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AUTH.NAME AUTHOR AFFILIATION
BASKIN,K.P. Southern California Edison Co.
RECIP.NAME RECIPIENT AFFILIATION
KERRIGAN,J.D. Licensing Branch 3

SUBJECT: Forwards info re natural recirculation test program & supporting analyses required in Branch Technical Position RSB 5-1 per NUREG-0737,Item 1.G.1, "Special Low Power Testing & Training."

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Southern California Edison Company

P. O. BOX 800
2244 WALNUT GROVE AVENUE
ROSEMEAD, CALIFORNIA 91770

September 16, 1982

K. P. BASKIN
MANAGER OF NUCLEAR ENGINEERING,
SAFETY, AND LICENSING

TELEPHONE
(213) 572-1401

Director, Office of Nuclear Reactor Regulation
Attention: Ms. Janis D. Kerrigan, Branch Chief
Licensing Branch No. 3
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

Subject: Docket No. 50-361
San Onofre Nuclear Generating Station
Unit 2

Consistent with the requirements of Item I.G.1 of NUREG-0737, "Special Low Power Testing and Training," SCE submitted a Natural Circulation Test Program to the NRC on April 15, 1982. SCE met with the NRC in Bethesda, Maryland on May 20, 1982 to discuss the April 15, 1982 submittal. The NRC subsequently approved the low power portion (less than 5% power) of the Natural Circulation Test Program and requested SCE to provide a comparison of the 20% and 80% power level Natural Circulation Tests (high power portion) with the recommendations of NRC Branch Technical Position (BTP) RSB 5-1, "Design Requirements of the Residual Heat Removal System."

SCE met with the NRC on September 8, 1982 at the San Onofre Site and provided the NRC a comparison of the Natural Circulation Test Program for San Onofre Unit 2 with the recommendations of BTP RSB 5-1. During the meeting, SCE stressed that the Natural Circulation Test Program for San Onofre Unit 2 (both the low power portion and high power portions) along with supporting analyses adequately address the recommendations of BTP RSB 5-1. Enclosure 1 contains the information presented to the NRC staff during the September 8, 1982 meeting.

In order to support the power ascension testing schedule for San Onofre Unit 2, both the NRC staff and SCE agreed during the meeting to support the following schedule:

1. Formal transmittal of SCE's position during the week of September 13, 1982 (Enclosure 1 of this letter).

2. Formal NRC response to the SCE position during the week of September 27, 1982. (NRC provided a preliminary response during the September 8, 1982 meeting.)

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3. Meet during the mid-October 1982 time frame to provide additional clarification/information requested by the staff.

Based on the preliminary response provided by the staff, which is to be confirmed by the forthcoming formal staff response, SCE is preparing to provide the NRC with the information/clarification which will confirm the adequacy of the existing Natural Circulation Test Program for San Onofre Unit 2 relative to the recommendations of BTP RSB 5-1.

If you have any questions or comments, please let me know.

Very truly yours,

K P Baskin

Enclosures

NATURAL CIRCULATION TEST PROGRAM
SAN ONOFRE NUCLEAR GENERATING STATION, UNIT 2

Consistent with the requirements of Item I.G.1 of NUREG-0737, "Special Low Power Testing and Training," SCE submitted a Natural Circulation Test Program to the NRC on April 15, 1982, which included both the low power (less than 5% power) and high power (20% and 80% power) portions of the test program.

SCE met with the NRC on May 20, 1982 to assist the NRC with the review of the test program. The NRC subsequently approved the low power portion of the Natural Circulation Test Program. The NRC requested that SCE provide a comparison of the high power portion of the test program with Branch Technical Position (BTP) RSB 5-1, "Design Requirements of the Residual Heat Removal System", and provided SCE with a position paper describing the NRC's request for testing as transmitted to other licensees (Enclosure A). This has never been formally transmitted as a request to SCE.

Enclosure A states that system(s) which can be used to take the reactor from normal operating conditions to cold shutdown shall satisfy the following four functional requirements:

1. The design shall be such that the reactor can be taken from normal operating conditions to cold shutdown using only safety-grade systems. These systems shall satisfy General Design Criteria 1 through 5.

2. The system(s) shall have suitable redundancy in components and features, and suitable interconnections, leak detection, and isolation capabilities to assure that for onsite electrical power system operation (assuming offsite power is not available) and for offsite electrical power system operation (assuming onsite power is not available) the system function can be accomplished assuming a single failure.

3. The system(s) shall be capable of being operated from the control room with either only onsite or only offsite power available. In demonstrating that the system can perform its function assuming a single failure, limited operator action outside of the control room would be considered acceptable if suitably justified.

4. The system(s) shall be capable of bringing the reactor to a cold shutdown condition, with only offsite or onsite power available, within a reasonable period of time following shutdown, assuming the most limiting single failure."

The NRC's position also indicates that the following four basic functions are involved during plant operation when the plant is being taken to cold shutdown and that with a loss of offsite power these functions must be accomplished with the RCS in a natural circulation condition:

1. Boration of the RCS to the cold shutdown concentration.

2. Circulation of the Reactor coolant to promote mixing and uniform cooldown.

3. Removal of stored and decay heat to reduce the RCS temperature from about 545^{o}F to 350^{o}F.

4. Depressurization of the RCS from about 2200 to 400 psig.

In addition, in view of the uncertainties involved in cooldown and depressurization under natural circulation conditions, RSB BTP 5-1 requires that tests for PWRs, with supporting analysis be conducted to (a) confirm that adequate mixing of borated water added prior to or during cooldown can be achieved under natural circulation conditons and permit estimation of the time required to achieve such mixing, and (b) confirm that the cooldown under natural circulation conditons can be achieved within the limits specified in the emergency operating procedures.

The NRC also recommended that effects such as reactor vessel stress limits, bubble formation, etc., be considered in development of the natural circulation test program and supporting analyses (see Enclosure A).

The San Qnofre Natural Circulation Test program, consisting of low power natural circulation testing, a Loss of Offsite Power test from 20% power, and a Natural Circulation Cooldown test from 80% power, is designed to demonstrate that San Onofre Unit 2 conforms to the staff position. This is shown within the constraints of an efficient test program and other test objectives (e.g., operator training and equipment verification) and within the guidance of Regulatory Guide 1.68, "Preoperational and Initial Startup Test Programs for Water-Cooled Power Reactors." The Natural Circulation Test Program is, therefore, not a "run-through" of a single scenario that falls outside the bounds of the "simulation of the effects of control system and equipment failures that could reasonably be expected to occur during the plant lifetime"; rather it is a systematic check of plant functions at points most appropriate to all of the test objectives.

During low power testing several significant plant manipulations are conducted for operator training. These include the isolation of a steam generator and de-energizing pressurizer heaters.

The two main test sequences during power ascension testing were chosen to represent situations that may reasonably be expected during plant lifetime and are therefore most appropriate for operator training and equipment verification. A review of natural circulation events indicates that there are

three basic causes requiring a plant to operate under conditions of natural circulation: (1) Loss of Power, (2) Loss of Cooling Water and (3) Operational procedures following a Safety Injection Actuation Signal. The loss of offsite power cause is the most prevalent, with 24 identified events; however none of these events have required a plant cooldown. The remaining causes accounted for 7 natural circulation cooldowns all of which were conducted with normal plant systems available.

Provisions and procedures for the natural circulation sequences at low power and during the power ascension program were varied as necessary to demonstrate conformance with RSB Branch Technical Position 5-1. Enclosure B, "Comparison of the Natural Circulation Test Program for San Onofre Unit 2 with RSB Branch Technical Position (BTP) 5-1," provides a detailed comparison which demonstrates conformance of the San Onofre Unit 2 Natural Circulation Test Program with RSB BTP 5-1. SCE considers that specific test results of the Natural Circulation Test Program along with supporting analyses, will (a) confirm that adequate mixing of borated water added prior to or during cooldown can be achieved under natural circulation conditions and permit estimation of the time required to achieve such mixing, and (b) confirm that the cooldown under natural circulation conditions can be achieved within the limits specified in the emergency operating procedures.

ENCLOSURE A
NATURAL CIRCULATION TEST AND
SUPPORTING ANALYSES REQUIRED
IN BRANCH TECHNICAL POSITION RSB 5-1

The functional requirements of Branch Technical Position RSB 5-1, "Design Requirements of the Residual Heat Removal System," are as follows:

"Functional Requirements

The system(s) which can be used to take the reactor from normal operating conditions to cold shutdown* shall satisfy the functional requirements listed below.

1. The design shall be such that the reactor can be taken from normal operating conditions to cold shutdown* using only safety-grade systems. These systems shall satisfy General Design Criteria 1 through 5.

2. The system(s) shall have suitable redundancy in components and features, and suitable interconnections, leak detection, and isolation capabilities to assure that for onsite electrical power system operation (assuming offsite power is not available) and for offsite electrical power system operation (assuming onsite power is not available) the system function can be accomplished assuming a single failure.

3. The system(s) shall be capable of being operated from the control room with either only onsite or only offsite power available. In demonstrating that the system can perform its function assuming a single failure, limited operator action outside of the control room would be considered acceptable if suitably justified.

*Processes involved in cooldown are heat removal, depressurization, flow circulation, and reactivity control. The cold shutdown condition, as described in the Standard Technical Specs refers to a subcritical reactor with a reactor coolant temperature no greater than 200 °F for a PWR and 212°F for a BWR.

4. The system(s) shall be capable of bringing the reactor to a cold shutdown condition, with only offsite or onsite power available, within a reasonable period of time following shutdown, assuming the most limiting single failure."

For PWRs, the loss of offsite power results in reactor scram and loss of the main condenser, the main feedwater pumps and the RCS pumps. The plant can be brought to a hot standby condition with feedwater supplied by the auxiliary feedwater pumps taking suction from the condensate storage tank and with steam discharge to the atmosphere via the atmospheric dump valves or steam generator safety valves. In accordance with the Standard Review Plan prior to incorporation of RSB 5-1, the auxiliary feedwater system, condensate storage tank and safety valves meet safety grade requirements. The residual heat removal system (RHRS), which was also required to be a safety grade system prior to incorporation of RSB 5-1, is used to take the reactor to cold shutdown conditions. However, the RHRS cannot be operated in this mode until the RCS pressure and temperature have been reduced to about 400 psig and 350°F*, respectively. Hence, the major new impact of the functional requirements of RSB 5-1 on PWR plant design involves the transition region from hot standby conditions down to the conditions permitting operation of the RHRS.

There are four basic functions involved during plant operation in this transition region when the plant is being taken to cold shutdown. These are (a) boration of the RCS to the cold shutdown concentration, (b) circulation of the reactor coolant to promote mixing and uniform cooldown, (c) removal of stored and decay heat to reduce the RCS temperature from about 545°F to 350°F and (d) depressurization of the RCS from about 2200 to 400 psig. With

*For B&W plants this temperature is 305°F loss of offsite power, these functions must be accomplished with the RCS in a natural circulation condition.

In addition, the requirement that the design be such that the plant could be taken to cold shutdown using only safety-grade systems has an impact on the systems and procedures used while the plant is operating in this transition region. For example, the letdown line in the chemical and volume control system has air-operated valves which are supplied by an air compressor which is not seismic Category 1. If the air supply is lost, boration of the RCS under natural circulation conditions and without letdown would be required.

There is insufficient information available to permit reliable estimates of the times required to achieve adequate mixing of borated water under natural circulation conditions and using the particular systems and procedures specified by the applicant to meet the functional requirements of RSB 5-1. In additon, there may be other factors involving, for example, vessel stress limits in the upper head region and steam bubble formation which could limit cooldown or depressurization rates. Some of the effects which should be considered in setting up the tests and supporting analyses are as follows:

A. Boration

1. stratification leading to delay in mixing time
2. regional non-uniformity of boron concentration (e.g., pressurizer versus loops, idle versus active loops, upper head region versus loops)

3. availability of letdown and auxiliary pressurizer spray
4. boration versus RCS temperature adequate to maintain margin for shutdown during cooldown

B. Circulation

1. effect of isolated steam generator
2. need for circulation promoted by heat removal at steam generator to cool loops after RHRS in operation since RHRS tends to cool only reactor

C. Heat Removal

1. thermal stress in vessel upper head region could limit cooldown rates
2. effect of isolated steam generator which acts as heat source during cooldown.

D. Depressurization

1. steam bubble formation in upper heat region which could limit depressurization rate

2. steam bubble formation on primary side of steam generators (particularly isolated steam generator) which could limit depressurization rate

In view of the uncertainties involved in cooldown and depressurization under natural circulation conditions, RSB 5-1 requires that tests for PWRs, with supporting analysis, be conducted to (a) confirm that adequate mixing of borated water added prior to or during cooldown can be achieved under natural circulation conditions and permit estimation of the time required to achieve such mixing, and (b) confirm that the cooldown under natural circulation conditions can be achieved within the limits specified in the emergency operating procedures.

The first goal of the test is to demonstrate that adequate mixing and cooldown during operation in the transition region can be obtained using the procedures, systems and equipment which have been determined to meet the functional requirements of RSB 5-1. Hence, any exceptions to these procedures, systems and equipment should be identified and justified by the applicant, and approved by the staff, on the basis that they do not have a significant effect on the achievement of this test goal. The second test goal is to obtain information which can be used to prepare emergency operating procedures and to determine the adequacy of sizing of the seismic Category 1 condensate storage tank.

Prior to the test, a report should be submitted to the staff which defines the test goals, gives the technical bases for the test and justifies the acceptance criteria. The report should include calculations of natural circulation flow rates and loop transit times, estimates of expected boron concentrations, and should consider the effects of instrument errors, sample line transient times and instrument response times on interpretation of the test results. This report would serve to justify the proposed operating conditions and procedures to be used in the test and would be reviewed by the staff in conjunction with the proposed test procedures.

Within ninety days after completion of the test, a report on the test results should be submitted to the staff. This report should describe the results of the test, the interpretation of the test results, and the use of the results in estimating cooldown times, preparation of operating procedures and sizing of the condensate storage tank.

COMPARISON OF THE NATURAL CIRCULATION TEST PROGRAM FOR SAN ONOFRE UNIT 2 WITH RSB BRANCH TECHNICAL POSITION 5-1

Requirement	SCE Testing	Discussion and Justification
I. All systems, procedures, and equipment used to demonstrate compliance with RSB BTP 5-1 must meet the four functional requirements stated therein. These functional requirements are as follows: 1) All systems must be safety-grade. 2) All system shall have suitable redundancy in components, features, etc., to permit system function to be accomplished assuming only onsite or only offsite power and a single failure. 3) System(s) shall be operable from the control room with only onsite or only off-site power. Limited action outside the control room is acceptable if suitably justified. 4) System(s) shall be capable of bringing the reactor to cold shutdown, with only offsite or only onsite power, within a reasonable time assuming the most limiting single failure.	The natural circulation test which will be performed at the 20% power level is designed to demonstrate system operability under conditions which involve loss of offsite power including a simulation of loss of all AC, i.e., loss of offsite and onsite power. The purpose of this test is (1) to verify the ability to shutdown and maintain the reactor in hot standby using only emergency power during a loss of offsite power, specifically operation of the emergency diesels will be demonstrated along with the bus transfer and load shedding features of the plant emergency buses and (2) to demonstrate system operation under conditions that simulate a total loss of AC power by securing certain safety related loads such as electric driven auxiliary feedwater pumps, auxiliary building emergency chiller, and the backup pressurizer heaters.	The 20% Loss of Offsite Power Test has been designed to address the first three functional requirements of RSB BTP 5-1. The Natural Circulation Test from 80% power has been designed to address all four functional requirements. Although letdown is not considered safety grade, during the Natural Circulation Test, from 80% power letdown will not be isolated until after boration and cooldown are complete just prior to depressurization. Operation of letdown, which will allow for continuous use of the Boronmeter, will not impact boron mixing or heat loss due to CVCS operation since letdown flow is small in comparison to total RCS natural circulation flow (less than 1%). Further, calculations showing the volume of borated water required to be charged to the RCS to obtain proper shutdown margins prior to cooldown are straight forward and clearly demonstrate that this process can be accomplished in the absence of letdown. Full pressurizer heaters will also be available to the operators throughout the Natural Circulation Test from 80% power. This is desirable since it will allow for plant cooldown at the maximum administrative rate of 75&F/hr while retaining the ability to maintain proper subcooling. The 20% Loss of Offsite Power Test will require pressure control with only those heaters supplied from the diesel generators; the Low Power Natural Circulation Tests will demonstrate plant response to a total loss of pressurizer heaters.

COMPARISON OF THE NATURAL CIRCULATION TEST PROGRAM FOR
SAN ONOFRE UNIT 2 WITH RSB BRANCH TECHNICAL POSITION 5-1

Requirement	SCE Testing	Discussion and Justification
	The Natural Circulation Test from 80% power performs boration and natural circulation cooldown to the Shutdown Cooling Sytem (SDCS) entry conditions using both steam generators. During boration, steam is dumped using the Steam Bypass Control System (SBCS). During the subsequent cool-down, steam will be dumped using the Atmospheric Dump Valves (ADVs). Letdown is isolated just prior to de-pressurization after boration and cooldown are complete.	
II. Tests should confirm adequate mixing of borated water prior to and during cooldown under natural circulation and should permit estimates of time to achieve such mixing. Effects which should be considered are as follows: stratification leading to delay in mixing times, availability of let-down and auxiliary spray, boration rate adequate to maintain shutdown margin during a cooldown, and regional non-uniformity of boron concentration (e.g., pressurizer vs. loops, idle vs. active loop, upper head vs. loops).	The Natural Circulation Test from 80% power requires sampling at the following locations and frequencies: hot leg #1 every 30 minutes, pressurizer every 60 minutes, volume control tank every 60 minutes, and Boronmeter reading every 10 minutes. Mixing in the pressurizer is maximized by simultaneous operation of heaters and auxiliary spray.	Sample locations and frequencies are adequate to supply data sufficient for proper analysis of the concerns in RSB BTP 5-1 regarding stratification leading to delay in mixing times and regional non-uniformities in boron concentration. The availability of letdown was discussed in Part I above; since auxiliary spray is safety related failure is considered unlikely. Finally, boration rate using only one charging pump (the plant is provided with a total of three charging pumps) is adequate to maintain shut-down margin during a cooldown.

COMPARISON OF THE NATURAL CIRCULATION TEST PROGRAM FOR
SAN ONOFRE UNIT 2 WITH RSB BRANCH TECHNICAL POSITION 5-1

Requirement	SCE Testing	Discussion and Justification
III. Tests to satisfy the requirements of RSB BTP 5-1 should provide information which can be used to prepare emergency operating procedures and determine the adequacy of sizing of the seismic Category I condensate storage tank. The seismic Category I water supply shall have sufficient inventory to permit operation at hot shutdown for at least four hours followed by cooldown to SDCS entry conditions. The inventory needed shall be based upon the longest cooldown time required with either only onsite or only offsite power available and an assumed single failure.	During the Natural Circulation Test from 80%power subsequent to boration and prior to plant cooldown adequate feedwater is verified. Plant cooldown and subsequent depressurization are performed while dumping steam to atmosphere via the Atmospheric Dump Valves (ADVs) and feeding the steam generators via the turbine driven auxiliary feedwater pump.	The San Onofre Units 2&3 design provides a 150,000 gallon seismic Category I condensate storage tank as the primary source of water for the auxiliary feedwater system. SCE has also provided seismic Category I reinforced concrete walls around the 500,000 gallon seismic Category II condensate storage tank in order to retain sufficient water after a safe shutdown earthquake to meet RSB BTP 5-1 requirements. Actual verification of condensate capacity will be made via careful analysis of feedwater inventory data taken during the Natural Circulator test from 80% power.
IV. Additional effects which should be considered in setting up tests and supporting analyses in compliance with the requiements of RSB BTP 5-1 are as follows:		
a. Effect on coolant circulation of an isolated steam generator	The Low Power Natural Circulation Demonstration Program performs a natural circulation test with reduced heat removal capacity. The purpuse of the test is to demonstrate natural circulation with one steam generator isolated and to demonstrate that full natural circulation can be reestablished when the isolated steam generator is returned to service.	Data to be taken during the present low power Natural Circulation test is sufficient to demonstrate the effect on coolant circulation due to isolation of one steam generator.

COMPARISON OF THE NATURAL CIRCULATION TEST PROGRAM FOR
SAN ONOFRE UNIT 2 WITH RSB BRANCH TECHNICAL POSITION 5-1

Requirement	SCE Testing	Discussion and Justification
b. Need for circulation promoted by heat removal at the steam generators to cool loops after SDCS is in operation since SDCS tends to cool the reactor only.	See discussion.	Once a Natural Circulation plant cooldown has been completed and the SDCS has been placed in operation, the need for circulation prompted by heat removal at the steam generators presents a problem from an operational standpoint
c. Thermal stress in upper region which could limit cooldown rates.	See discussion.	Analyses contained in CE-NPSD-154, "Natural Circulation Cooldown," indicate that negligible thermal stresses exist in the upper heat reagion and on reactor vessel internals during cooldown.
d. Effect of isolated steam generator which acts as a heat removal source during cooldown.	The Low Power Natural Circulation Tests with Reduced Heat Removal Capacity demonstrates the effect of isolating a steam generator while maintaining the plant in hot standby.	Adequate analyses exist to show predicted plant behavior with one steam generator isolated during both steady state natural circulation and during a natural circulation cooldown. Current tests will provide sufficient empirical data to properly verify plant behavior.
e. Steam bubble formation in upper head region which could limit depressurization rate.	During the depressurization portion of the Natural Circulation Test from 80% power careful monitoring of the RCS for head voiding will be performed. The procedure will attempt early depressurization to check the accuracy of existing calculations predicting head cooldown rates.	Existing calculations and test procedures are adequate to meet the concerns regarding steam bubble formation in the upper head region

COMPARISON OF THE NATURAL CIRCULATION TEST PROGRAM FOR
SAN ONOFRE UNIT 2 WITH RSB BRANCH TECHNICAL POSITION 5-1

Requirement	SCE Testing	Discussion and Justification
f. Steam bubble formation on primary side of steam generator (particularly the isolated steam generator) which could limit depressurization rate.	See discussion.	The RCS will be carefully monitored and appropriate actions will be performed in the event of a void formation on the primary side of the isolated steam generator during the low power Natural Circulation test with reduced heat removal capacity. The probability of a void formation is minimized by maintaining at least 20&F of subcooling in the RCS loops.
V. Four basic functions are involved during plant operation from hot standby to cold shutdown. These functions, which must be accomplished with the RCS in a natural circulation mode during a loss of offsite power, are as follows: 1. Boration of the RCS to the cold shutdown concentration 2. Circulation of the reactor coolant to promote mixing and uniform cooldown 3. Removal of stored and decay heat to reduce the RCS temperature from 545&F to 350&F. 4. Depressurization of the RCS from about 2200 to 400 psig.	See discussions	The four basic functions involved during plant operations from hot standby to cold shutdown will be addressed in various key tests throughout the Natural Circulation Test Program as discussed above. While no one test by itself is designed to demonstrate compliance with the single scenario of RSB BTP 5-1, the overall results from these key tests will adequately address the concerns stated therein.