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GE Nuclear Energy

General Electric Company
175 Curtner Avenue, San Jose, CA 95125

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PWM-9443

Mr. S. M. Franks, Chief
LWR Safety and Technology Branch
Office of Nuclear Energy NE-45
U.S. Department of Energy
19901 Germantown Road
Germantown, MD 20874

Subject: GE Response to DOE External Review Team

Dear Sterling:

Enclosed are the GE responses to the DOE External Review Team Key Recommendations and Observations. Since this review GE-NE has issued the "SBWR Test and Analysis Program Description" (NEDO/C-32391) which incorporates many of these recommendations.

Please call Bharat Shiralkar or me should you have any questions or comments.

Sincerely yours,

P. W. Marriott, Manager
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Enclosure

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Enclosure to
GE Letter PWM-9443

GE RESPONSES TO DOE EXTERNAL REVIEW TEAM KEY RECOMMENDATIONS AND OBSERVATIONS

KEY RECOMMENDATIONS

Recommendation-1	GE should evaluate the need to prepare and issue a comprehensive, living document that describes the SBWR Test and Analysis Program. Its purpose is to document the tests and analyses required for the design and certification of the SBWR. This program document should include the process for and identification of design, analysis, and performance data needs; the specification of test and analysis program elements and quality standards to address those data needs; and the utilization of test and analysis results to support the design and certification of the SBWR.
GE Response	GE has prepared and issued NEDC-32391P, **SBWR Test and Analysis Program Description** (TAPD), which documents the tests and analyses required for the design and certification of the SBWR. NEDC-32391P includes the process for identification of design, analysis, and performance data needs, and the specification of test and analysis program elements. The TAPD addresses all the elements of this recommendation.

Recommendation-2	GE should evaluate the need to perform further TRACG qualification for application to containment analyses. The assessment team recommends this qualification task include existing relevant large scale containment test data. The team recommends GE perform TRACG nodalization sensitivity studies with the SBWR containment model, guided in part by the nodalization for large scale containment tests. The team suggests GE consider comparing TRACG results against other containment analysis methods that already contain relevant phenomena models.
GE Response	Additional TRACG qualification against existing large scale containment data is a specific task in the TRACG Qualification Plan (NEDC-32391P, Table 6.1-1). This set of qualification studies will provide guidance for the SBWR containment nodalization (NEDC-32391P, Table 6.2-1). The Design Team prefers to perform direct comparisons versus relevant data rather than against other design codes which have conservative models.

Recommendation-3	As PANDA is a large, well scaled, low pressure test facility, GE should ensure that all test data needs for the late blowdown (GDCS initiation) and long-term cooling period of LOCAs are provided by the PANDA test matrix. PANDA tests are particularly useful because the facility has good simulation fidelity, the capability to represent system interactions (e.g., GDCS/PCCS, IC/PCCS), and can examine an extended accident time range in these tests.
GE Response	GE agrees with this recommendation and has added specific tests in PANDA Phase 2 to ensure complete test data coverage NEDC-32391P, Appendix A). This includes tests to be initiated as early as possible in the GDCS phase of the LOCA transient, consistent with facility capabilities.

Recommendation-4	GE should evaluate the need to clarify and strengthen the TRACG qualification approach during the early blowdown period of SBWR LOCAs using relevant tests from FIST, TLTA, and GIST. GE needs to strengthen the use and applicability of GIST data in the period of GDCS water addition by presenting TRACG runs for those GIST tests with key measured parameters more representative of the current SBWR design, and then compare them to TRACG runs for prototypical SBWR plant design evolutions.
GE Response	In the TAPD (NEDC-32391P) GE has clarified the use of the TRACG assessment data base for the early blowdown period. This includes the roles of the TLTA, FIST, GIST and the PSTF containment data (Figure 5.3-1). GE has strengthened the case for the applicability of the GIST data, as recommended by the Review Team. Key parameters (depressurization rate, GDCS driving head) have been shown to be representative of the current SBWR design. Additional GIST data have been recommended (Appendix A) to broaden the range of comparisons. Comparisons have also been made with TRACG predictions of LOCA response for both the 1988 and current SBWR design, which show excellent agreement between GIST, TRACG prediction of GIST and the SBWR (1988) calculations. Differences between the response of the 1988 and current SBWR designs are readily explainable and represent only a modest extrapolation of the range of relevant parameters.

Recommendation-5	GE should obtain or perform an independent review of the SBWR unique features and TRACG qualification data base issues and their prioritization, treating this work like a GE design calculation.

GE Response	GE agrees with this recommendation. R.T.Fernandez (EPRI) has performed an independent evaluation of the SBWR unique features and issues, their prioritization, and the TRACG Qualification Data Base. The Qualification Data Base sheets are also being independently verified.

OBSERVATIONS

The assessment team recommends that GE clarify or address the following topics in the SBWR Test and Analysis Program Description:

Observation-a — Describe controls to maintain technical integration between the SBWR design, analysis, and testing activities.

GE Response — Figure 1.4-1, Technology Basis for SBWR Design, and Figure 1.4-2, Overall Test and Analysis Plan, of the TAPD (NEDC-32391P) show the overall plan for the integration of SBWR design, analysis and testing activities. "Control" is provided in many ways. As described in Section 1.2 of the TAPD, "...GE has developed one computer code (TRACG) to use for design and for three out of the four most limiting licensing analyses." TRACG has been validated by operating plant experience and testing, which includes that specifically done for the SBWR as discussed in the TAPD. The code and its testing bases are being reviewed by the NRC. Thus, the primary design and analysis tool (TRACG) provides a focal point for technical integration of SBWR design, analysis, and testing. Further, preparation of the SBWR Standard Safety Analysis Report (SSAR), which is reviewed by the NRC and contains the output of both the design and the system analyses, is yet another means of insuring adequate technical integration. At a lower level, the design and analyses are accomplished using GE's Engineering Operating Procedures (EOPs), the NRC approved NEDO-11209-04A, "GE Nuclear Energy Quality Assurance Program Description", and SBWR project-specific processes/procedures/practices that taken together provide assurance of technical integration.

Observation-b — Ensure that test facility quality assurance practices will result in reliable data that can satisfy current NRC review standards.

GE Response — Appendix A of the TAPD details the tests and facilities. GE engineers specify the facility design and instrumentation requirements necesary to assure applicability of test resulls. In addition, GE engineers review and comment on the detailed test plans and procedures. Test plans are provided to the NRC for their comment. GE performs Quality Assurance (QA) reviews of the facilities before and during the testing. The NRC is able to perform QA audits of the facilities at their discretion. These activities ensure that the test facility quality assurance practices before and/or during the tests are able to be assessed by both GE and NRC. Issues that arise during the course of these activities will be resolved by GE in cooperation with the concerned parties. Of the tests yet to be performed, PANTHERS and PANDA will be run in conformance with the NQA-1 standard. The GIRAFFE helium tests will be

performed in compliance with the applicable Japanese standard, which references 10CFR50 Appendix B.

Observation-c	Justify why modeling noncondensables as one gas in TRACG is adequate for SBWR analyses of design basis events.
GE Response	TRACG explicitly models one noncondensible gas in addition to steam. A mixture of two or more gases can be treated as a gas with averaged, mixture properties. For the containment design basis accident, the analysis is required to consider hydrogen release corresponding to 100% metal-water reaction in the core. The resulting gas mixture in the drywell then includes lighter-than-steam and heavier-than-steam gases. The TRACG single gas model cannot adequately represent the buoyancy effects that might be important in this case. To resolve this issue, a model for a second noncondensible gas field is being implemented in TRACG. This will be qualified against relevant PANTHERS and GIRAFFE data with light noncondensibles.

Observation-d	Ensure that the test and analysis program supports realistic design basis event scenarios including taking credit for the ICs.
GE Response	The Test and Analysis Program will support realistic scenarios, including taking credit for ICs. Tests with the ICs operational have been included in PANDA Phase 2 testing (M7-M9) as documented in NEDC-32391P, Tables A.3-5b and A.3-6. A number of calculations with the ICs operational have also been performed, and the benefit due to the ICs has been quantified.

Observation-e	Identify and stress pre-test predictions and post-test calculations for future tests, particularly integral system tests.
GE Response	Tests that will be used for pre- and post-calculations have been identified in NEDC-32319P, Appendix A, Tables.A.3-2, A.3-4, and A.3-6.
Observation-f	Provide an integrated matrix (or sets of matrices) that shows all tests completed and planned, the purpose of each test, and pertinent test conditions for those tests that support the SBWR design and certification program.
GE Response	Planned and existing test data have been tabulated in NEDC-32391P, Appendix A, and include the purpose (Table A.2-1) and test conditions (A.3 Tables).

Observation-g	Provide an Appendix that lists all existing and planned reports, including test reports, test analysis reports, and code validation reports. The information should include the title, number, and actual or planned date of issuance.
GE Response	All existing reports relevant to the SBWR test and analysis program are referenced in NEDC-32391P, and listed in Section 8. Progress and Final Test Reports for future tests will be issued as appropriate to test progress.

Observation-h	The assessment team observes there is a need to recognize feedback from tests (e.g. PANDA), interaction studies, and sensitivity studies upon the TRACG code qualification, potential changes to the code or SBWR models, and the possible need to repeat SBWR analyses.
GE Response	GE agrees with the need to allow for feedback from the qualification effort on the TRACG models. Potential feedback from the remaining qualification work on the TRACG program is recognized and possible impacts on the models and nodalization have been tabulated in NEDC-32391P, Table 6.2-1. The SBWR SSAR calculations will be repeated with the qualified version of TRACG.

Observation-i	The assessment team recommends that GE develop a strategy and priority for performing the most useful tests first, along with pre- and post-test analyses of designated tests, so that

program resources are used most effectively.

Contingency plans should be established, with criteria and a strategy, for allowing code and/or SBWR model changes. The goal is to avoid using up available funds on early tests and not have sufficient funds for later, possibly more vital, tests (i.e. categorize the tests and analyses into "musts" and "wants").

GE Response

The PANTHERS PCCS tests have been prioritized into three categories with the most important being done first. The PANTHERS IC tests have also been similarly prioritized. The PANDA Phase 2 tests address high priority data needs. Similarly the qualification tasks have been grouped into high and low priority tasks.

Observation-j

GE should ensure that the identified reassessment issues requiring further tests are addressed in the appropriate test programs, particularly the PANTHERS and PANDA test facilities. Furthermore, GE should ensure that the test facilities have the instrumentation capability to measure the parameters necessary to address the specific issues raised.

GE Response

The range of the PANTHERS tests has been compared with the expected range of SBWR conditions in Figure A.3-3 of NEDC-32391P. The PANDA Phase 2 tests have been formulated to address the needs identified in the reassessment program. The instrumentation in the facilities has been reviewed and found to be consistent with the qualification needs.

Observation-k

The assessment team recommends that GE continue the scaling study in order to characterize the significant parameter differences between the SBWR and test facilities. For each test facility, GE should identify the most significant parameters and how they are scaled for subsequent use in TRACG qualification.

GE Response

The scaling studies for GIST, PANDA and PANTHERS as documented in Appendix B and Attachment B1 of NEDC-32391P are complete, apart from two specific issues. The GIST comparisons will be extended to broaden the range of parameters; and the scaling compromises involved with starting the PANDA tests earlier will be examined. For the other major facilities (TLTA, FIST, PSTF, 1/6th Scale Boron Mixing, CRIEPI and Dodewaard), the range of the main parameters of interest will be compared with the SBWR and documented in the TRACG Qualification report for the SBWR.

Observation-l	The assessment team recommends that GE re-evaluate the completeness of the PIRT for TRACG containment analysis, such as 3D mixing of steam and noncondensables, and suppression pool thermal stratification.
GE Response	The PIRT for the containment shown in the review was an abbreviated early version. The detailed PIRT has been included in NEDC-32391P.

Observation-m	The assessment team observes that GE needs to be more clear about the need for and applications of the TRACG mixing model (turbulent, two-phase flow), and reflect the outcome of these decisions within the qualification program.
GE Response	The use of the TRACG mixing model and the boron stratification model has been clarified in the qualification plan in the TAPD. Specifically, neither of these models has been used for the SBWR related qualification or application studies. If the current nodalization is not sufficient and a much finer one is needed to capture these effects in the tests, a decision will be made to qualify and use these models. The tests to be used for this purpose are the PANDA asymmetric steam injection tests and the boron mixing tests, respectively.

Observation-n	GE reported that TRACG has not been completely run utilizing the Dodewaard startup and stability data. The assessment team recommends that GE address whether and why the Dodewaard data will be used for TRACG qualification.
GE Response	As detailed in the TRACG Qualification Plan (Table 6.1-1, NEDC-32391P), the Dodewaard startup tests will be used for TRACG qualification. The Dodewaard stability tests have not been included because of the significant uncertainty in the flow measurements.

Observation-o	The assessment team recommends that GE consider running TRACG against the UC Berkeley and MIT single tube condensation tests in order to verify and confirm the implementation of the condensation correlation.
GE Response	The TRACG correlation for condensation heat transfer is based on data derived from the UC Berkeley tests. It has been verified against data from GIRAFFE and will be compared with full scale data from PANTHERS. It does not appear

sufficiently beneficial technically to spend resources to model these test loops in TRACG to verify correct implementation of the correlations.

Observation-p	GE indicated that the early stages of a LOCA event, including part of the blowdown phase and all of the GDCS actuation period, are supported by test data from GIST. However, GIST scaling was based on an earlier 1988 SBWR design. The assessment team observes that GE needs to determine and implement the appropriate actions and contingencies necessary such that the existing GIST test data will be usable for TRACG qualification.
GE Response	See response to Recommendation 4, wherein GE clarified and strengthened the case for the applicability of the GIST data, as recommended by the Review Team.

Observation-q	The assessment team recommends that GE clarify and strengthen the TRACG qualification approach during the early blowdown period of SBWR LOCAs using relevant tests from FIST, TLTA, and GIST. This would include strengthening the use and applicability of GIST data in the period of GDCS water addition by performing TRACG runs for other available GIST tests with key measured parameters more representative of the current SBWR design, and comparison to TRACG runs for prototypical SBWR plant design evolutions.
GE Response	See response to Recommendation 4.

Observation-r	The assessment team recommends that GE continue to use GIRAFFE test data, where appropriate, to further support the PANDA test matrix and results, and to gain further confidence in the TRACG qualification. The team recommends GE place emphasis on using the Phase 2 tests wherever possible.
GE Response	GE plans to use the GIRAFFE Phase 1 test data in a confirmatory role to gain further confidence in the TRACG qualification. GE has recently negotiated a series of tests with Toshiba, which will be performed in conformance with the applicable Japanese quality assurance standards. These tests will be performed with the Phase 2 configuration, and will include: a tieback test to a previous Phase 2 test; a test in which the nitrogen in the drywell is replaced by helium; a test with a mixture of steam, nitrogen and helium initially in the

drywell; and a test in which helium is injected over a period of time into the drywell, which is initially filled with steam and nitrogen. These tests will be used for TRACG qualification.

Observation-s

The assessment team suggests that GE consider the possibility of reverse flow occurring in some of the IC and PCC tubes, and evaluate whether the PANTHERS facility instrumentation is adequate to meet the analysis and performance data needs.

GE response

PANTHERS has several tubes with detailed axial temperature measurements. The distribution of temperatures should provide information on possible maldistribution of flow and flow reversals in the tubes. Test data to date has shown that the heat transfer characteristics are very similar among the different tubes.

Observation-t

The assessment team suggests that GE review their structural testing plans for the PCCS. The team suggests that the design basis (if GE intends to use within design certification) be limited to 90 integrated leak rate test cycles [3 ILRTs per decade x 60 year life x 5 safety margin]. The proposed values of 300 or 150 cycles appear to be excessively conservative.

GE Response

GE agrees with the Review Team observation. The test will be limited to 120 integrated leak rate test cycles, per Table A.4-17 of Appendix A of NEDC-32391P.

Observation-u

The assessment team observes that PANDA is a large, well scaled, low pressure test facility. Therefore, GE should reevaluate the PANDA test matrix to include as many of the test data needs for the late blowdown and long-term cooling period of LOCAs as possible. PANDA tests are particularly useful because the facility has good simulation fidelity, the capability to represent system interactions (e.g., GDCS/PCCS, IC/PCCS), and can examine an extended accident time range.

The assessment team recommends that GE obtain IC steady state performance test data at PANDA to check the PANDA-IC performance against the PANTHERS-IC tests, and to check the TRACG model for the PANDA-ICs.

GE Response

GE has reevaluated the PANDA test matrix to address the data needs for the late blowdown and early GDCS phase. This is reflected in Phase 2 test matrix shown in Appendix A of NEDC-32391P.

The PANDA IC and PCC units are geometrically similar. The IC has 20 tubes with an outside diameter (o.d.) of 50.8mm x 2.11 mm thickness. The PCC has 20 tubes with an o.d. of 50.8 mm but a wall thickness of 1.65 mm. The tube length is 1750 mm in both cases. The headers are also similar, with a diameter of 750 mm. The header length is larger for the IC - 318 mm vs 240 mm. Thus, the PCC steady state test data should be closely applicable to the IC unit.

Observation-v

The assessment team recommends that GE use more realistic initial system conditions in tests, e.g., consider including ICs in the PANDA tests. The IC/PCC secondary side pool levels should be controlled in PANDA to match those expected for the SBWR to assure the boiling boundary conditions are matched.

GE Response

The IC will be activated in some of the PANDA Phase 2 tests. There is no plan to control the secondary side pool level in PANDA to match the SBWR transient. The pool is of prototypical height and will have the correct initial level. Because the secondary side exit losses are not represented in PANDA, the backpressure effects in the pool will not be exactly prototypical. It is expected that TRACG can represent these differences and account for their effects. The PANTHERS facility will have a prototypical secondary side configuration and will serve to qualify TRACG for these effects.

Observation-w

The TRACG models for the SBWR apparently combine three PCCs as one, and three vacuum breakers as one. This may overemphasize the magnitude of cyclic behavior between separate PCCs and vacuum breakers that might occur. The assessment team recommends that GE consider running TRACG sensitivity calculations with these units represented as separate components.

GE Response

Subsequent to the Design Review, the TRACG model for post-LOCA containment performance evaluations was modified to include two PCC components. One PCC component models the two PCCs which drain to one GDCS pool and the second PCC component models the one PCC that drains to a second GDCS pool. This division of the PCCS is necessary to properly simulate the consequences of a break in a GDCS injection line. The Design Team believes that this model modification will also provide adequate flexibility for evaluation of non-identical performance of the three PCC units.

Similarly, the Design Team proposes a model modification

which utilizes two components to represent the three vacuum breakers (V/Bs). This will provide sufficient flexibility to evaluate the consequences of differing V/B setpoints or the imperfect closing of a single V/B.

Observation-x

GE should further evaluate reasonable system interactions within design basis events (including single failures), such as the potential for excess water added to the containment. GE should also consider whether the TRACG model assumptions (LOCA-ECCS, LOCA-Containment, WW-SP stratification model) are appropriate for the system interaction studies.

GE Response

All possible scenarios that might challenge the design were not studied under this task because the emphasis in the system interaction studies was on new phenomena that might be encountered that need experimental verification. GE considers that the studies conducted as part of the reassessment effort fulfill that need. The issue of excess feedwater flow to the containment, followed by loss of offsite power at a later point in the transient, has been addressed separately. In this situation, there is no core overheating or damage because the reactor vessel and containment are full of water. The only possible adverse consequence is an increase in containment pressure during this low probability, no-radioactivity-release event.

The TRACG calculations made to study primary vessel interactions and containment interactions did have some differences in assumptions. However, these do not affect the conclusions reached in the study. For each study, the TRACG model included both the reactor vessel and the containment; thus, the assumptions were internally consistent. Differences in the assumptions between cases led to minor differences in scenarios; the phenomena and interactions were preserved.

Observation-y

GE should reach agreement with NRC on the analytical approach to be used for IC and PCCS heat exchanger tube fouling.

GE Response

Conventional heat exchanger design values have been used for tube fouling resistances. These are in agreement with past practice for the IC. GE agrees that these values should be agreed upon with the NRC in a timely fashion.