Southern California Edison Company

SAN ONOFRE NUCLEAR GENERATING STATION

P. O. BOX 128

SAN CLEMENTE, CALIFORNIA 92674-0128

R. W. KRIEGER
STATION MANAGER

TELEPHONE
(714) 368-6255

March 18, 1991

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

Subject: Docket No. 50-206
30-Day Report
Licensee Event Report No. 91-004
San Onofre Nuclear Generating Station, Unit 1

Pursuant to 10 CFR 50.73(d), this submittal provides the required 30-day written Licensee Event Report (LER) for the identification of a calculational error affecting the time interval for initiation of hot leg recirculation. Neither the health nor the safety of plant personnel or the public was affected by this occurrence.

If you require any additional information, please so advise.

Sincerely,

RWKrieger

Enclosure: LER No. 91-004

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)

IE22
1/1

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 0 8

Title (4)

Calculational Error Affecting the Time Interval for Initiation of Hot Leg Recirculation

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)
0 2	1 4	9 1	9 1	---	0 0 4	---	0 0	0 3	1 8	9 1	NONE	0 5 0 0 0
												0 5 0 0 0

OPERATING MODE (9): 5

POWER LEVEL (10): 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10CFR (Check one or more of the following) (11)

___	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	MANUFAC-TURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFAC-TURER	REPORTABLE TO NPRDS

SUPPLEMENTAL REPORT EXPECTED (14)

___ Yes (If yes, complete EXPECTED SUBMISSION DATE) X NO

Expected Submission Date (15): Month | Day | Year

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

On February 14, 1991, with Unit 1 in Mode 5, SCE's Design Basis Documentation (DBD) program determined that the calculated post-Loss of Coolant Accident (LOCA) time to initiation of hot leg recirculation (HLR) was non-conservative. HLR is utilized to prevent boron precipitation in the core during long term cooling following certain LOCAs. Under conservative calculational assumptions (e.g., RCS temperature is assumed to be 212°F, the temperature at which the boron precipitation design limit is based) following a large cold leg break LOCA, precipitation of boric acid is predicted to occur in the reactor vessel prior to HLR being established in accordance with Emergency Operating Instructions (EOIs).

The time to initiation of HLR was established based upon calculations performed from 1976 to 1978. These calculations contained errors and assumptions which resulted in a non-conservative time to HLR initiation in the EOIs. However, this event is of no safety significance since under more realistic post-accident conditions, HLR would have been established prior to a degradation in core cooling due to boron precipitation. Given the length of time since the original calculations were performed, SCE has been unable to definitively determine the cause of the errors.

A complete revision to the calculations was performed, and EOIs have been revised to align HLR at a time consistent with corrected design assumptions. Since the original calculations were performed, additional administrative controls have been implemented to ensure that newly issued design calculations are subject to a rigorous and questioning review to identify errors such as those described above. In addition, the review of original design documentation such as that found to be in error here will continue within the DBD program.

Plant: San Onofre Nuclear Generating Station
Unit: One
Reactor Vendor: Westinghouse
Event Date: 02-14-91

B. BACKGROUND INFORMATION:

Safety Injection System

The Safety Injection System (SIS) [BQ] delivers borated coolant to the Reactor Coolant System (RCS) [AB] and therefore, assists in providing reactivity control and heat removal following certain design basis accidents. After a loss of coolant accident (LOCA), the SIS injects borated water from the Refueling Water Storage Tank (RWST) [T] through the SIS header and into the three RCS loops via separate SIS lines.

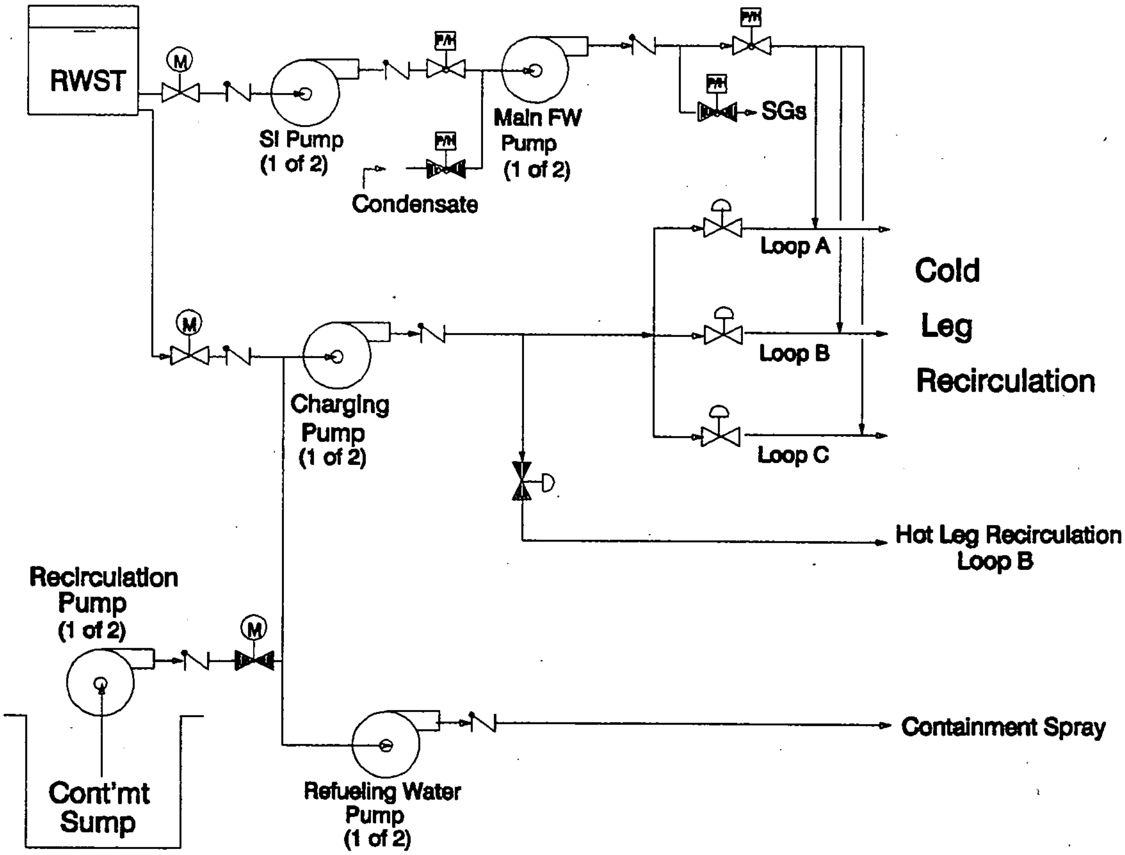

Figure - SIS During Injection Phase

When the RWST level is below 20%, core cooling is transferred from the SIS to the Recirculation System (RS) [BP] which provides long term core cooling using borated water which has accumulated in the containment sump. Two containment sump recirculation pumps discharge to a common header, through the Recirculation Heat Exchanger, to the suction of the charging pumps [CB,P] for recirculation to the RCS and to the suction of the refueling water pumps for recirculation to the containment spray system. Recirculation of the RCS post-LOCA is by means of Cold Leg Recirculation (CLR) and/or Hot Leg Recirculation (HLR) as described below.

The post-LOCA boron sources to the containment sump water consist of the contents of the RCS, the RWST, and potentially the Boric Acid Storage Tank (BAST)[CB].

Hot Leg Break LOCA

CLR flow is provided from the containment sump by means of a charging pump to the three RCS cold legs via three cold leg flow control valves. After the core has been re-flooded following a postulated LOCA in one of the RCS hot legs, the CLR flow path delivers borated water to the reactor downcomer, up through the core and out the ruptured hot leg. The recirculation flow through the core and out through the hot leg prevents concentration and any potential precipitation of boron in the core.

Cold Leg Break LOCA

For a postulated LOCA in one of the RCS cold legs, the CLR flow path results in borated water preferentially flowing around the reactor downcomer and out the ruptured cold leg with little or no flow through the core. A lack of mixing of the fresh injection water and the water in the core could result in the accumulation of boric acid in the core region until saturation concentrations are reached and boric acid begins to precipitate out of solution. HLR flow mitigates the concentration of boric acid in the reactor vessel during a postulated RCS cold leg break by providing a flow path through the core from top to bottom, and then out the cold leg break. HLR, in conjunction with CLR, is utilized to prevent boron precipitation in the core during long term cooling following a cold leg LOCA.

Basis

The time for initiation of HLR is a calculated value which considers the time it takes for the boiling coolant in the core region to reach a limiting concentration of 23.53 wt% boron post-LOCA. The limiting boron concentration of 23.53 wt% was chosen by the NRC staff and offers a margin of at least 4 wt% to the solubility limit of boron at 212°F. The actual solubility limit at 212°F is 27.5 wt% boron and increases with temperature to 42.5 wt% at 260°F.

Technical Specification (TS) 3.3.3., "Minimum Boron Concentration In The Refueling Water Storage Tank (RWST) and Safety Injection (SI) Lines and Minimum RWST Water Volume" specifies a boron concentration of not less than 3750 ppm and not greater than 4300 ppm. TS 3.2, "Chemical And Volume Control System" specifies that the BAST contains a solution of at least 3450 pounds of boric acid in not less than 3500 gallons of water.

RCS Reflux Condensate Cooling

As the secondary heat sink is established via the steam generators following a LOCA, steam generated in the core flows through the steam generator tubes and is condensed. The condensation process reduces the core pressure due to the change in the volumetric balance between vapor production and the liquid flow out the break to containment. If this condensation process is efficient, all of the steam produced in the core could be condensed and the RCS pressure would approach that of the containment atmosphere. This condensate is called reflux flow and is affected by the conditions in the steam generator secondary side and by the presence of noncondensible gases in the RCS.

Reflux fluid from the condensation process would flow back into the steam generator inlet plenum, hot legs, and reactor vessel. The condensate flow direction would be opposed to the steam flow direction. Calculations have been performed assuming the reflux condensation mechanism was suddenly established 10 hours after the accident. The results indicate that the time to reach the 23.5 wt% boron limits may be extended indefinitely provided that reflux flow rates remain above 2 lbm/second per steam generator.

C. DESCRIPTION OF THE EVENT:

1. Event:

On February 14, 1991, with Unit 1 in Mode 5, SCE's Design Basis Documentation (DBD) program determined that the calculated post-LOCA time to initiation of HLR was non-conservative. This time was established based upon calculations performed from 1976 to 1978, which were determined to contain non-conservate assumptions and errors which were carried forward in subsequent calculations, as follows:

a. An incorrect ppm to wt% boron conversion factor.

b. Inclusion of stagnant water volumes not in direct communication with core water in the establishment of reactor vessel water volume.

c. The original model assumed sensible heat was negligible. It has now been determined that this heat source should be accounted for in the HLR calculation.

d. The original calculation limited its scope to the concentration of boron in the core region. It was subsequently determined that a large volume of evaporated water would accumulate in the atmosphere of containment, thereby increasing the boron concentration in the containment sumps. This has the effect of increasing the initial boron concentration in the core region when CLR is initiated. This was factored into the revised model for boron accumulation.

e. The contents of the BAST were not assumed to be introduced into the RCS post-LOCA. The BAST is not credited for use post-LOCA and therefore was not expected to contribute to the boron concentration in the containment sump. However, subsequent investigation revealed a path might be established due to equipment failure. This was incorporated into the revised model.

In 1989, the time to initiate HLR was utilized as part of a study of reflux condensation utilizing input parameters from the original HLR calculations. It was identified at that time that the original calculation had assumed the minimum concentration of boron in the RWST existed at the time of the LOCA, rather than the maximum (4300 ppm) permitted by the TS. Utilizing the new inputs, it was determined that HLR was required to be initiated at or before 15.5 hours post-LOCA using an acceptance criteria of 23.53 wt% boron. Based on these analyses, the EOIs were revised to direct the operators to transfer to HLR at 8 hour post-LOCA. This period of time allowed a 2-hour margin to establish reflux condensation flow (as discussed above in Part B, analyses demonstrated that if reflux condensation was established 10 hours post-LOCA at a reflux flow rate above 2 lbm/second per steam generator, no reliance on HLR was necessary). The additional 5.5 hours was assigned as margin. The scope of the 1989 evaluation only included utilizing the original calculation for determination of the required HLR flow and reflux condensation effect and was not intended to validate existing assumptions.

In February 1991, a complete calculation revision, which does not credit reflux condensation and utilizes the more conservative assumptions, identified that HLR should be established at 4-hours post-LOCA. Under the conservative calculational assumptions (e.g., RCS temperature is assumed to be 212°F, the temperature at which the boron precipitation design limit is based) following a large cold leg break LOCA, precipitation of boric acid is predicted to occur in the reactor vessel prior to HLR being established in accordance with Emergency Operating Instructions (EOIs).

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

Not applicable.

3. Sequence of Events:

DATE	ACTION
1976-1978	SCE design calculations performed, including "Boron Concentration versus time for SONGS 1"
1989	Calculations were performed as part of a study of reflux condensation. Westinghouse calculated the effect of reflux condensation and SCE calculated the minimum HLR flow rate required to terminate boron accumulation. The calculation also incorporated the maximum RWST boron concentration (4300 ppm) instead of the minimum (3750 ppm) which was used in the 1977 calculation.
11/90	Design basis documentation review performed on the recirculation and containment spray system. Discrepancies identified.
2/14/91	Calculational discrepancies confirmed by design bases reconstitution (new and revised calculations).

4. Method of Discovery:

See Section C.1.

5. Personnel Actions and Analysis of Actions:

Not applicable.

6. Safety System Responses:

Not applicable.

D. CAUSE OF THE EVENT:

SCE has been unable to definitively determine the cause of the errors and non-conservative methodology employed in the original HLR calculations, due to the length of time since the calculations were performed.

With respect to the BAST, its contents were not assumed in the original analysis to be introduced into the RCS following a LOCA and were thus not factored into the HLR calculation. While the contents of the BAST are neither automatically nor procedurally introduced into the RCS following a LOCA, we have conservatively accounted for this contribution if, for example, an outlet valve were to spuriously fail open. If this were to occur, the BAST contents would be delivered to the RCS via the charging pumps.

E. CORRECTIVE ACTIONS:

1. Corrective Actions Taken:

a. A complete revision to the calculation was performed as a part of the DBD program. This revision revalidated all assumptions in order to identify and correct errors associated with the allowable time to initiation of HLR.

b. Emergency Operating Instructions have been revised to initiate HLR alignment 2-hours post-LOCA. This provides adequate assurance that one of the two methods (primary or alternate) for establishing HLR will be completed within the 4-hour post-LOCA time limit, thus satisfying present design requirements.

c. The design review process has been substantially improved since the original calculations were performed. New procedures have strengthened the process to prevent errors such as those discussed herein. These improvements, together with the DBD program, ensure that design basis documentation such as calculations and analyses, are reviewed such that similar errors will be identified. These programs are ongoing.

F. SAFETY SIGNIFICANCE OF THE EVENT:

This event is determined to have no safety significance since, under realistic RCS post-LOCA conditions, a degradation in core cooling due to boron precipitation would not be expected to occur even if HLR was initiated as long as 19 hours post-LOCA, as previously specified in the EOIs. This is based upon the following:

The time to initiate HLR is based upon a reactor vessel water temperature of 212°F, with a corresponding boron solubility limit of 23.5 wt%. However, during the initial 24-hour post-LOCA period, containment pressure is expected to remain above 20 psig with a corresponding saturation temperature, and hence coolant temperature, of 260°F (this value is based upon more realistic containment conditions post accident and includes, for example, ambient heat losses and containment cooling processes which are expected to be available). The solubility limit of boric acid solutions at 260°F is 42.5 wt%. Boron precipitation is therefore not anticipated at concentrations below 42.5 wt%.

The design basis calculation contains assumptions substantially more conservative than actual conditions (e.g., Core power is currently restricted to 92%, rather than the 102% assumed in the calculations; Equipment failures are assumed to occur, emptying the entire contents of the BAST into the RCS; Maximum BAST and RWST boron concentrations are assumed to exist). An evaluation was performed in which operating conditions more realistic than those upon which the calculation is based were assumed. Specifically; 1) if a BAST outlet valve were to fail open, it is assumed that this would be recognized and isolated within one hour, 2) reactor power is assumed to be at the administrative limit of 92%, 3) nominal, rather than maximum, boron concentrations are assumed for the RWST and the BAST.

The resulting boric acid concentration at 20 hours post-LOCA under these realistic conditions was determined to be 42.4 wt%, which does not exceed the solubility limit of 42.5 wt% at the anticipated coolant temperature of 260°F. This result indicates that boric acid accumulation in the reactor vessel would not have reached the solubility limit prior to the times previously specified in the EOIs for HLR initiation.

G. ADDITIONAL INFORMATION:

1. Component Failure Information:

Not applicable.

2. Previous LERs for Similar Events:

LER 91-002 (Docket No. 50-206) identified a calculation error affecting the design performance of the system for controlling pH of containment sump water following a LOCA. This was another calculational error (from 1975) which was identified as part of the DBD effort, and corrective actions could not have precluded this event.