Guidelines," Revision 2, May 2002.
8. NUREG-0711, "Human Factors Engineering Program Review Model," Revision 2, February 2004.
9. NEI 06-13A, "Template for an Industry Training Program Description," Revision 2, March 2009.
10. NEI 09-09, "Nuclear Power Plant-Referenced Simulator Scenario Based Testing Methodology," Revision 1, December 2009.
11. VCSNS Units 2 and 3 Updated Final Safety Analysis Report, Revision 3, June 2015.