U. S. NUCLEAR REGULATORY COMMISSION

REGION I

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Report Nos:	50-272/97-20, 50-311/97-20
Licensee:	Public Service Electric and Gas Company
Facility:	Salem Nuclear Generating Station, Units 1 and 2
Location:	Hancocks Bridge, NJ
Dates:	October 20, 1997 - November 13, 1997
Inspector:	Aniello L. Della Greca, Sr. Reactor Engineer, DRS, EEB
Approved by:	William H. Ruland, Chief Electrical Engineering Branch Division of Reactor Safety

EXECUTIVE SUMMARY

Salem Inspection Reports 50-272; 311/97-20
October 20, 1997 - November 13, 1997

This inspection included aspects of licensee engineering and plant support. The report covers a 3-week period of intermittent inspection related to the calculation of primary containment air temperature.

Engineering

Based on his review of engineering and operations documents related to the issue, the inspector concluded that:

- The licensee was proactive in seeking the assistance of a consultant to determine the best averaging method, but their decision to return to the ten-sensor arithmetical average was not adequately supported.

- Two calculations used to justify a lower calculated average temperature were either unclear or did not sufficiently justify the basis for their conclusions.

- The acceptability of the current method to calculate the temperature that is representative of the entire containment volume was unresolved pending the licensee's evaluation of the upper containment temperature records from the power ascension and the use of the results in accident analyses and plant procedures.

III. Engineering

E1 Conduct of Engineering

E1.1 Pressure Testing of Modified Piping

a. Scope of Inspection (37550)

Licensee Event Report (LER) No. 95-004, dated May 18, 1995, informed the NRC that the monitoring of the primary containment average air temperature had not been done in strict compliance with the surveillance requirements specified in section 4.6.1.5 of the Salem, Units 1 and 2, technical specifications (TS). Since the issuance of the LER, the licensee revised the method for measuring the containment temperature at least three times. The purpose of the inspection was to evaluate the adequacy of the measuring methods used by the licensee.

b. Observations and Findings

Background

The primary containment average air temperature is used as an assumed initial condition in the: (1) steam line break and loss of coolant accident analyses; (2) containment functional analyses and external pressure analyses; and (3) design basis accident analyses that establish the environmental qualification operating envelope for both pressure and temperature. Current calculations assume a maximum average air temperature of 120° F; the TS requires reactor shutdown if this temperature is exceeded and cannot be restored to below its maximum value within eight hours.

Although other sensors exist in the areas monitored, ten sensors were used to measure the containment average air temperature. Of these, four are located in the annular region (at elevations 106' and 121'), three are located below the operating floor, in the vicinity of NSSS equipment (at elevation 84'), and three are located above the operating floor (at elevation 136'). At the time of the LER, the TS provided a list of the sensor locations and specified that "the primary containment average air temperature shall be the arithmetic average of the temperatures at any 5 of the 10 following locations at least once per 24 hours." According to the LER, the licensee historically calculated the containment average air temperature by performing the arithmetical average of all ten thermocouple readings.

Temperature Measuring Methods

The inspector's review of the operating procedures in effect prior to the issuance of the LER determined that, despite the licensee's practice, the instructions appeared to conform to the requirement of the TS. For instance, procedure SC.OP-DD.ZZ-OD23(Q), "Control Room Readings - Mode 1 - 4," Revision 18, dated December 23, 1994, required that, if the P-250 computer was unavailable, the operators should "calculate the average using temperatures from any five containment locations." The sensor locations were listed in procedure SC.OP-DD.ZZ-OD40(Q), "Shift Routines" (e.g., Revision 9, dated January 13, 1995).

The procedures as well as the TS apparently left to the judgement of the operating staff the selection of the five sensors that best represented the containment average air temperature. However, because a gradient of approximately 20° F exists between the average air temperatures at elevation 84' and 136', the arithmetical average of ten sensors used by the licensee could provide either a larger or a smaller containment average air temperature value, depending upon which five of the ten sensors would have been selected to satisfy the TS requirements.

In March 1996, when PSE&G originally discovered the inconsistency between their surveillance practice and the TS surveillance requirements, they revised the above procedures to paraphrase the TS requirements. The new wording, however, continued to leave the responsibility of the sensors selection to the operating staff and to provide no guidance in the matter.

This weakness was corrected in May 1996, in coincidence with the event report. At that time, procedure OD40(Q) was revised to specify the arithmetic average of five designated sensors, two above and three below the operating floor. This selection of specific sensors not only provided for a more consistent way to measure the average air temperature, but also yielded an average temperature that was more conservative and perhaps more representative than the ten-sensor average used previously. For instance, based on Unit 2 temperature data recorded in Calculation S-C-SW-MDC-1068, Revision 1, "Service Water System Design Basic Temperature Change from 85° F to 90° F," the ten-sensor averages for July 4 and August 17, 1988, were 104.5° F and 113.4° F, respectively. For the same days, the averages calculated using the new recommended method would have yielded 110° F and 119.4° F, respectively.

Between March and July 1996, the licensee issued four Performance Improvement Requests (PIRs) to address various issues associated with the identified discrepancy. In addition, they contracted a consultant to address the containment average air temperature. On October 4, 1996, PSE&G issued engineering evaluation (EE) No. S-2-CBV-MEE-115, Revision 0, "Salem Unit 2 - Containment Temperature Monitoring Design Basis." In this analysis, the consultant evaluated the locations of the sensors and air recirculation flow, during normal operation of containment fan cooling units, and recommended the use of a volume-weighted average, using five sensors they considered best to represent the temperature of the volumes. For the above specified days, a calculation based on the formula provided by the consultant would have resulted in average air temperatures of 114.0° F and 124.4° F, respectively.

The licensee consultant, recognizing that the containment air might not be well mixed, also recommended "a survey of the containment air temperatures to quantify any stratification in the upper containment air space. [This survey should have been performed] with plant at full power, prior to summer operation, to allow adjustment of the containment average air temperature equation." The consultant believed that in the upper region of the containment the temperature could be lower than the one measured by the representative sensors and that margin could be gained from such survey. They also warned, however, that poor mixing could result in "hot spots" and that "the average temperature could be hotter than the temperature measured at the fan cooler inlet." Because the Unit 2 reactor did not achieve full power until September 23, 1997, a survey prior to summer operation, as recommended in the engineering evaluation, could not be performed by the licensee.

The equation recommended by the consultant in the engineering evaluation was first introduced on March 7, 1997, in Revision 2 of operations procedure S2.OP-DL.ZZ-0003(Q), "Control Room Readings - Mode 1 - 4."

License Change Request

On January 31, 1997, PSE&G submitted a request for change to the technical specifications. This request eliminated the surveillance requirement for the arithmetical average of any five of the ten temperature sensors and replaced it with the more general requirement to "verify [that the] containment average air temperature is within limit at least once per twenty four hours." In the TS Bases the licensee clarified that the average was "calculated using measurements taken at locations within containment selected to provide a representative sample of the overall containment atmosphere."

In their letter to the NRC, PSE&G stated that the changes to the Containment System Air Temperature TS were consistent with NUREG 1431, the standard TS for Westinghouse plants, and that they were to ensure that a representative average air temperature was measured. In their justification for the changes, PSE&G further stated that they had performed a temperature profile study to determine the locations that best represented actual containment conditions and that this review had resulted in establishing five locations to calculate the average. This justification was consistent with their conclusions when they reported the surveillance inconsistencies and with the existing surveillance procedure.

The TS change request was approved by the NRC on June 13, 1997, via Amendment Nos. 195 and 178, for Units 1 and 2, respectively. The NRC safety evaluation confirmed the consistency of the new TS wording with NUREG 1431.

Current Temperature Measuring Method

On July 18, 1997, in Revision 11 of procedure S2.OP-DL.ZZ-0003(Q), PSE&G changed the method for calculating the average air temperature again. This time the licensee went back to the old arithmetical average of ten sensors that was used prior to the issuance of the LER 95-004, on May 18, 1995. This revised method, in effect at the time of the inspection, was the result of licensee's discussions with Westinghouse regarding the use of containment bulk air temperature in the accident analysis. These discussions were documented in Revision 1 of EE No. S-2-CBV-MEE-115, dated July 17, 1997.

According to the revised engineering evaluation, the 120° F initial condition used in the accident analysis represented the average temperature of the air and the other passive structural heat sinks inside containment and that localized air temperatures in excess of 120° F were not expected to be indicative of the heat sink temperatures. Furthermore, these higher air temperatures were insignificant with respect to calculated post-accident containment temperature and pressure, because the initial temperature of the heat sinks had been conservatively set at 120° F. Because of these reasons, the licensee believed that the use of the volume-weighted average endorsed by EE No. S-2-CBV-MEE-115, Revision 0, was not advisable.

Upper Containment Air Stratification

On July 8, 1997, "to refine" the volumetric average containment air temperature obtained through the use of the existing procedure S2.OP-DL.ZZ-0003(Q), the licensee conducted a survey of the upper containment volume and attempted to establish a correlation between the existing temperatures sensors and an additional ten sensors located at different locations of the containment. This correlation was evaluated in calculation No. S-2-CBV-MDC-1738.

Apparently, based on one-day sampling of the containment temperatures, the licensee constructed a straight line relationship between the two sets of sensors that lowered the average containment air temperature by as much as 6.5° F. However, the calculation provided no information regarding: (1) the temperature measurements taken with the existing sensors; (2) the location of and the criteria used for locating the new set of sensors; (3) how the measurements were taken; and (4) the method used to manipulate the data to construct the straight line. The inspector's review of the table of measurements and the associated volumes indicated that the calculated average temperature was somewhat sensitive to volume manipulation. The review also showed that except for one sensor in the upper containment that was reading lower than the others, the average temperature appeared to rise slightly with the containment height.

Similar results regarding the relationship between temperature and containment height were obtained by the licensee during the power ascension of Unit 2, as apparent from temperature measurements recorded at different containment heights during the period between August 1 and October 5, 1997. At the time of the inspection the temperature data was still under review by the licensee. Therefore, a conclusion had not yet been drawn.

Additional Licensee Evaluation

The relationship between containment air temperature, heat sinks, and post-accident temperature/pressure profile was not formally evaluated by the licensee. However, they recently conducted an informal sensitivity study. In this study, using a model that is different than that used by Westinghouse, the licensee prepared, first, post-accident temperature and pressure profiles assuming an initial temperature of 120° F for both the heat sinks and the bulk air. Then, they superimposed temperature and pressure curves resulting from independently increasing the initial temperature of the air and the heat sinks by 10° F.

The inspector's review of the curves generated by the licensee for two different accidents determined that impact on the peak post-accident temperature and pressure was limited. For instance, for the worst postulated steamline break accident, a 10° F increase in bulk air *or* heat sink temperature produces a peak temperature increase of approximately 3° F. However, for the same accident, a 10°F increase in bulk air temperature produced a peak pressure decrease of about 0.3 psig but a 10°F increase in heat sink temperature produced 0.9 psig pressure increase.

Analysis of Observations

A comparison of the air temperature averages obtained by using the three methods described in the licensee's operations procedures, the current method (and the method that was used prior to the issuance of the LER) provides the lowest average. In contrast, the highest average is obtained using the volumetric formula derived by the licensee consultant. The current and previous TS surveillance requirements are not and were not restrictive in the determination of the average air temperature to be used as the initial condition for accident analysis. However, there was a clear expectation that, regardless of the method, the calculated average should be representative of the bulk containment air temperature.

Theoretically, the use of ten thermocouples in lieu of five should provide a better definition of the bulk air temperature. At Salem, all thermocouples are located at elevation 136' or below and there is a large volume of air above elevation 136'. The ones located at elevation 136', which are representative of the large volume overhead, register the highest temperature. In contrast, some smaller volumes below the operating floor register temperatures that are nearly 20° F less than the temperature at elevation 136'. Because of the large difference in volumes and temperatures, the relationship between temperature and volume becomes significant in the calculation of the bulk air average temperature.

In 1995, when the licensee recognized that the arithmetical average of ten sensors was not supported by the TS surveillance requirements, they corrected the deficiency and selected five sensors that better represented the bulk air and ensured that future measurements would be more consistent and less subjective. By selecting the thermocouples that indicated higher temperature for a particular elevation, the licensee also obtained more conservative results. The licensee concurrently initiated steps to evaluate alternatives and better define the bulk air temperature.

The volumetric average method recommended by the consultant was more conservative, but it required a survey of the containment volumes by the licensee. An initial survey of the containment temperature in the upper elevations of the containment did not convincingly show that this method was too conservative. It showed, instead, that in the upper elevations the air could be at a higher temperature than the one used in the calculation to represent this volume. Preliminary indications from a two-month survey of other areas of the containment support this possibility. The licensee was reviewing the results of the two-month survey.

A sensitivity study performed by the licensee to evaluate the impact of higher bulk air temperature on the post-accident temperature and pressure profiles determined that such impact was very limited and that the temperature of the heat sinks in containment were significant in the accident analysis. The study, however, was very preliminary and was not performed using the Westinghouse method. Therefore, the results could not be easily compared with the analyses of record. The study also supported the statements regarding the significance of the heat sinks in the revised the consultant analysis, but it did not necessarily support the reversal of the bulk air temperature calculation to the arithmetical average of ten thermocouples. This would depend on the results of the licensee's analysis of the temperatures recorded during power ascension in August and September 1997.

Because the containment bulk air temperature is summer/winter dependent, i.e., is dependent on the temperature of the cooling water as well as the heat loads, all the calculations produce averages below 120°F except during the summer. Therefore, this issue is not a current concern.

c. <u>Conclusions</u>

The containment average air temperature is an input to the plant accident analyses. This average, however calculated, must be representative of the entire containment volume. Since 1995, the licensee has used three methods to calculate the average air temperature. The arithmetical averaging method that is currently used produces the lowest average and, therefore, is the least conservative of the three. Because the licensee was evaluating the results of a containment temperature survey, the acceptability of the current averaging method was unresolved pending the licensee's completion of the analysis and the NRC review of the results. Also unresolved was the use of these results in applicable accident analyses and plant procedures. **(URI 50-272; 311/97-20-01)**

The inspector also concluded that the licensee was proactive in seeking the assistance of a consultant to determine the best averaging method, but their decision to return to the ten-sensor arithmetical average was not adequately supported. Also, two calculations used to justify a lower average temperature were either unclear or did not sufficiently justify the basis for their conclusions.

<u>V. Management Meetings</u>

X1 Exit Meeting Summary

The inspectors presented the inspection results to members of licensee management at the conclusion of the inspection on November 13, 1997. The licensee acknowledged the findings presented and indicated the intent to complete their evaluation of the issue before the next summer.

The inspector asked the licensee whether any material reviewed during the inspection should be considered as proprietary information. No proprietary information was identified.

PARTIAL LIST OF PERSONS CONTACTED

Public Service Electric and Gas Company

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LIST OF ACRONYMS USED

ADFCS	Advanced Digital Feedwater System
ANSI	American National Standards Institute
AR	Action Request
ASME	American Society of Mechanical Engineers
CCHX	Component Cooling Heat Exchanger
CFCU	Containment Fan Coil Unit
CFR	Code of Federal Regulations
CJP	Code Job Package
COTSS	Commercial Off The Shelf Software
CR	Condition Report
DCP	Design Change Package
ECCS	Emergency Core Cooling System
I&C	Instrumentation and Controls
ISI	Inservice Inspection
ISLT	Inservice Leak Testing
MCR	Modifications Concerns and Resolution
MT	Magnetic particle Examination
N/A	Not Applicable
NDE	Non-destructive examination
NPS	Nominal Pipe Size
NOP	Normal Operating Pressure
NRC	Nuclear Regulatory Commission
NSRB	Nuclear Safety Review Board
OTSC	On-The-Spot Change
PMT	Post-Maintenance Testing
PT	Dye Penetrant Examination
PSE&G	Public Service Electric and Gas
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RHR	Residual Heat Removal
RPM	Revolutions per minute
RT	Radiographic examination
SER	Safety Evaluation Report
SGFP	Steam Generator Feedpump
SI	Safety Injection
SNSS	Senior Nuclear Shift Supervisor
SORC	Station Operations Review Committee
SRO	Senior Reactor Operator
SSFI	Safety System Functional Inspection
SW	Service Water
TRB	Test Review Board
TRIS	Tagging Request Inquiry System
TS	Technical Specification
UFSAR	Updated Final Safety Analyses Report
UT	Ultrasonic Examination