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June 14, 1991

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Subject: Docket No. 50-206
Supplemental Report
Licensee Event Report No. 91-007, Revision 1
San Onofre Nuclear Generating Station, Unit 1

Reference: Letter, R. W. Krieger (SCE) to USNRC Document Control Desk, dated April 29, 1991.

The referenced letter provided Licensee Event Report (LER) No. 91-007, for an occurrence involving the reactor vessel refill volume value utilized in the Large Break Loss of Coolant Accident Analysis performed by Westinghouse. The enclosed supplemental LER provides additional information concerning the event, causes, and corrective actions. Neither the health and safety of plant personnel or the public was affected by this occurrence.

If you require any additional information, please so advise.

Sincerely,

Enclosure: LER No. 91-007, Rev. 1

cc: C. W. Caldwell (USNRC Senior Resident Inspector, Units 1, 2 and 3)
J. B. Martin (Regional Administrator, USNRC Region V)
Institute of Nuclear Power Operations (INPO)

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LICENSEE EVENT REPORT (LER)

Facility Name (1)	Docket Number (2)	Page (3)
SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1	0 5 0 0 0 2 0 6	1 of 1 1

Title (4)
LARGE BREAK LOSS OF COOLANT ACCIDENT ANALYSES NON-CONSERVATISMS DUE TO INCORRECT REACTOR COOLANT SYSTEM VOLUMES UTILIZED IN THE ANALYSES

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
Month	Day	Year	Year	/// Sequential Number ///	Revision Number	Month	Day	Year	Facility Names	Docket Number(s)
				---	---				NONE	0 5 0 0 0
0 3	2 8	9 1	9 1	0 0 7	0 1	0 6	1 4	9 1		0 5 0 0 0

OPERATING MODE (9)	1	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10CFR (Check one or more of the following) (11)			
POWER LEVEL (10) 0 2 0		___ 20.402(b)	___ 20.405(c)	___ 50.73(a)(2)(iv)	___ 73.71(b)
		___ 20.405(a)(1)(i)	___ 50.36(c)(1)	___ 50.73(a)(2)(v)	___ 73.71(c)
		___ 20.405(a)(1)(ii)	___ 50.36(c)(2)	___ 50.73(a)(2)(vii)	___ Other (Specify in Abstract below and in text)
		___ 20.405(a)(1)(iii)	___ 50.73(a)(2)(i)	___ 50.73(a)(2)(viii)(A)	
		___ 20.405(a)(1)(iv)	X 50.73(a)(2)(ii)	___ 50.73(a)(2)(viii)(B)	
		___ 20.405(a)(1)(v)	___ 50.73(a)(2)(iii)	___ 50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

Name	TELEPHONE NUMBER AREA CODE
R. W. Krieger, Station Manager	7 1 4 3 6 8 - 6 2 5 5

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS

SUPPLEMENTAL REPORT EXPECTED (14)	Expected Submission Date (15)	Month	Day	Year
___ Yes (If yes, complete EXPECTED SUBMISSION DATE) XX NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

On 3/28/91, with Unit 1 operating at 20% reactor power, it was determined that the value for the reactor vessel refill volume used in the Large Break Loss of Coolant Accident (LBLOCA) analysis performed by Westinghouse was underestimated by approximately 182 cubic feet. An initial evaluation of the effects of this volume discrepancy using actual plant operating parameters in the event of LBLOCA indicate that the Peak Clad Temperature (PCT) would not have exceeded the SONGS 1 acceptance criteria of 2300 degrees F. Although actual operation could not have resulted in exceeding the LOCA/PCT limit, under hypothetical operating conditions assumed in the design basis accident analysis, it is possible that LOCA/PCT limit exceedence could be predicted to occur.

Corrective actions included: 1) immediately restricting reactor power level to 75% (this reduced power level ensured that the SONGS 1 PCT acceptance criteria following a LBLOCA would have been satisfied), and 2) administratively restricting Incore Axial Offset (IAO) to allow for full power operation.

Subsequently, additional volume differences were identified in other analyses performed by Westinghouse. These additional differences could affect the LBLOCA/PCT and the LBLOCA Containment Mass and Energy Analyses, conservatively assuming these differences to be errors. Our evaluation has concluded that the controls restricting IAO, and operation within the currently allowed T_{avg} provide sufficient margin to compensate for all of the identified volume differences, conservatively assuming these differences are non-conservative modeling errors.

Westinghouse was unable to determine the basis for the original calculation of the refill volume in the LBLOCA analysis. The additional volume differences are largely attributable to differences in calculational approach as compared to current analysis methods and standards.

The volume differences described in this LER have been documented in SCE letters to the NRC dated 3/29/91, 5/10/91, and 5/17/91.

Plant: San Onofre Nuclear Generating Station
Unit: One
Reactor Vendor: Westinghouse
Event Date: 03-28-91
Time: 1005

A. CONDITIONS AT TIME OF THE EVENT:

Mode: 1, Power Operation

B. BACKGROUND INFORMATION:

1. Reactor Vessel Refill Volume:

The reactor vessel refill volume is the combined volume of that portion of the reactor vessel downcomer region and the lower vessel plenum which is below the active fuel region.

2. Incore Axial Offset:

Incore Axial offset (IAO) is a measure of the power (neutron flux) displacement from the reactor core center towards the top and bottom of the core. The amount of this displacement is limited by analysis and Technical Specifications to prevent power configurations which could cause unacceptable results in the analysis of the plant response in the event of an accident.

3. Technical Specifications (TS):

TS 3.11, "Continuous Power Distribution Monitoring" specifies IAO limits as a function of reactor power in accordance with the equations below:

For positive offsets:

$$IAO = \frac{2.78/P - 2.10}{0.033} - FCC$$

For negative offsets:

$$IAO = \frac{2.78/P - 2.10}{-0.033} + FCC$$

where

IAO = incore axial offset

P = fraction of rated thermal power

FCC = The larger of 3.0 or the value in percent of IAO by which the current correlation check differs from the incore-excore correlation.

The axial offset limits are conservatively established with respect to the core design peaking factor. Analytical determination of the relationship between core peaking factors and IAO considers a wide range of maneuvers and core conditions, and actual measurements relating IAO to the axial offset monitoring systems.

C. DESCRIPTION OF THE EVENT:

1. Event:

On March 28, 1991, with Unit 1 operating at 20% power, it was determined that the value for the reactor vessel refill volume used in the Large Break Loss of Coolant Accident (LBLOCA) analysis performed by Westinghouse was underestimated by approximately 182 cubic feet (total Reactor Coolant System (RCS) volume is approximately 7200 cubic feet) in comparison to that recently calculated using current analysis techniques. An initial evaluation of the effects of this volume discrepancy using actual plant operating parameters in the event of LBLOCA indicate that the Peak Clad Temperature (PCT) would not have exceeded the SONGS 1 acceptance criteria of 2300 degrees F. Although actual operation never resulted in the possibility of exceeding the LBLOCA/PCT limit of 2300 degrees F, under hypothetical operating conditions assumed in the design basis accident analysis (e.g., worst allowed IAO, 102% reactor power, worst possible single failure, etc.), it is possible that LBLOCA/PCT limit exceedence could be predicted to occur. Therefore, this LER is being submitted pursuant to the requirements of 10 CFR 50.73(a)(2)(ii)(B) as a condition outside the design basis of the plant.

After the above refill volume discrepancy was identified, SCE initiated an independent effort to confirm the volume information used in other analyses performed by Westinghouse. Additional volume differences (described in Section F below) were identified by that effort. These additional volume differences affect the LBLOCA/PCT Analysis (the total discrepancy was determined to be 550 cubic feet), and the LBLOCA Containment Mass and Energy Analysis (the total discrepancy was determined to be 300 cubic feet). Although some of the volume differences may represent acceptable variations consistent with the specific modeling methodologies used for the various analyses, SCE conservatively treated all of the identified volume differences as non-conservative discrepancies. Additional engineering evaluations were

performed as a result of this event and are described in Section G.3 below.

The volume differences described in this LER have been documented in SCE letters to the NRC dated 3/29/91, 5/10/91, and 5/17/91.

2. Inoperable Structures, Systems or Components that Contributed to the Event:

None.

3. Sequence of Events:

Not applicable.

4. Method of Discovery:

While performing a scoping study for Cycle 12 modifications, SCE conducted a review of the results from SCE's recently completed the Small Break LOCA (SBLOCA) analysis in which the RCS volumes were calculated using current methods and practices. During this review, SCE identified the 182 cubic feet difference between the reactor vessel refill volume which was utilized in the Westinghouse LBLOCA analysis of record (performed in 1970) and that recently calculated using current analysis techniques for a new SBLOCA analysis.

After the above volume difference was identified, SCE initiated an independent effort to confirm the volume information used in other analyses performed by Westinghouse. This effort identified the additional volume differences.

5. Personnel Actions and Analysis of Actions:

Refill Volume Difference

Upon identification of the refill volume difference, SCE immediately imposed administrative controls to limit plant power level to less than 75% of rated thermal power (RTP). This reduced power level ensured that adequate PCT margin would be maintained assuming the difference was a non-conservative error, while the cause of the difference was being investigated.

When Westinghouse confirmed to SCE that the difference was an error, an administrative restriction in the axial offset (+/- 12% at 100% RTP versus +/-17% at 100% RTP) was imposed on plant operation to provide sufficient margin such that full power operation could be resumed within the LBLOCA analysis assumptions for PCT.

Additional Volume Differences

After SCE identified the additional volume differences, Westinghouse performed an engineering evaluation (sensitivity study) to determine the impact that these volume differences had on applicable accident analyses.

This is further discussed below in Section F, Safety Significance of the Event.

6. Safety System Responses:

Not applicable.

D. CAUSE OF THE EVENT:

A review by Westinghouse of the available documentation was not successful in determining the basis for the original refill volume calculation in the LBLOCA analysis. Westinghouse has concluded that the refill volume used for the LBLOCA analysis is not consistent with the volumes which are calculated using current analysis methodology, and it is therefore being conservatively treated as an error.

Refill Volume Difference

Westinghouse performed the original input calculations for the SONGS 1 LBLOCA analysis in 1970 prior to implementation of the requirements of 10 CFR 50, Appendix B. When the LBLOCA was re-analyzed in 1980 and 1987, there was no reason to believe that the refill volume input from the 1970 analysis was incorrect and therefore it was reused.

Additional Volume Differences

SCE's further verification of volumes used in Westinghouse analyses identified 550 cubic feet total volume difference in the LBLOCA/PCT analysis compared to that which would be calculated using current analysis techniques. Additionally, 300 cubic feet difference was identified in the RCS volume assumed in the LBLOCA Mass and Energy Release Analysis compared to that which would be calculated using current day techniques.

LBLOCA/PCT

The 550 cubic feet total volume difference associated with the LBLOCA/PCT Analysis is attributed to 1) the previously identified 182 cubic feet refill volume underestimation, 2) the omission of the core baffle region (the 150 cubic feet volume between the reactor vessel baffle and core barrel) in the LBLOCA analysis model, and 3) small volume differences (totaling 218 cubic feet) in other areas of the RCS due to apparent differences in calculational approach as compared to current analysis methods and standards.

LBLOCA/Mass Energy Release

The 300 cubic feet volume difference associated with the LBLOCA Containment Mass and Energy Analysis is attributed to 1) the previously identified 182 cubic feet refill volume underestimation, and 2) small volume differences (totaling 118 cubic feet) in other areas of the RCS due to apparent differences in calculational approach as compared to current analysis methods and standards.

E. CORRECTIVE ACTIONS:

1. Corrective Actions Taken:

   a. Upon identification of the potentially underestimated refill volume, administrative controls were implemented to immediately limit plant power level to less than 75% RTP to ensure that adequate PCT margin would be maintained while the volume underestimation was evaluated. After completion of the evaluation, the power restriction was supplanted with administrative controls allowing full power operation. The administrative controls for full power operation placed requirements on IAO which are more restrictive than those specified in TS 3.11. NRC concurrence of these administrative controls was obtained prior to plant operation above 75% RTP.

   b. Following the identification of the refill volume discrepancy, SCE initiated an independent effort to confirm the volume information used in other analyses performed by Westinghouse. Additional volume differences were identified by that effort.

      This is further discussed below in Section F, Safety Significance of the Event.

2. Planned Corrective Actions:

   a. An amendment application will be submitted to the NRC by June 18, 1991, to request a change to TS 3.11 reflecting the current administratively imposed IAO values and also to change the basis of TS 3.5.2 for the new values of specific power and peaking factors.

   b. The LBLOCA analysis will be reperformed utilizing modern analytical methods prior to restart from the Cycle 12 refueling outage.

F. SAFETY SIGNIFICANCE OF THE EVENT:

SCE, with the participation of Westinghouse, performed an engineering evaluation to determine the impact of the identified volume differences on the SONGS 1 design basis accident analyses. Our evaluation has concluded that the administrative controls restricting IAO, and operation within the currently

allowed T_{avg} provide sufficient margin to compensate for all of the identified volume differences, conservatively assuming these differences are non-conservative modeling errors.

Additionally, a review was performed to determine the impact of the volume differences reported here to the conditions reported in LER 89-011, Revision 2 (Docket No. 50-206), which reported potential safety injection flow delays and diversions. We have concluded that the combined effect of the volume differences and the conditions reported in LER 89-011 would not have resulted in the PCT exceeding the SONGS 1 acceptance criteria of 2300 degrees F.

A detailed discussion of the analyses that are affected by the identified volume differences are described below:

LBLOCA/PCT ANALYSIS

The 550 cubic feet RCS volume difference in the LBLOCA/PCT analysis is comprised of 1) the 182 cubic feet refill volume underestimation, 2) 150 cubic feet in the core baffle region (the volume between the reactor vessel baffle and core barrel was not modeled), and 3) small volume differences in other areas of the RCS due to differences in calculational approach which total 218 cubic feet. We have conservatively assumed these volume differences represent non-conservative discrepancies. On that basis, Westinghouse completed an evaluation (sensitivity study) of the effect of these volume differences on the LBLOCA/PCT analysis by considering the three phases of a LOCA, i.e., blowdown, refill, and reflood. A PCT penalty of 188.5 degrees F was assessed as a result of the extended time required for refill. Based on the sensitivity study and comparison with other plants and test results, Westinghouse concluded that no penalty is expected for the blowdown and reflood phases due to the volume differences between the interim acceptance criteria calculation and current methods.

The Westinghouse sensitivity study performed to assess the volume differences estimated a benefit of 122 degrees F due to the extended blowdown. However, due to the complexity of the blowdown phase phenomena and the approximate nature of the sensitivity study, SCE is not crediting this benefit and has instead conservatively assessed a penalty of 21 degrees F. The 21 degrees F penalty was calculated by assuming the worst case blowdown phase heatup rate (70 degrees F/sec) and a 0.3 second increase in the blowdown duration. SCE has also assessed a penalty for the reflood phase of the transient. A penalty of 36.3 degrees F was assessed by assuming a delay of reflood for 3 seconds (as determined by the sensitivity study) and an adiabatic heatup rate of 12.1 degrees F/second. Therefore, although Westinghouse has concluded no penalty is expected from blowdown and reflood phases, SCE is conservatively assessing a penalty of 57.3 degrees F.

Our present administratively imposed controls on IAO provide 237.5 degrees F of PCT margin. Additionally, we have identified 46 degrees F of margin due to more realistic (but nevertheless conservative) assumptions on safety injection mini-flow. Therefore, the combined margin of 283.5 degrees F associated with

the IAO restrictions and the safety injection mini-flow assumptions are sufficient to offset the 245.8 degrees F PCT penalty (188.5 + 57.3 degrees F).

Based upon surveillance data reviewed by SCE, the actual IAO values from Cycle 8 through the present, did not exceed the new administrative IAO limits imposed during Cycle 11. For Cycles 5 to 10, SCE has verified that the maximum calculated total peaking factor (Fq) did not exceed 2.52. This provides an Fq margin of 0.26 (corresponding to a PCT margin of approximately 154 degrees F) to the current analyzed Fq value of 2.78. Prior to Cycle 5, IAO was not calculated or monitored; however, the behavior of the core is expected to have been similar to later cycles since design and operational strategies have not changed. Therefore, SCE concludes that previous operation was at all times, within the design basis.

Although not credited by SCE, other factors also support the conclusion that previous operation was within the design basis. For all operating cycles, the decay heat model used in the LBLOCA analysis was based on a preliminary ANS standard issued in 1971. The more recent 1979 standard specifies decay heat levels approximately 21% lower than the 1971 standard. This translates directly to reduced peak linear heat rate during the blowdown, refill, and reflood periods. A conservative estimate of the potential reduction in PCT from this source of margin can be made by applying a 21% lower adiabatic heatup rate during the refill period. This results in a PCT benefit of 219 degrees F. Therefore, a total of 373 degrees F (154 + 219) margin was available in previous cycles to offset the 245.8 degrees F penalty assessed for the RCS volume differences.

LOCA CONTAINMENT MASS AND ENERGY ANALYSIS

Volume differences also appear in the Westinghouse LBLOCA mass and energy analyses. The total RCS volume used in the LBLOCA containment mass and energy design basis analyses is approximately 300 cubic feet less than the volume utilized in the recent NOTRUMP analysis. This volume anomaly includes the previously discovered 182 cubic feet in the lower plenum and other differences in various areas of the RCS. Assuming these differences represent non-conservative discrepancies, they result in an underestimate of the RCS mass and energy released during the LBLOCA. This adversely affects the calculated peak containment pressure and temperature after a LBLOCA.

Westinghouse completed an evaluation of the impact of the 300 cubic feet volume difference. The 300 cubic feet volume difference translates into approximately 8 MBTU of increased energy released into the containment as a result of a LBLOCA. However, the SONGS 1, Cycle 11 design basis LBLOCA mass and energy analyses have, among other conservatisms, not credited plant operation at the currently allowed RCS average coolant temperature, T_{avg} (since Cycle 8). Operating with the currently allowed lower T_{avg} reduces the energy available to be released to the containment by approximately 11 MBTU. This margin is more than sufficient to offset the 8 MBTU penalty associated with the volume difference. The current administrative controls will be maintained to limit the lower T_{avg}.

Prior to Cycle 8, the plant operated at the nominal 100 % T_{avg} value. However, assuming best estimate initial plant conditions (e.g., T_{avg} and pressurizer volume) results in approximately 5 MBTU margin. In addition, current methodology employs the ANS 1979 decay heat curve and steam/water mixing. Based on the results of plants analyzed with the new methodology, mass and energy releases are reduced leading to a reduction in peak containment pressure of approximately 5 psi. For SONGS 1, this is equivalent to a reduction of approximately 15 MBTU in energy release. Hence, approximately 20 MBTU margin is available to offset the 8 MBTU penalty associated with the RCS volume differences.

G. ADDITIONAL INFORMATION:

1. Component Failure Information:

   Not applicable.

2. Previous LERs for Similar Events:

   None.

3. Other Additional Information:

   SCE has also explored the possibility of volume differences affecting the results of non-LOCA analyses that use digital computer codes in which volume is a modeled parameter. We did not investigate the potential for volume differences in accident analyses performed with analog simulation techniques since those analyses are non-limiting, small volume differences are considered insignificant, and little documentation is available for those analyses performed in the late 1960's.

   Westinghouse evaluated the effect of the identified volume differences for the following non-LOCA events: 1) rod withdrawal at power (RWAP), 2) dropped rod, 3) loss of flow, 4) reactor coolant pump locked rotor, 5) steamline break, 6) loss of normal feedwater (LONF), and 7) feedline break (FLB). In addition, SCE evaluated the impact of volume differences on the boron dilution analysis. The results of these evaluations are summarized below.

   LOFTRAN is the Westinghouse computer code used for non-LOCA events for which RCS volumes are modeled. Therefore, the LOFTRAN volumetric inputs were checked against equivalent volumes based on the Westinghouse plant component data base (that was used to calculate the RCS volumes for the recent NOTRUMP small break LOCA analysis). That effort uncovered a 366 cubic feet difference between the total RCS volume used in the LOFTRAN analyses (LOFTRAN being lower) and that based on the component data base. Approximately 148 cubic feet of the total difference is associated with 1) the dead volume in the reactor vessel head and 2) the total upper core plenum volume. The remaining volume difference is attributed to small differences in calculational approach in computing various volume inputs

and has been confirmed not to be a discrepancy. The effect of the two volume differences on the limiting non-LOCA events is discussed below.

Steamline Break Analysis

The effect of the identified volume differences on the LOFTRAN steamline break analysis was evaluated by re-performing the analysis with corrected volumes. The new analysis showed that the LOFTRAN volume differences resulted in 1) a 36.6 psi increase in RCS pressure, 2) a small increase in the peak heat flux from 0.403 to 0.407 (fraction of nominal), and 3) a change of -1.0 degrees F and +0.5 degrees F in the hottest and coldest core inlet temperatures, respectively. RCS pressure increase has a beneficial effect on DNBR and is sufficient to offset the small heat flux and temperature increases. Therefore, the smaller dead volume and upper plenum volume in the steamline break analysis of record is conservative with respect to DNBR.

The effect of the volume differences on steamline break mass and energy release was also evaluated by Westinghouse and found to be inconsequential. Based upon the Westinghouse results, SCE evaluated the calculated peak containment pressure resulting from a steamline break and concluded that the volume differences had no effect on the peak containment pressure for the limiting hot full power condition and that the hot full power condition remained the limiting case.

Other Non-LOCA LOFTRAN Analyses

The dead volume difference is of most concern for depressurization events where the dead volume acts like a pressurizer. For events like the RWAP, LONF, and FLB, a smaller RCS volume is conservative since the smaller volume would cause higher RCS pressures and less total RCS volume available before a water solid condition would be reached. In addition, a smaller initial coolant inventory would be conservative with respect to ensuring the core remains covered after the pressurizer relief valves discharge during a feedline break transient. Westinghouse completed a new feedline break analysis to confirm these conservatisms.

For the remaining non-LOCA events analyzed with LOFTRAN, the primary concern is DNB and the parameters of importance (e.g., power, pressure, temperature, flow) are defined independently of the RCS volumes. Therefore, the dead volume and the upper plenum volume will not significantly affect the results of the other non-LOCA events analyzed with LOFTRAN. Thus, the SONGS 1 non-LOCA analyses of record that were performed with the LOFTRAN code are either conservative or were not significantly impacted by the identified volume differences.

Boron Dilution Analysis

The SONGS 1 boron dilution accident analysis was performed by SCE. As part of the RCS volume differences evaluation, we have verified that the volumes used in that accident analysis were 1) calculated independently of the RCS volumes calculated by Westinghouse, and 2) are conservative relative to the applicable NOTRUMP RCS volumes.