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Gentlemen:

Subject: VIRGIL C. SUMMER NUCLEAR STATION
DOCKET NO. 50/395
OPERATING LICENSE NO. NPF-12
RESPONSE TO NRC BULLETIN 88-11
COMPLETION OF STRESS AND FATIGUE ANALYSES (IEB 880011-0)

On January 3, 1991, South Carolina Electric & Gas Company (SCE&G) completed the analyses for the Virgil C. Summer Nuclear Station (VCSNS) as required by Action 1.d of NRC Bulletin 88-11, "Pressurizer Surge Line Thermal Stratification." This letter provides the information requested in Reporting Requirement 3 of the Bulletin.

A plant specific evaluation of the pressurizer surge line considering the effects of thermal stratification was performed by Westinghouse for VCSNS. A description of the analytical approaches used and a summary of the results is included as Attachment I. The detailed analyses results are available for inspection on-site.

As discussed in Attachment I, the piping analyses determined that during certain conditions of plant heatup and cooldown in which the effects of thermal stratification are severe, spring support RCH002 could bottom out and pipe stresses could exceed ASME Code allowables. Further analysis of the structural capacity of the support in the bottomed out condition concluded that the pipe loads on the support during severe thermal stratification conditions could exceed ASME Code allowables. As required by the Bulletin, a Justification for Continued Operation was performed for the pipe loads on the support RCH002 and is included as Attachment II.

SCE&G has determined that several actions are required in order to maintain pipe stresses and support loads within ASME Code allowables. Until permanent pipe support modifications can be made, the following operating restrictions have been imposed for plant heatups and cooldowns:

1. Differential temperature (ΔT) between the pressurizer and loop A hot leg has been restricted to 280°F with Reactor Coolant Pump (RCP) A in operation.

2. Differential temperature (ΔT) between the pressurizer and loop A hot leg has been restricted to 230°F with RCP A not in operation.

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The above interim restrictions have been incorporated in plant operating procedures and will be retained until support modifications have been completed.

Modification to the appropriate supports will be performed in the next scheduled Refueling Outage (RF6), currently scheduled to commence in September 1991. Following support modification, the ΔT design basis limit of 320°F assumed in the Westinghouse evaluation will be proceuuralized. After the implementation of these modifications and procedura revisions, VCSNS will satisfy the requirements of NRC Bullctin 88-11.

I declare that the statements and matters set forth herein are true and correct to the best of my knowledge, information, and belief.

Should you have any questions, please call at your convenience.

Very truly yours,

John L. Skolds

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Attachments

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PIPING STRESS AND FATIGUE ANALYSES SUMMARY

The plant specific evaluation of the surge line was performed by Westinghouse, and is documented in WCAP-12785-Proprietary Class 2 and WCAP-12786-Proprietary Class 3, "Structural Evaluation of the Virgil C. Summer Unit 1 Pressurizer Surge Line Considering the Effects of Thermal Stratification." The WCAPs provide the details of the analytical approaches used. In summary, the primary purpose of the task was to develop transients for VCSNS which included the effects of stratification and to analyze those effects on the structural integrity of the surge line. The transients were developed following the same general approach originally established for the Westinghouse Owners Group's generic review of the stratification issue. The plant specific analyses refined the transients through the use of plant operating procedures, operator interviews, and historical data for plant operation. The resulting transients were used to perform structural analyses of the surge line to determine surge line displacements, stresses, and support loadings. The calculated stresses were then used to perform a fatigue analysis for the surge line.

The analyses determined that the pipe movements due to thermal stratification during plant heatup and cooldown exceeded the available travel range for pressurizer surge line support RCH002 (a variable spring hanger support) resulting in a bottomed out condition for the support. During certain conditions in which the effects of thermal stratification may be severe, the support in the bottomed out condition causes pipe stresses to exceed ASME Code allowables. The analyses determined that modification to two spring hangers (RCH002 and RCH004) is required to allow free travel under all stratified conditions. The pipe stresses will then conform to ASME Code allowables for all anticipated stratified conditions up to the design basis limit associated with a differential temperature (system ΔT) between the pressurizer and loop A hot leg of 320°F. In the interim prior to these modifications, the piping analyses determined that the system ΔT during plant heatup or cooldown should not exceed certain maximum values. Restricting plant operation to the system ΔT values determined in Attachment II (230°F with the RCP A off or 280°F with RCP A on) would maintain pipe stresses within ASME Code allowables. With the implementation of the above recommendations, the piping stress analyses demonstrated acceptance to the requirements of the ASME Code, Section III, including both stress limits and fatigue usage, for the full life of the plant. These analyses also considered past heatup and cooldowns in which support RCH002 was potentially in the bottomed out condition.

VIRGIL C. SUMMER NUCLEAR STATION
JUSTIFICATION FOR CONTINUED OPERATION FOR THE PRESSURIZER SURGE LINE SUPPORT RCH002

PURPOSE

Reference 8 provides an analysis of the pressurizer surge line considering the effects of thermal stratification. The resulting pipe movements due to thermal stratification exceeded the available travel range for support RCH002, a variable spring hanger support, causing it to bottom out. When the support bottoms out, the piping is restrained from further movement during the stratification event. Additional stratification induced support loads will result as the stratification condition increases in severity. The loads developed from the design analysis indicated that the design capacity of the support may have been exceeded during severe thermal stratification conditions.

The design analysis for the surge line contains many "design" safety margins and conservative assumptions. These assumptions are appropriate for initial plant design or permanent modifications, but may be overly conservative when evaluating safe plant operations for only one fuel cycle (i.e., until a permanent modification can be installed). An example is the conversion factor of .95 used to convert pipe ΔT to system ΔT.

System ΔT = Pipe ΔT / (.95) EQUATION #1

Definitions:

System ΔT - Liquid temperature difference between the Reactor Coolant Loop Hot Leg and the Pressurizer.

Pipe ΔT - Maximum metal temperature difference between the top of the pipe and the bottom of the pipe containing stratified liquid. This value is a critical parameter of the piping structural analysis considering thermal stratification.

This value of .95 was used in the design analysis, Reference 8. Actual data from plants typical of VCSNS has shown this value to range from .50 to .95, depending upon the plant piping configuration. Utilizing .95 in the design analysis is very conservative. A lower conversion factor in Equation #1 would reduce the the effects of thermal stratification for a given system ΔT. The following operability evaluation is intended to scrutinize the design assumptions utilized in the thermal stratification analysis and remove or reduce those that will not impact safe plant operations for one fuel cycle.

BACKGROUND

The load on the support is a function of the severity of thermal stratification in the surge line. The stratification is a direct result of the difference in densities between the pressurizer water and the generally cooler Reactor Coolant System (RCS) hot leg water. The lighter pressurizer water tends to float on the cooler, heavier hot leg water. The potential for stratification is increased as the system ΔT increases. The magnitude of the system ΔT value is directly proportional to the severity of the thermal stratification. At power when the system ΔT is relatively small, the extent and effects of stratification have been observed to be small. However, during certain modes of plant heatup and cooldown, the system ΔT could be as large as 320°F, in which case the effects of stratification are potentially significant.

Support RCH002 has been in operation for over eight years and has not experienced any failure or deformation (per References 6 and 7). During this time, the plant has had several occurrences where the system ΔT was in the range of 320°F (with RCP A off, the pump in the reactor coolant loop containing the surge line connection). One occurrence had a system ΔT (RCP A off) of 340°F. Therefore, it can be concluded that the stratification load on the support could have been slightly less than the ultimate capacity of the support structure at a system ΔT (RCP A off) of 320°F. If the load had been greater than the ultimate capacity, failure should have resulted and would have been detected.

Visual inspections of support RCH002 were conducted during Refuel Outage #4 (11/88) and Refuel Outage #5 (4/90). These inspections are documented in References 6 and 7, respectively. There were no visual anomalies identified during these inspections. Therefore, it is concluded that the existing installation for support RCH002 is structurally sound and has not yet seen the significant loads predicted by the design analysis. This JCO evaluates the support's structural integrity during future plant heatups and cooldowns for the present fuel cycle.

APPROACH

The operability evaluation consists of two phases. Phase I develops the allowable operability load for support RCH002 in the bottomed out condition. This load will be calculated using operability criteria based primarily on ASME Service Level D allowables.

Phase II of this evaluation will define the relationship between the magnitude of the load on support RCH002 and the amount of system ΔT. Once this relationship is established, it will determine the value of system ΔT associated with the allowable operability load for support RCH002 determined in Phase I. This system ΔT value will be the operability limit for support RCH002 during plant heatup or cooldown.

PHASE I -SUPPORT OPERABILITY LOAD

The operability evaluation documented in Reference 1 assessed the capability of the support RCH002 to withstand loads when in the bottomed out condition. The evaluation considered deadweight and thermal stratification support loads. The evaluation did not consider a seismic developed support load because the spring support is not required during a seismic event to maintain piping structural integrity (i.e., the seismic analysis does not include a restraint at the location of support RCH002). Any additional restraint provided by support RCH002 during the seismic event will assist in maintaining structural integrity.

Linear elastic analysis methods were used to assess the impact of the deadweight and thermal stratification loads in accordance with the operability criteria listed in Table A (Attached). These criteria are based on faulted (Level D) allowables of the ASME Code, Section III (Reference 4), Supplement No. 1 to IE Bulletin 79-02 (Reference 3), and Regulatory Guide 1.124 (Reference 5). The operability evaluation of support RCH002 addressed the following structural attributes:

- concrete anchor bolts,
- structural steel members,
- structural welding, and
- standard vendor supplied catalog items.

The analysis of support RCH002 concluded that the structure meets the operability criteria of Table A in the bottomed out condition up to the following allowables:

Operability Criteria Maximum Allowable Load = 12.6 KSI
Operability Criteria Stratification Allowable Load = 12.6 - 4.5 (Deadweight Load)
= 8.1 KSI

PHASE II - SUPPORT LOAD VERSUS SYSTEM ΔT

The support ultimate capacity at a system ΔT (RCP A off) of 320°F defines a data point which is the basis for the development of a linear relationship between the support load and the system ΔT. This relationship also assumes the same slope for the linear relationship between system ΔT and support load as was generated in the design analysis (documented in Reference 2).

An elastic/plastic analysis (Reference 1) was performed on the support structure utilizing an ANSYS computer model to determine the ultimate allowable load. Using this method and based upon material properties for stress and strain, the ultimate loads are:

Ultimate Allowable Load = 13.5 KSI
Stratification Allowable Load = 13.5 - 4.5 (Deadweight Load)
= 9.0 KSI @ 320°F

The ultimate load of the support of 9.0 KSI could therefore be projected to occur at a system ΔT of 320°F based upon the previous discussion. Using this information, a linear relationship is established from which the following data points are established:

System ΔT	Support RCH002 Load (RCP A-Off)
320°F	Ultimate Load 9.0 KSI
311°F	Operability Criteria 8.1 KSI
230°F	Bottomed Out 0 KSI

With RCP A in operation, turbulence in the surge line can be expected. This will cause mixing of the fluid layers in the surge line, thus reducing the effects of thermal stratification. With RCP A in operation, the relationship between support loads and system ΔT indicates a higher system ΔT is tolerable:

System ΔT	Support RCH002 Load (RCP A-On)
390°F	Ultimate Load 9.0 KSI
379°F	Operability Criteria 8.1 KSI
280°F	Bottomed Out 0 KSI

This data indicates support RCH002 will remain operational up to a system ΔT of 311°F with the RCP A off or 379°F with the RCP A on. In order to provide additional margins of safety to this evaluation, SCE&G has specified the following system ΔT restrictions for plant operation during heatup and cooldown.

RCP A Off - System $\Delta T \leq 230$°F
RCP A On - System $\Delta T \leq 280$°F

The operability evaluation indicates these system ΔT limits provide reasonable assurance that the loads due to thermal stratification on support RCH002 are negligible, provide a significant margin of safety, and ensure continued safe plant operation.

CONCLUSIONS

Based on the above information, it is concluded that support RCH002 will remain operable with the restrictions for plant heatup and cooldown as specified until the next scheduled Refueling Outage (RF6) currently scheduled to commence in September 1991. During Refuel 6, support RCH002 will be modified to satisfy the design basis requirements.

TABLE A
RCH002 OPERABILITY LIMITS

SUPPORT ATTRIBUTE	DESIGN CHECK	OPERABILITY LIMIT	JUSTIFICATION SOURCE
Anchor bolts	shear, tension interaction	Manufacturer's ultimate capacity with FS = 2.0	Supplement 1 IE Bulletin 79-02
Structural	tension	Ft = 1.2 Sy but < 0.7 Su	ASME Section III Appendix F
	shear	Fv = 0.72 Sy but < 0.42 Su	ASME Section III Appendix F
	bending	Fb = 1.2 Sy but < 0.7 Su	ASME Section III Subsection NF Level D & Reg Guide 1.124
	welds	1.88 x S (AISC) < 0.42 Su shear	Reg Guide 1.124
Catalog	all	Manufacturer's published Level D load rating	ASME Section III Subsection NF Level D

VIRGIL C. SUMMER NUCLEAR STATION
OPERABILITY EVALUATION FOR THE PRESSURIZER
SURGE LINE SUPPORT RCH002

References

1. ABB Impell Calculation 0980-108-C001 Revision 0.

2. Westinghouse Letter No. CGE-91-1004, dated January 4, 1991.

3. NRC IE Bulletin No. 79-02, Revision 1, Supplement 1, dated August 20, 1979, "Pipe Support Base Plate Design Using Concrete Anchor Bolts."

4. ASME Boiler and Pressure Vessel Code, 1983 Edition, Section III, Subsection NF, and Appendix F

5. U. S. Nuclear Regulatory Commission Regulatory Guide 1.124, Service Limits and Loading Combinations for Class 1 Linear-Type Component Supports, Revision 1, January 1978.

6. SCE&G Letter No. CGSW-1377-DE, dated January 11, 1989.

7. Engineer's Technical Work Record of M. A. Barth, Serial 12555, dated January 7, 1991.

8. Westinghouse WCAP-12785, dated December 1990, Structural Evaluation of the V. C. Summer Pressurizer Surge Line Considering the Effects of Thermal Stratification.