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March 29, 1991

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

Gentlemen:

Subject: **Docket No. 50-206**
Underestimation of Refill Volume Assumed in Large Break LOCA Analysis
San Onofre Nuclear Generating Station, Unit 1

SCE recently discovered that the value for the reactor vessel refill volume used in the SONGS 1 large break Loss of Coolant Accident (LBLOCA) analysis was underestimated. The purpose of this letter is to:

- Identify the effect on safety analysis results of the underestimated refill volume;
- Confirm that the underestimated refill volume used in the LBLOCA analysis does not affect the results of other accident analyses;
- Describe the restriction on power level that has been implemented to assure safe plant operation during our investigation of the effects of underestimating the refill volume; and
- Provide administrative controls planned for plant operation at full power.

EFFECT OF UNDERESTIMATED REFILL VOLUME

On March 26, 1991, during review of the recently completed small break LOCA (SBLOCA) analysis, and LBLOCA analysis of record (performed in 1981) SCE personnel identified a possible discrepancy in the refill volume* utilized in the two analyses. Specifically, the SBLOCA utilized a value of 672 ft^3 for refill volume, whereas the LBLOCA appeared to use a smaller value of 490 ft^3 for this same parameter. We immediately initiated dialogue with Westinghouse to determine the reason for the apparent difference in the refill volumes. In preliminary discussions on the following day, Westinghouse could not

* The refill volume consists of the reactor vessel lower plenum and downcomer volumes.

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satisfactorily reconcile the difference. At that time, SCE conservatively implemented administrative controls to limit reactor power to less than 75% of rated thermal power in order to ensure that adequate margin would be maintained should the discrepancy be shown to be an error.

On March 28, 1991, Westinghouse completed an evaluation of the refill volume and concluded that 672 ft^3 was the correct value. This value was consistent with hand calculated estimates performed by Edison. Therefore, the 490 ft^3 utilized in the LBLOCA analysis was underestimated by 182 ft^3.

The underestimated refill volume results in a delay in refilling the reactor vessel lower plenum to the bottom of the active fuel region after a LBLOCA. At a safety injection flow rate of 655 lbm/sec., it would take approximately 17.3 seconds longer than previously calculated to refill. The delay in refill occurs during a period of adiabatic heat up of the core at a rate of 12.1°F per second. Therefore the underestimated volume results in a predicted increase in peak clad temperature (PCT) of 210°F.

DESIGN BASIS EVENTS

The design basis events were reviewed to determine events affected by the underestimated refill volume. The non-LOCA events are not affected since they do not result in primary system transients which void the refill volume. The Small Break LOCA is not affected because the appropriate refill volume was used in the recently performed NOTRUMP analyses. The Large Break LOCA is the only event affected by the underestimated refill volume because the vessel completely voids and the refill time impacts core recovery and therefore the peak clad temperature.

EXISTING ADMINISTRATIVE CONTROLS

The calculated PCT based on the LBLOCA analyses of record is 2278.5°F. This provides 21.5°F margin to the SONGS 1 PCT limit of 2300°F. Reducing the refill penalty in PCT of 210°F by this 21.5°F margin results in a net penalty of 188.5°F. By restricting reactor power to 75% of rated thermal power, 200°F of margin is provided to compensate for the net penalty. This is based on Westinghouse sensitivity studies (described in the attachment) which demonstrate a PCT reduction of 8°F per percent power.

Several existing factors could be credited to provide additional margin in peak clad temperature. Conservative assumptions utilized in the LBLOCA analysis Safety Injection system mini-flow rate would provide about 46°F PCT margin. Specifically, the LBLOCA analysis conservatively assumed a Safety Injection mini flow rate higher than the rate appropriate for an LBLOCA. The appropriate miniflow rate increases the safety injection delivery rate by 27 lbm/sec. and results in a more rapid reactor vessel reflood. As stated, this has a net effect of reducing PCT by approximately 46°F. The accident analysis also assumes plant operation at 100% rated thermal power. Actual operation at 92% power due to operation at reduced Tave provides about

64 degrees of margin (8°F per percent power). These conservatisms are described in the attached Westinghouse letter.

Additionally, the existence of the larger refill volume also provides additional blowdown volume, extending the blowdown time and decreasing the adiabatic heat up period by approximately 2 seconds. This would provide approximately 24 degrees of margin. To assure the conservatism of the reevaluation effort, no credit was taken for any of these factors, which total approximately 134°F of additional PCT margin.

OPERATION AT FULL POWER

Upon verification by Westinghouse on March 28, 1991 of the underestimated refill volume, Edison in conjunction with Westinghouse undertook an effort to identify compensatory measures which would allow full power operation. These efforts identified available margin by reducing the expected peaking factor (F_Q) through the use of administrative controls limiting axial offset.

SONGS 1 is currently analyzed at a total peaking factor (F_Q) of 2.78 (which results in a linear heat rate of 13.2 kw/ft). Reanalysis of the current cycle has demonstrated that reducing axial offset limits results in an overall peaking factor of 2.38 (resulting in a linear heat rate of 11.3 kw/ft). For conservatism a value of 2.595 has been utilized in the IAO equations below. Westinghouse studies with the IAC model have shown a PCT sensitivity of 50°F per 0.4 kw/ft (see attachment). Based on this sensitivity, the PCT benefit due to this restriction in F_Q is -237.5°F. This margin compensates for the 210°F penalty associated with the underestimated refill volume.

These restrictions on F_Q will be achieved by administrative controls which will place limits on axial offset which are more restrictive than those included in Technical Specification (TS) 3.11, "Continuous Power Distribution Monitoring." The axial offset limits will be as follows:

$$\text{For Positive Offsets: } IAO = \frac{2.595/P - 2.10}{0.033} - FCC$$

$$\text{For Negative Offsets: } IAO = \frac{2.595/P - 2.10}{-0.033} - FCC$$

These equations result in an allowable axial offset of ±15% at 100% power (expected incore/excore correlation uncertainty will result in axial offset limits of approximately ±12% at 100% power). This is a reduction of 5.6% from the technical specification limits.

These controls assure that PCT will remain below the presently predicted value of 2278.5°F in the event of a LBLOCA. We are currently performing a review of the SONGS 1 Technical Specifications to determine if it is appropriate to apply the reduced F_Q value to other operating limits (e.g. rod insertion limits). We will not increase power above 75% of full rated power until this review is completed and appropriate administrative controls are implemented. We will administratively implement these controls while the appropriate TS change request is prepared by SCE and approved by the NRC.

CONCLUSION

We reviewed the impact on plant operation resulting from the underestimated refill volume used in the Large Break LOCA. It was confirmed that the Large Break LOCA was the only design basis event affected.

The resulting net penalty on peak clad temperature was determined to be 188.5°F. For operation below 75% power, the penalty can be compensated for by the 200°F margin available from the reduced power operation. For operation above 75% power, the penalty is compensated for by limiting the axial offset window to ±15% at 100% full power which reserves 237.5°F of PCT margin. The compensatory margins credited are conservative since additional margin is available. Therefore, sufficient margin exists to assure safe plant operation for Cycle 11 pending revision of Technical Specification 3.11 to adjust the axial offset limits in accordance with the administrative controls described above.

Very truly yours,

R M Rosenblum

cc: George Kalman, NRC Project Manager, San Onofre Unit 1
J. B. Martin, Regional Administrator, NRC Region V
C. W. Caldwell, NRC Senior Resident Inspector, San Onofre Units 1, 2 & 3
C. D. Townsend, NRC Resident Inspector, San Onofre Unit 1

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SCE-91-528

March 28, 1991

Mr. J. T. Reilly
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Irvine Operations Center
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SOUTHERN CALIFORNIA EDISON COMPANY
SAN ONOFRE NUCLEAR GENERATING STATION
Large Break LOCA Lower Plenum Volume Discrepancy

Dear Mr. Reilly:

Attached is the Westinghouse evaluation of the Large Break Loss of Coolant Accident to address the discrepancy discovered in the volume of the lower plenum assumed in the analysis. As discussed in the evaluation, the penalty associated with this discrepancy is offset by a revision in Technical Specification 3.11 or administrative control which will limit the axial offset window to +/- 15% at 100% full power, and crediting operation of SONGS 1 at 92% full power. Therefore, sufficient margin exists to assure Cycle 11 operation within analyzed limits.

Regards,

Sam B. for POE

H. C. Calton, Manager
Western Area
Domestic Customer Projects

/slf

Attachment

cc: C. Caso - W
M. Young - W
R. M. Rosenblum - Irvine
A. J. Eckhart - Irvine

SAN ONOFRE NUCLEAR GENERATING STATION UNIT 1

JUSTIFICATION FOR CONTINUED OPERATION FOR INCREASED LARGE BREAK LOCA REFILL VOLUME

BACKGROUND

On March 26, 1991, Southern California Edison personnel identified an inconsistency between the SONGS-1 lower plenum volume assumed in the Westinghouse IAC (Interim Acceptance Criteria) large break LOCA analysis and the recent small break LOCA NOTRUMP analysis. Review of the SONGS-1 vessel diagrams indicates that this volume is underestimated in the large break analysis and results in an increase in calculated peak cladding temperature. The only accident affected by this inconsistency is the large break LOCA. The purpose of this evaluation is quantify the penalty associated with this discrepancy in the lower plenum volume, identify margins which may be used to offset the penalty. This information, in conjunction with recommended compensatory action may then be used by SCE to support continued safe operation of SONGS-1 through cycle 11.

EVALUATION

As part of the NOTRUMP analysis performed to support increases in safety injection (SI) miniflow, SONGS-1 plant data was collected for the Westinghouse plant component data base (IMP). This data base automatically generates the small break analysis noding model. Generation of the NOTRUMP deck provided a lower plenum volume of 611 ft^3 to the bottom of the active fuel inside the core barrel. An additional 61 ft^3 represents the downcomer volume from the bottom of the core barrel to the bottom of the active fuel elevation. Together, this 672 ft^3 volume comprises what can be termed "refill volume" with respect to the IAC large break evaluation model (EM).

The current licensing basis large break LOCA analysis assumes a refill volume of 490 ft^3, which is apparently underestimated by 182 ft^3. This value is used in the large break analysis to calculate the time to bottom of core (BOC) recovery following the RCS blowdown. From the end of blowdown (EOB) to BOC, an adiabatic clad heat up rate is assumed. Once BOC is reached, the clad temperature transient soon reverses and clad temperatures begin to decrease.

For SONGS-1, this adiabatic heat up rate is 12.1°F/sec. The current SI flow rate assumed in the latest evaluation for increased SI miniflow is 655 lbm/sec. At an assumed density of 62.3 lb/ft^3, the delay in BOC is:

$$\Delta T_{BOC} = (182\ ft^3)(62.3\ lb/ft^3)/(655\ lbm/sec) = 17.31\ sec$$

At a 12.1°F/sec adiabatic heat up rate, the PCT penalty is:

$$\Delta PCT = (17.31\ sec)(12.1°F/sec) = 209.5°F$$

The current large break peak clad temperature has been evaluated at 2278.5°F for increased miniflow. Therefore, to maintain compliance with the 2300°F IAC PCT limit, at least 188.0°F of margin is needed to accommodate the larger refill volume.

Reduced Axial Offset (Peaking Factors)

SONGS-1 is analyzed at a total peaking factor (F_Q) of 2.78 (13.2 kw/ft). Reanalysis of the current cycle has demonstrated that reducing axial offset limits results in an overall peaking factor of only 2.38 (11.3 kw/ft). Past sensitivities with the IAC model have shown a PCT sensitivity of 50°F for 0.4 kw/ft. Based on this sensitivity, the expected PCT benefit from this change is:

$$\Delta PCT_{FQ} = [(11.3 - 13.2)kw/ft](50°F/0.4\ kw/ft) = -237.5°F$$

which compensates for the penalty associated with the increased refill volume.

92% Power Operation

Further margin is available in the large break analysis by crediting power level. SONGS-1 is physically limited to 92% power operation. The current analyses assume 100% power. Power sensitivities with the IAC large break EM have shown PCT benefits of 8°F for a 1% decrease in power level. Therefore:

$$\Delta PCT_{power} = (92\% - 100\%)(8°F/1\%) = -64°F$$

Reduced Safety Injection Miniflow

As previously stated, a large break LOCA evaluation has been performed which included an operator action to increase miniflow prior to 30 minutes following a LOCA. This action is not required for the large break LOCA since the transient is terminated within several minutes of break initiation. The assumption of lower miniflow increases SI from 655 lb/sec to 682 lb/sec. The estimated PCT at this higher flow rate is 2232.5°F, such that:

$$\Delta PCT_{miniflow} = (2232.5 - 2278.5)°F = -46°F$$

This could be used to provide additional margin within the SONGS-1 licensing basis.

CONCLUSION

Increasing the 490ft^3 refill volume assumed in the large break analysis to the NOTRUMP supported value of 672ft^3 results in a 209.5°F PCT penalty. The following margin is available to offset this penalty and maintain compliance with the 2300°F IAC PCT limit:

ΔPCT_{FQ}	= -237.5°F
ΔPCT_{power}	= -64.0°F
$\Delta PCT_{miniflow}$	= -46.0°F
TOTAL AVAILABLE MARGIN	= 347.5°F

Safe operation of SONGS-1 at its established power level can be assured by adjusting inward the axial offset operating band width to compensate for the penalty associated with the lower plenum volume discrepancy.

RECOMMENDED ACTIONS

Westinghouse has confirmed that the maximum total peaking factor (Fq*P) for SONGS-1 cycle 11 will be maintained below 2.38 provided the axial offset limit equations in Technical Specification 3.11 are changed to the following:

For Positive Offsets: $$IAO = \frac{2.595/P - 2.10}{0.033} - FCC$$

For Negative Offsets: $$IAO = \frac{2.595/P - 2.10}{-0.033} - FCC$$

The above equations result in an allowable axial offset window of +/- 15% at 100% full power, which is a 5.6% reduction on both sides of the window. The incore/excore correlation uncertainty (FCC) is not included in the calculation of the +/- 15%, such that the actual axial offset allowed at the plant will be more on the order of +/- 12% at 100% power, or +/- 19% at 92% power. It is recommended that during cycle 11, SCE limits axial offset to the above values either by a Technical Specification revision or by administrative control, in order to assure that the limits of the IAC are met.