March 29, 1983

Docket No. 50-206
LS05-83-03-044

Mr. R. Dietch, Vice President
Nuclear Engineering and Operations
Southern California Edison Company
2244 Walnut Grove Avenue
Post Office Box 800
Rosemead, California 91770

Dear Mr. Dietch:

SUBJECT: SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1
SEP TOPIC XV-10, CHEMICAL AND VOLUME CONTROL SYSTEM MALFUNCTION THAT RESULTS IN A DECREASE IN BORON CONCENTRATION IN THE REACTOR COOLANT

By letter dated April 20, 1982, the staff issued a safety evaluation on the above topic. Your letter of March 17, 1983, provided editorial corrections. Enclosed is the final safety evaluation report.

The enclosed safety evaluation will be a basic input to the integrated safety assessment for your facility. The assessment may be revised in the future if your facility design is changed or if NRC criteria relating to this tppic are modified before the integrated assessment is completed.

Sincerely,

Original signed by:

Walter A. Paulson, Project Manager
Operating Reactors Branch No. 5
Division of Licensing

SE04

DSU USE (08)

ADD:
G. Staley

Enclosure:
As stated

cc w/enclosure:
See next page

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Mr. R. Dietch, Vice President
Nuclear Engineering and Operations
Southern California Edison Company
2244 Walnut Grove Avenue
Post Office Box 800
Rosemead, California 91770

Docket No. 50-206
San Onofre 1

cc
Charles R. Kocher, Assistant General Counsel
James Beoletto, Esquire
Southern California Edison Company
Post Office Box 800
Rosemead, California 91770

David R. Pigott
Orrick, Herrington & Sutcliffe
600 Montgomery Street
San Francisco, California 94111

Harry B. Stoehr
San Diego Gas & Electric Company
Post Office Box 1831
San Diego, California 92112

Resident Inspector/ San Onofre NPS
c/o U.S. Nuclear Regulatory Commission
Post Office Box 4329
San Clemente, California 92672

Mayor
City of San Clemente
San Clemente, California 92672

Chairman
Board of Supervisors
County of San Diego
San Diego, California 92101

California Department of Health
ATTN: Chief, Environmental Radiation
Control Unit
Radiological Health Section
714 P Street, Room 498
Sacramento, California 95814

U.S. Environmental Protection Agency
Region IX Office
ATTN: Regional Radiation Representative
215 Freemont Street
San Francisco, California 94111

Robert H. Engelken, Regional Administrator
U.S. Nuclear Regulatory Commission, Region V
1450 Maria Lane
Walnut Creek, California 94596

SYSTEMATIC EVALUATION PROGRAM

TOPIC XV-10

SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1

TOPIC: XV-10, Chemical and Volume Control System Malfunction That Results in a Decrease in Boron Concentration in the Reactor Coolant

I. INTRODUCTION

Inadvertent boron dilution adds positive reactivity to the core and produces temperature and power increases that may cause an approach to both the DNBR and the fuel centerline to melt (CTM) limits. Improper boron dilution via the Chemical and Volume Control System can be initiated by operator actions accompanied by a single equipment failure.

The piping arrangement at San Onofre Unit 1 is such that there are two possible sources of unborated water which could be injected into the primary system. These two sources are the Chemical and Volume Control System (CVCS), and the Feedwater and Condensate System (FCS). In order to inject water from the FCS, it is required that at least two valve failures on the same source line be assumed. This situation is not considered credible and, therefore, this evaluation will only be concerned with the CVCS.

The Boron Dilution Events were first analyzed in the FSAR (Reference 1), then reanalyzed in Reference 2.

II. REVIEW CRITERIA

Section 50.34 of 10 CFR Part 50 requires that each applicant for a construction permit or operating license provide an analysis and evaluation of the design and performance of structures, systems and components of the facility with the objective of assessing the risk to public health and safety resulting from operation of the facility, including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility.

Section 50.36 of 10 CFR Part 50 requires the Technical Specifications to include safety limits which protect the integrity of the physical barriers which guard against the uncontrolled release of radioactivity.

The General Design Criteria (Appendix A to 10 CFR Part 50) establish minimum requirements for the principal design criteria for water-cooled reactors.

GDC 10 "Reactor Design" requires that the core and associated coolant control and protection systems be designed with appropriate margin to assure that specified acceptable fuel design limits are not exceeded during normal operation, including the effects of anticipated operational occurrences.

GDC 15 "Reactor Coolant System Design" requires that the reactor coolant and associated protection systems be designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during normal operation, including the effects of anticipated operational occurrences.

GDC 26 "Reactivity Control System Redundancy and Capability" requires that the reactivity control systems be capable of reliably controlling reactivity changes to assure that under conditions of normal operation, including anticipated operational occurrences, and with appropriate margin for malfunctions such as stuck rods, specified acceptable fuel design limits are not exceeded.

III. RELATED SAFETY TOPICS

Various other SEP topics evaluate such items as the reactor protection system. The effects of single failures on safe shutdown capability are considered under Topic VII-3.

IV. REVIEW GUIDELINES

The review is conducted in accordance with SRP Section 15.4.6.

The evaluation includes review of the analysis for the event and identification of the features in the plant that mitigate the consequences of the event as well as the ability of these systems to function as required. The extent to which operator action is required is also evaluated. Deviations from the criteria specified in the Standard Review Plan are identified.

V. EVALUATION

Demineralized water is provided to the CVCS from the Primary Plant Make-Up Tank (PPMUT). The operation of the Primary Plant Make-Up pumps, which take suction from this tank, provides the only supply of demineralized water to the CVCS and then ultimately to the RCS. In order for demineralized water to be added to the RCS during operation at pressure, either a charging pump (or pumps) or the test pump must be running in addition to the primary plant make-up pump (or pumps). (The shutoff head of the make-up pump is 125 psi and cannot deliver water directly to the RCS when the RCS pressure is greater than 125 psi.) The principal charging line to the RCS is through the Regenerative Heat Exchanger through control valve FCV-1112. The charging flow enters the RCS in the cold leg of loop A. During operation, water is also injected into the reactor coolant pump seals through each of the injection lines to the individual pumps. A portion of the seal water injection flow also mixes with the reactor coolant flow. The post accident recirculation lines branch off of the pump seal injection lines and are piped into each of the safety injection lines. The motor operated valves on these recirculation lines are normally closed and are used only for the recirculation function following a loss of coolant. The above points are the only paths whereby demineralized water can be introduced into the RCS.

The rate of addition of unborated make-up water to the RCS is limited to the capacity of the charging pumps or the test pump during normal plant operation. The charging pumps are capable of delivering 125 gpm through the charging line when the plant is fully pressurized. During low pressure conditions in the RCS, when higher flows are possible through the charging line, the limiting make-up is determined by the make-up water pump characteristic and the resistance of the dilution flow path from the make-up pumps. In the very conservative case where these pumps deliver directly to the charging pump suction with all valves wide open and the RCS at atmospheric pressure, the limiting addition rate is less than 225 gpm for both make-up pumps and 195 gpm for a single pump. During refueling, with the charging pumps out of service, the maximum flow possible through the charging line from both make-up pumps is approximately 70 gpm assuming no-flow resistance through the charging pump.

The indications available to the operator during a boron dilution event and the time available to take corrective actions differ for various plant conditions as described below.

Refueling

During refueling, continuous mixing flow will be maintained through the reactor vessel by utilizing an RHR pump. The RHR flow enters through the cold leg on loop A, flows up through the core and out through the hot leg connection on loop C. The charging pumps are lined up for addition of concentrated boric acid water. Any change in the RCS boric acid concentration at this time would be made only through adjustments of the boric acid concentration in the charging line.

The boron concentration (2500 ppm) in the refueling water is periodically sampled during refueling operations. This concentration is sufficient with the control rods to maintain the reactor approximately 10% shutdown. During this period, detectors with audible count rates provide direct monitoring of the core.

During this mode, the operator would be alerted to a dilution event by the following:

1. increase in the audible count rate from the ex-core detectors,

2. alarm from both primary plant make-up pumps operating (if both were operating),

3. indication of a charging pump operating (if it were),

4. flow indication on FI-1112 on the charging line,

5. flow indication on FR-1102 if the dilution path were through line 2052-2"-HN1,

6. alarm and flow indication from FIT-1102A if dilution were through 716-2"-151N

7. alarm on boric acid addition 5% below setpoint if dilution were through the chemical blend device and no boric acid were being added; and

8. volume control tank high level alarm if dilution were through line 2036-3"-151R and a charging pump were not running.

In addition, in order to dilute to a critical condition, more than 9400 gallons of demineralized water would need to be added to the RCS. The licensee stated that this increase in RCS inventory would surely be detected by the operator, and that under the most extreme conditions, the operator would have more than 40 minutes to take action from the time of the first audible alarm indicating a boron dilution event. The staff finds this acceptable.

Cold Shutdown

The plant conditions for cold shutdown are similar to Refueling except that:

1. RCS volume is greater (5849 ft^3 or 43,477 gallons),

2. lower boron concentration (1240 vs. 2500 ppm); and

3. most reactive control rod assumed to be stuck in the full out position.

Alarms and indications are similar to the refueling mode.

The licensee stated that under the most extreme conditions, the operator would have more than 75 minutes to take action from the time the dilution started at which time he would receive the first audible alarms (pump start). The staff finds this acceptable.

Hot Shutdown

The plant conditions assumed for this analysis are:

1. Beginning of life (BOL)

2. all rods in (ARI), except most reactive rod in full out position

3. $K_{eff} = 0.97$

Alarms and indications for the operator are similar to those given in the discussion of Refueling.

The licensee stated that under the most extreme conditions, the operator would have more than 33 minutes to take action from the time of the first audible alarm indicating a boron dilution event. The staff finds this acceptable.

Hot Standby

The plant conditions assumed are:

1. BOL

2. all rods out (ARO)

3. hot zero power (HZP)

4. $K_{eff} = 0.99$

Alarms and indications for the operator are similar to those given in the discussion of Refueling except for numbers 1 and 8. In this condition, there would be no audible count rate and a charging pump would be running with suction aligned to the volume control tank.

The licensee stated that under the most extreme condition, the operator would have more than 15 minutes to take action before the reactor reaches criticality. The reactor could be made subcritical by borating the RCS as described above or by a reactor scram on:

1. high power (25%)(automatic)

2. variable low pressure (automatic)

3. high pressure (automatic)

4. manual (operator action)

Following the scram, the operator would have an additional 33 minutes before the reactor would return to critical (or a total of more than 49 minutes). Therefore, this operating condition is less severe than the hot shutdown boron dilution event. The staff finds this acceptable.

Full Power

The plant conditions assumed for this analysis are:

1. BOL

2. ARO

3. Equilibrium Xenon

Under normal operating conditions, the reactor control system is in automatic. The control rods would be automatically adjusted to maintain a constant Tave. Since the Reactor Control System can decrease reactivity faster than dilution can add reactivity, the reactor would remain at 100% power. The operator would be alerted to the dilution event by:

1. high power alarm 106%,

2. both charging pumps operating,

3. both primary pumps operating,

4. rod insert (in automatic),

5. same demineralized water flow indications and alarms as in Refueling,

6. increasing RCS pressure (in manual); and

7. increasing RCS level or letdown flow.

With the reactor control system in manual and under the most limiting initial conditions, the reactor would scram on high power (109%) approximately 3.5 minutes after the dilution commences. An additional 33 minutes or more of uncontrolled dilution would be required to return to criticality. Therefore, assuming reactor scram to be the first alarm, the licensee stated that there would be 33 minutes for operator action in the worst case. The staff finds this acceptable.

VI. CONCLUSION

As part of the SEP review for San Onofre Unit 1, the analyses for a chemical and volume control system malfunction that results in a descrease in boron concentration in the reactor coolant have been evaluated. We have concluded that all of the consequences of this event are in conformance with the criteria of SRP Section 15.4.6 and, therefore, are acceptable.

VII. REFERENCES

1. San Onofre Nuclear Generating Station, Unit 1, Final Safety Analysis Report; Southern California Edison Company, San Diego Gas and Electric Company, Part II, Volume III, Section 2.6.

2. Southern California Edison Company letter to NRC; SEP Topic XV-10 and XV-15 and (additional information); February 8, 1982.

3. Southern California Edison Company letter to NRC; SEP Topic XV-10; March 17, 1983.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

March 29, 1983

Docket No. 50-206
LS05-83-03-044

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Nuclear Engineering and Operations
Southern California Edison Company
2244 Walnut Grove Avenue
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Sincerely,

Walter A. Paulson

Walter A. Paulson, Project Manager
Operating Reactors Branch No. 5
Division of Licensing

Enclosure:
As stated

cc w/enclosure:
See next page

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Mr. R. Dietch, Vice President
Nuclear Engineering and Operations
Southern California Edison Company
2244 Walnut Grove Avenue
Post Office Box 800
Rosemead, California 91770

Docket No. 50-206
San Onofre 1

cc
Charles R. Kocher, Assistant General Counsel
James Beoletto, Esquire
Southern California Edison Company
Post Office Box 800
Rosemead, California 91770

David R. Pigott
Orrick, Herrington & Sutcliffe
600 Montgomery Street
San Francisco, California 94111

Harry B. Stoehr
San Diego Gas & Electric Company
Post Office Box 1831
San Diego, California 92112

Resident Inspector/ San Onofre NPS
c/o U.S. Nuclear Regulatory Commission
Post Office Box 4329
San Clemente, California 92672

Mayor
City of San Clemente
San Clemente, California 92672

Chairman
Board of Supervisors
County of San Diego
San Diego, California 92101

California Department of Health
ATTN: Chief, Environmental Radiation
Control Unit
Radiological Health Section
714 P Street, Room 498
Sacramento, California 95814

U.S. Environmental Protection Agency
Region IX Office
ATTN: Regional Radiation Representative
215 Freemont Street
San Francisco, California 94111

Robert H. Engelken, Regional Administrator
U.S. Nuclear Regulatory Commission, Region V
1450 Maria Lane
Walnut Creek, California 94596

SYSTEMATIC EVALUATION PROGRAM

TOPIC XV-10

SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 1

TOPIC: XV-10, Chemical and Volume Control System Malfunction That Results in a Decrease in Boron Concentration in the Reactor Coolant

I. INTRODUCTION

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Various other SEP topics evaluate such items as the reactor protection system. The effects of single failures on safe shutdown capability are considered under Topic VII-3.

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The review is conducted in accordance with SRP Section 15.4.6.

The evaluation includes review of the analysis for the event and identification of the features in the plant that mitigate the consequences of the event as well as the ability of these systems to function as required. The extent to which operator action is required is also evaluated. Deviations from the criteria specified in the Standard Review Plan are identified.

V. EVALUATION

Demineralized water is provided to the CVCS from the Primary Plant Make-Up Tank (PPMUT). The operation of the Primary Plant Make-Up pumps, which take suction from this tank, provides the only supply of demineralized water to the CVCS and then ultimately to the RCS. In order for demineralized water to be added to the RCS during operation at pressure, either a charging pump (or pumps) or the test pump must be running in addition to the primary plant make-up pump (or pumps). (The shutoff head of the make-up pump is 125 psi and cannot deliver water directly to the RCS when the RCS pressure is greater than 125 psi.) The principal charging line to the RCS is through the Regenerative Heat Exchanger through control valve FCV-1112. The charging flow enters the RCS in the cold leg of loop A. During operation, water is also injected into the reactor coolant pump seals through each of the injection lines to the individual pumps. A portion of the seal water injection flow also mixes with the reactor coolant flow. The post accident recirculation lines branch off of the pump seal injection lines and are piped into each of the safety injection lines. The motor operated valves on these recirculation lines are normally closed and are used only for the recirculation function following a loss of coolant. The above points are the only paths whereby demineralized water can be introduced into the RCS.

The rate of addition of unborated make-up water to the RCS is limited to the capacity of the charging pumps or the test pump during normal plant operation. The charging pumps are capable of delivering 125 gpm through the charging line when the plant is fully pressurized. During low pressure conditions in the RCS, when higher flows are possible through the charging line, the limiting make-up is determined by the make-up water pump characteristic and the resistance of the dilution flow path from the make-up pumps. In the very conservative case where these pumps deliver directly to the charging pump suction with all valves wide open and the RCS at atmospheric pressure, the limiting addition rate is less than 225 gpm for both make-up pumps and 195 gpm for a single pump. During refueling, with the charging pumps out of service, the maximum flow possible through the charging line from both make-up pumps is approximately 70 gpm assuming no-flow resistance through the charging pump.

The indications available to the operator during a boron dilution event and the time available to take corrective actions differ for various plant conditions as described below.

Refueling

During refueling, continuous mixing flow will be maintained through the reactor vessel by utilizing an RHR pump. The RHR flow enters through the cold leg on loop A, flows up through the core and out through the hot leg connection on loop C. The charging pumps are lined up for addition of concentrated boric acid water. Any change in the RCS boric acid concentration at this time would be made only through adjustments of the boric acid concentration in the charging line.

The boron concentration (2500 ppm) in the refueling water is periodically sampled during refueling operations. This concentration is sufficient with the control rods to maintain the reactor approximately 10% shutdown. During this period, detectors with audible count rates provide direct monitoring of the core.

During this mode, the operator would be alerted to a dilution event by the following:

1. increase in the audible count rate from the ex-core detectors,

2. alarm from both primary plant make-up pumps operating (if both were operating),

3. indication of a charging pump operating (if it were),

4. flow indication on FI-1112 on the charging line,

5. flow indication on FR-1102 if the dilution path were through line 2052-2"-HN1,

6. alarm and flow indication from FIT-1102A if dilution were through 716-2"-151N

7. alarm on boric acid addition 5% below setpoint if dilution were through the chemical blend device and no boric acid were being added; and

8. volume control tank high level alarm if dilution were through line 2036-3"-151R and a charging pump were not running.

In addition, in order to dilute to a critical condition, more than 9400 gallons of demineralized water would need to be added to the RCS. The licensee stated that this increase in RCS inventory would surely be detected by the operator, and that under the most extreme conditions, the operator would have more than 40 minutes to take action from the time of the first audible alarm indicating a boron dilution event. The staff finds this acceptable.

Cold Shutdown

The plant conditions for cold shutdown are similar to Refueling except that:

1. RCS volume is greater (5849 ft^3 or 43,477 gallons),
2. lower boron concentration (1240 vs. 2500 ppm); and
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The licensee stated that under the most extreme conditions, the operator would have more than 75 minutes to take action from the time the dilution started at which time he would receive the first audible alarms (pump start). The staff finds this acceptable.

Hot Shutdown

The plant conditions assumed for this analysis are:

1. Beginning of life (BOL)
2. all rods in (ARI), except most reactive rod in full out position
3. $K_{eff} = 0.97$

Alarms and indications for the operator are similar to those given in the discussion of Refueling.

The licensee stated that under the most extreme conditions, the operator would have more than 33 minutes to take action from the time of the first audible alarm indicating a boron dilution event. The staff finds this acceptable.

Hot Standby

The plant conditions assumed are:

1. BOL

2. all rods out (ARO)

3. hot zero power (HZP)

4. $K_{eff} = 0.99$

Alarms and indications for the operator are similar to those given in the discussion of Refueling except for numbers 1 and 8. In this condition, there would be no audible count rate and a charging pump would be running with suction aligned to the volume control tank.

The licensee stated that under the most extreme condition, the operator would have more than 15 minutes to take action before the reactor reaches criticality. The reactor could be made subcritical by borating the RCS as described above or by a reactor scram on:

1. high power (25%)(automatic)

2. variable low pressure (automatic)

3. high pressure (automatic)

4. manual (operator action)

Following the scram, the operator would have an additional 33 minutes before the reactor would return to critical (or a total of more than 49 minutes). Therefore, this operating condition is less severe than the hot shutdown boron dilution event. The staff finds this acceptable.

Full Power

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1. BOL

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3. Equilibrium Xenon

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1. high power alarm 106%,
2. both charging pumps operating,
3. both primary pumps operating,
4. rod insert (in automatic),
5. same demineralized water flow indications and alarms as in Refueling,
6. increasing RCS pressure (in manual); and
7. increasing RCS level or letdown flow.

With the reactor control system in manual and under the most limiting initial conditions, the reactor would scram on high power (109%) approximately 3.5 minutes after the dilution commences. An additional 33 minutes or more of uncontrolled dilution would be required to return to criticality. Therefore, assuming reactor scram to be the first alarm, the licensee stated that there would be 33 minutes for operator action in the worst case. The staff finds this acceptable.

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