CEOG COMBUSTION ENGINEERING OWNERS GROUP

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Arizona Public Service Co. Palo Verde 1, 2, 3	Consumers Energy Co. Palisades	Florida Power & Light Co. St. Lucie 1, 2	Northeast Utilities Service Co. Millstone 2	Southern California Edison SONGS 2,3

April 28, 2000
CEOG-00-121

NRC CEOG Project Number 692

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Attn: Chief, Information Management Branch, Division of Inspection and Support Programs

Subject: CE Owners Group Submittal of CE NPSD-1186, "Technical Justification for the Risk Informed Modification to Selected Required Action End States for CEOG PWRs", April 2000

Gentlemen:

This letter submits CE Owners Group Joint Applications Report (JAR) for modification of selected required action end states for CEOG PWRs, report CE NPSD-1186. Enclosed for your use are 12 copies of the report. The enclosed report provides a technical basis for changing the safe mode end state from Mode 5 to Mode 4 for 29 Technical Specifications. The enclosed report was developed using the joint application/cross comparison process pioneered by the CEOG to support risk informed decisions.

The report is being submitted for review and approval as part of a collaborative effort of participating Combustion Engineering Owners Group members. The safety evaluation prepared by the NRC should specifically identify the acceptability of the results to the plants referenced in CE NPSD-1186 and should identify any additional information required to be provided when the plant specific license amendment requests are submitted to the NRC for approval.

The NRC should address technical questions related to CE NPSD-1186 to the Chairman of the CE Owners Group. Invoices for review fees should also be directed to the Chairman with a copy to:

D047 | 6

Mr. Gordon Bischoff
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If you have any questions, please contact me.

Very truly yours,

R J Phelps

Ralph Phelps, Chairman
CE Owners Group

Enclosures

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Licensing Subcommittee w/o
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COMBUSTION ENGINEERING OWNERS GROUP

CE NPSD-1186

TECHNICAL JUSTIFICATION FOR THE RISK INFORMED MODIFICATION TO SELECTED REQUIRED ACTION END STATES FOR CEOG PWRs

FINAL REPORT
TASK 1115

April 2000

PREPARED FOR THE
COMBUSTION ENGINEERING OWNERS GROUP

BY

ABB C-E NUCLEAR POWER, INC.
2000 DAY HILL ROAD
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ABB C-E Nuclear Power, Inc.

TECHNICAL JUSTIFICATION FOR THE RISK INFORMED MODIFICATION TO SELECTED REQUIRED ACTION END STATES FOR CEOG PWRS

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TABLES

FIGURES

ATTACHMENTS

ACRONYMS

AAC	-	Alternate AC
ADVs	-	Atmospheric Dump Valves
AFW	-	Auxiliary Feedwater
AOO	-	Anticipated Operational Occurrence
AOT	-	Allowed Outage Time
ASP	-	Alternate Shutdown Panel
ATWS	-	Anticipated Transient without Scram
BAMU	-	Boric Acid Makeup
BAT	-	Boric Acid Tank
BWRs	-	Boiling Water Reactors
CC	-	Containment Cooling
CCAS	-	Containment Cooling Actuation Signal
CCF	-	Common Cause Failure
CCW	-	Component Cooling Water
CD	-	Core Damage
CDF	-	Core Damage Frequency
CEA	-	Control Element Assembly
CEOG	-	Combustion Engineering Owners Group
CHARMs	-	Containment High Area Radiation Monitors
CIAS	-	Containment Isolation Actuation Signal
CIV	-	Containment Isolation Valve
CPS	-	Power Conversion System
CPIS	-	Containment Purge Isolation Signal
CR	-	Control Room
CRC	-	Control Room Cooling
CREACUS	-	Control Room Emergency Air Cleanup System
CRMP	-	Configuration Risk Management Program
CRV	-	Control Room Ventilation
CS	-	Containment Spray
CST	-	Condensate Storage Tank
CT	-	Completion Time
CTMT	-	Containment
CVCS	-	Chemical and Volume Control System
CVCSIS	-	Chemical and Volume Control System Isolation Signal
DBA	-	Design Basis Accident
DGs	-	Diesel Generators
EAB	-	Exclusion Area Boundary
ECCS	-	Emergency Core Cooling System
ECW	-	Emergency Chilled Water
EDGs	-	Emergency Diesel Generators
EOPs	-	Emergency Operating Procedures
EPGs	-	Emergency Procedure Guidelines
ESF	-	Engineered Safety Feature
ESFAS	-	Engineered Safety Feature Actuation System
FCS	-	Ft. Calhoun Station
GL	-	Generic Letter
HEP	-	Human Error Probabilities
HEPA	-	High Efficiency Particulate Air
HPSI	-	High Pressure Safety Injection
ICCDP	-	Incremental Conditional Core Damage Probability

ACRONYMS CONTINUED

ICLERP	-	Incremental Conditional Large Early Release Probability
IEF	-	Initiating Event Frequency
INEL	-	Idaho Nuclear Engineering Laboratory
INs	-	Information Notices
IPE	-	Individual Plant Examination
IPEEE	-	Individual Plant Examination of External Events
ISLOCA	-	Intersystem LOCA
ISTS	-	Improved Standard Technical Specifications
LCO	-	Limiting Conditions for Operation
LERF	-	Large Early Release Frequency
LERP	-	Large Early Release Probability
LOCA	-	Loss of Coolant Accidents
LOFW	-	Loss of Feedwater Events
LOI	-	Loss of Inventory
LOOP	-	Loss of Offsite Power
LOSDC	-	Loss of Shutdown Cooling
LOW	-	Low Population Zone
LPSI	-	Low Pressure Safety Injection
LPZ	-	Low Population Zone
LTOP	-	Low Temperature Overpressure Protection
MDAFW	-	Motor Driven Auxiliary Feedwater
MFW	-	Main Feedwater
MHA	-	Maximum Hypothetical Accident
MR	-	Maintenance Rule
MSIV	-	Main Steam Isolation Valve
MSLB	-	Main Steam Line Break
MSSV	-	Main Steam Safety Valves
OTCC	-	Once Through Core Cooling
PCS	-	Power Conversion System
PORV	-	Power Operated Relief Valve
PRA	-	Probabilistic Risk Assessments
PSA	-	Probabilistic Safety Assessments
PWR	-	Pressurized Water Reactor
RAS	-	Recirculation Actuation Signal
RCP	-	Reactor Coolant Pump
RCS	-	Reactor Coolant System
RGs	-	Regulatory Guides
RPS	-	Reactor Protection System
RWST	-	Refueling Water Storage Tank
SB	-	Shield Building
SBEACS	-	Shield Building Exhaust Air Cleanup System
SBFAS	-	Shield Building Filtration Actuation Signal
SDC	-	Shutdown Cooling
SDCS	-	Shutdown Cooling System
SDM	-	Shutdown Margin
SER	-	Safety Evaluation Report
SG	-	Steam Generator
SGHR	-	Steam Generator Heat Removal
SIAS	-	Safety Injection Actuation Signal
SIRWT	-	Safety Injection Refueling Water Tank
SIT	-	Safety Injection Tank

ACRONYMS CONTINUED

SGTR	-	Steam Generator Tube Rupture
SLB	-	Steam Line Break
SRPs	-	Standard Review Plans
SSC	-	Structures, Systems and Components
SWC	-	Salt Water Cooling
TDAFW	-	Turbine Driven Auxiliary Feedwater
TS	-	Technical Specification
UHS	-	Ultimate Heat Sink

1.0 PURPOSE

This report presents a risk informed approach to the identification of proposed modifications to the end state Required Actions in the Improved Standard Technical Specifications (ISTS, Reference 1) and provides a risk informed technical basis for their implementation. The technical bases of the recommended changes also apply to equivalent conditions that exist within CEOG customized technical specifications and CEOG Standard Technical Specifications (See Attachment A). The assessment presented in this report is consistent with the guidance contained in Regulatory Guides (RGs) 1.174 (Risk Informed Decision-Making, Reference 2) and 1.177 (Risk Informed Changes to Technical Specifications, Reference 3) regarding the use of Probabilistic Risk Assessments (PRA) in risk-informed applications.

2.0 SCOPE AND DESCRIPTION OF PROPOSED CHANGES

This report presents recommendations for replacing the cold shutdown required action with a recommendation to allow continued operation at hot shutdown for a large number of TSs. The scope of the TS end state review was limited to those end states where the entry condition is initiated by the INOPERABILITY of a single train of equipment or a restriction on a plant operational parameter (e.g. RWST boron, Containment Pressure or Temperature). A summary list of the proposed changes is provided in Table 2-1.

This task is also limited in scope to the modification of the shutdown end state condition. That is, a risk informed assessment of the decision of the action to require shutdown was performed even if that action would be of lower risk. In general, TS end state changes focus on defining the end state that results in acceptable operational risks and requires the minimum of plant transitions and configuration changes. In most cases this results in a risk informed selection between operation in hot shutdown or cold shutdown. For most equipment INOPERABILITIES, hot shutdown was selected as the preferred mode because of the low risks in hot shutdown operation. In specific instances hot shutdown operation was restricted to heat removal via steam generators. In two instances related to TSs concerning boron concentration limits, a hot standby end state modification is recommended based on considerations of acceptable risk.

Table 2-1 Results of Technical Specification Review: Summary of Recommended Changes to Technical Specification Require Actions						
ISTS		SONGS T.S. #	Title	Current End State		Proposed End State
Analog	Digital			ISTS	SONGS	
3.1 Reactivity Control Systems						
NONE[2]	NONE[2]	3.1.9 C.1	Boration Systems – Operating	NA	Mode 5 - 30 hrs	Mode 3 – 6 hrs (See Note 5)
3.3 Instrumentation						
3.3.4 F.2	3.3.5.E.2	3.3.5 H.2	ESFAS Instrumentation (RAS-RWST low)	Mode 4 - 12 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs
3.3.4 F.2	3.3.5 E.2	3.3.6 F.2	ESFAS Logic and Manual Trip SIAS, CIAS, RAS & CCAS	Mode 4 - 12 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs
3.3.7 B.2	3.3.8 B.2	3.3.8 B.2	CPIS	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs
3.3.8 B.2	3.3.9 B.2	3.3.9 B.1	CRIS[7,15]	Mode 5 - 36 hrs	Manually Align 1 Train of CREACUS into Emergency*	See Note 18. Mode 4 - 12 hrs
3.3.9 B.2	NA	NA	CVCS Isolation Signal	Mode 5 - 36 hrs	NA	Mode 4 - 12 hrs
3.3.10 B.2	NA	NA	Shield Building Filtration Actuation Signal[8]	Mode 5 - 36 hrs	NA	Mode 4 - 12 hrs
3.4 RCS						
3.4.6 B.1	3.4.6 B.1	3.4.6 B.1	RCS Loops-Mode 4	Mode 5 - 24 hrs	Mode 5 - 24 hrs	Mode 4 - 12 hrs
3.5 ECCS						
3.5.4 C.2	3.5.4 C.2	3.5.4 C.2[9]	RWST	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 3 – 6 hrs (See Note 5)
3.6 Containment Systems						
3.6.1 B.2	3.6.1 B.2	3.6.1 B.2	Containment[17]	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs
3.6.2 D.2	3.6.2 D.2	3.6.2 D.2	CTMT Air Locks	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs
3.6.3 F.2	3.6.3 E.2	3.6.3 G.2	CIVs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs
3.6.4 B.2	3.6.4 B.2	3.6.4 B.2	CTMT Pressure	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs
3.6.5 B.2	3.6.5 B.2	3.6.5 B.2	CTMT AirTemp	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs
3.6.6A B.2 & F.2	3.6.6A B.2 & F.2	3.6.6.1B.2 & F.2	CTMT Spray and Cooling Systems (Credit taken for Iodine Removal)	Mode 5 - 84 hrs (CTMT spray) Mode 5 -36 hrs (CTMT cooling)	Mode 4 - 84 hrs (CTMT spray) Mode 4 -36 hrs[16] (CTMT cooling)	Mode 4 - 84 hrs[6] (CTMT Spray)[4] Mode 4 – 36 hrs (CTMT Cooling)
3.6.6 B F.2	3.6.6B F.2	3.6.6.2 C.1	CTMT [Spray and] Cooling Systems [Mode 4] (Credit not taken for Iodine Removal[10])	Mode 5 - 36 hrs[10]	Mode 5 - 36 hrs (CTMT cooling)[16]	Mode 4 - 12 hrs[6]

Table 2-1 Results of Technical Specification Review: Summary of Recommended Changes to Technical Specification Require Actions						
ISTS		SONGS T.S. #	Title	Current End State		Proposed End State
Analog	Digital			ISTS	SONGS	
3.6.11.B.2	3.6.11 B.2	NA	Shield Building	Mode 5 - 36 hrs[10]	NA	Mode 4 - 12 hrs[6]
3.7 Plant Systems						
3.7.5 C.2	3.7.5 C.2	3.7.5 E.2	AFW	Mode 4 w/o SG HR - 18 hrs	Mode 4-12 Hrs	Mode 4 w/o[3] SG for HR -18 hrs
3.7.7 B.2	3.7.7 B.2	3.7.7 B.2	CCW[1,2,12]	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs
3.7.8 B.2	3.7.8 B.2	3.7.8 B.2	SWC[2,12]	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs
3.7.9 B.2	3.7.9 B.2	NA	UHS[2,12]	Mode 5 - 36 hrs	NA	Mode 4 - 12 hrs
3.7.10	3.7.10 B.2	3.7.10 B.2	ECW[2]	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs
3.7.11	3.7.11 B.2	3.7.11 B.2	CREACUS[13,14]	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs
3.7.12 B.2	3.7.12 B.2	NA	CREATCS[14]	Mode 5 - 36 hrs	NA	Mode 4 - 12 hrs
3.7.13 B.2	3.7.13 B.2	NA	ECCS Pump Room EACS[2, 14]	Mode 5 - 36 hrs	NA	Mode 4 - 12 hrs
3.7.15 B.2	3.7.15 B.2	NA	Penetration Room EACS[2,14]	Mode 5 - 36 hrs	NA	Mode 4 - 12 hrs
3.8 Power Sources						
3.8.1	3.8.1 F.2	3.8.1 F.2	AC Sources-Operating	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs (W SGHR)
3.8.4 B.2	3.8.4 B.2	3.8.4.B.2	DC Sources-Operating	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs (W SGHR)
3.8.7 D.2	3.8.7 D.2	3.8.7 B.2	Inverters-Operating	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs (W SGHR)

<u>Footnotes to Table 2-1</u>

1) If the plant were already in Mode 4 with an affected SDC loop, Condition B of 3.4.6 is also applicable. It requires entry into Mode 5 within 24 hours.
2) Technical specification is not applicable to all PWR designs.
3) 18 hours provides time to transition to Mode 4 on SDC (consistent with ISTS).
4) Times chosen consistent with SONGS Units 2 & 3 bases.
5) Mode 3 within 6 hours for condition when Tank Contents out of limits. Mode 5 within 36 hours for other inoperabilities.
6) Mode 4 for plants with diverse and redundant CTMT cooling systems. Palo Verde, SONGs, St. Lucie and ANO require CS in Mode 1, 2 & 3 only.
7) System called CREFAS (Control Room Essential Filtration Actuation Signal) at APS.
8) Applicable to St. Lucie Units 1 & 2 and Waterford Unit 3.
9) Section 3.5.5 for APS.
10) APS "Two Containment Spray Trains shall be Operable." Required Actions is to be in Mode 4 with RCS pressure < 385 psig.
11) Deleted
12) Systems vary among utilities, equivalent systems for APS is EW, ESPS, UHS (T.S. 3.7.9A.2) and EC. SONGS has a CCW flow path and tank level Technical Specification 3.7.7.1 for the Primary Plant Makeup Storage Tank (PPMST).
13) Also referred to as CREACS, CREVAS, CREVS and CREAFS.
14) These systems have similar functions to maintain environmental conditions for personnel and ECCS equipment.

15) System called CRRS at Calvert Cliffs.
16) SONGs TS is unique and requires applicability of CS and CCs in Modes 1, 2 and 3. Only CC units are TS'd in Mode 4. The variations are based on level of redundancy. The CC system consists of 2 CS trains and 2 cooling trains. Inoperability of 1 CS train is given a longer time to enter Mode 4.
17) Other restrictions apply, see Section 5.5.10 of this report.
18) Manually aligning 1 train of CREACUS into emergency Mode accomplishes function of CRIS.

* If not accomplished, then 3.0.3 entry. For LCO 3.0.3, be in Mode 5 in 37 hours. This is the defacto current end state.

The technical basis for the end state changes included in this report also apply to equivalent TS Conditions and Required Actions (or equivalent) contained within CEOG member plant's individual Customized and Standard Technical Specifications, (See Attachment A).

3.0 BACKGROUND

10CFR50.36 (Reference 4) requires that each applicant for a nuclear power plant operate the plant in accordance with a set of TSs. These TSs include safety limits, control settings and Limiting Conditions for Operation (LCO). The intent of these LCOs is to ensure that the plant is operated in a manner consistent with its design basis. The regulation recognized that at times equipment failures may result in the temporary loss of system redundancy, and hence require plant operation at a somewhat greater risk. The regulation therefore requires that when the LCOs are not met the licensee will either shutdown the reactor or follow, "any remedial action permitted by the Technical Specification" until the condition can be met. In the process of constructing the plant TSs, risk insights known at the time were melded with deterministic considerations to establish several fundamental principles upon which the TSs would be developed. Fundamental to these principles was that when redundancy in a design basis system existed, a Limited Condition for Operation (LCO) was defined such that TS equipment (typically one train) would be allowed to be out of service (INOPERABLE) for a finite time period (Allowed Outage Time/Completion Time). During this limited time interval, the availability of the redundant train of that system was credited for meeting the plant design basis. When the plant could not be returned to the desired state, a second principle was invoked which required the plant to be transitioned to a mode where the INOPERABLE system is no longer needed as part of the plant design basis. This last state was frequently defined as cold shutdown.

In the cold shutdown state, the plant is taken to a subcritical condition with reactor temperatures below 200 °F. The selection of cold shutdown as the target end state most often required in the plant's Required Action Statements was based on the belief that by transitioning the plant to a low pressure, cold temperature (< 200 °F) condition, the risk of Loss of Coolant Accidents (LOCAs) is significantly reduced and hence plant safety is enhanced. While the cold shutdown state could be successfully and safely maintained with minimal plant systems, the designation of this state as the default shutdown state was often inconsistent with the plant design features (and design philosophy) which, typically were designed with hot shutdown as a long term safe shutdown mode. In fact, plant design features at hot shutdown provided additional redundancy and diversity to core and Reactor Coolant System (RCS) heat removal and hence, would also provide a low risk (and in many instances, the more desirable) end state.

3.1 HISTORICAL PERSPECTIVE ON PLANT RISKS DURING SHUTDOWN OPERATION

Over the past many years, the occurrence of operational events at shutdown has increased attention to risks of shutdown operation. These events have captured the attention of the regulator and the industry and have prompted the issuance of several Information Notices (INs) and Generic Letters (GLs). Through 1992, at least 28 events were identified that resulted in Loss of Shutdown Cooling. In several instances the plant was operating in Mode 5. Several of these events were initiated while the plant was at mid-loop conditions. In that same general time frame, 17 shutdown events were identified as being associated with loss of electrical power and 6 events had been classified as loss of inventory (Reference 5). More recent updates of plant shutdown incidents (References 6 and 9) indicate that by 1995 the number of loss of coolant events at shutdown had risen to 19. Loss of inventory was generally a result of unintentional inventory diversion away from the RCS. These events were traced to the need for improvements in training and procedures. Of those events only two events had taken place at temperatures and pressures sufficient to result in voiding refueling water storage tank piping.

A 1987 loss of shutdown cooling event with the plant in midloop operation resulted in loss of SDC for more than 1 hour. Following the incident the NRC issued Generic Letter 88-17 (Reference 7). The intent of this GL was to enhance the safety of shutdown operations and to reduce public risk from reduced inventory operations. While the frequency of shutdown initiated events seems to be decreasing, events still occur. In 1995 the NRC issued two information Notices 95-03 and 95-03, Supplement 1, (References 8 and 9) to address a draindown event that occurred during shutdown. This event involved the operator's inadvertent rapid transfer of 9000 gallons of reactor coolant to the RWST while the plant was pressurized at 340 psig and at a temperature of 300 F (typical of hot shutdown SDC entry conditions). The event was precipitated by the concurrent performance of two incompatible activities which, taken together, opened two isolations valves creating a flow path that allowed the inadvertent draindown. Unmitigated, this event could have had significant consequences including a potential for containment bypass.

On May 28, 1998, the NRC issued Generic Letter 98-02 concerning the "Loss of Reactor Coolant Inventory and Associated Potential for Loss of Emergency Mitigation while in a Shutdown Condition," (Reference 10). The intent of this letter was to have the licensees evaluate the susceptibility of their Residual Heat Removal and Emergency Core Cooling systems to a common cause failure as a result of a reactor coolant system draindown while in a shutdown condition. The staff was specifically concerned with the conduct of activities during hot shutdown that may affect safety related functions of the RHR and ECCS, for example methods utilized to verify valve position, controls in place to assure compliance with plants surveillance, maintenance, modification of operating procedures and adequacy of operator training.

Additional loss of RCS inventory events occurred at Quad Cities Unit 2, Arkansas Nuclear One Unit 2, Fitzpatrick and Salem Unit 2. Information Notice 99-14 (Reference 11) was issued to alert utilities to the potential for personnel errors during infrequently performed evolutions. The IN addressed the first three incidents which resulted in unanticipated reactor water draindowns. The safety significance of these events was low because the draindowns were terminated with water level well above the top of the active fuel. The Salem event consisted of a loss of inventory event resulting from an RCS heatup with an unexpected challenge to the LTOP relief valve at an RCS pressure in the vicinity of 370 psig. The relief valve challenge resulted in a substantial RCS leakage (between 350 and 500 gpm). The challenge appeared to be due to operator error resulting from a weakness in procedural guidance.

In summary, preventing plant challenges during shutdown conditions has been, and continues to be, an important aspect of ensuring safe operation of the plant. Past events demonstrate that risk of core damage associated with entry into, and operation in, shutdown cooling is not negligible and should be considered when a plant is required to shutdown. Therefore, the TS should encourage plant operation in the steam generator heat removal mode whenever practical, and <u>require</u> SDC entry only when it is a risk beneficial alternative to other actions.

3.2 PROBABILISTIC ASSESSMENT OF SHUTDOWN RISKS

PRA techniques have been developed to consider risks associated with plant operation in transition and shutdown modes (hot standby, hot shutdown and cold shutdown). Shutdown mode models have been developed by Southern California Edison (SCE) over the past several years. These models focus on the risks associated with quasi-steady state operation under shutdown conditions. Transition risks arise as a result of transitory mode changes. In considering issues associated with repair of plant equipment, three mode transition risks are of interest: transition risk from Mode 1 (at power) to Mode 3 (hot standby), transition risk from Mode 3 to Mode 4 (hot shutdown) and transition risk from Mode 4 using steam generators for heat removal to either Mode 5 (cold shutdown) or to Mode 4 on SDC and the associated risks for return to power. As discussed in Section 2.1, transition risks are important since the risk of transition is often not negligible and there is an increased probability of events occurring during plant transitions. This is particularly true when plant configuration changes are required as a result of the mode change.

Transition risk models have been developed by Mankamo for Boiling Water Reactors (BWRs, Reference 12) and more recently by the Combustion Engineering Owners Group (CEOG) for Pressurized Water Reactors (PWRs, Reference 13). The CEOG methods were primarily focused on the risks of transition from power operation to hot standby. The CEOG models are restricted in use to the low power, hot standby and hot shutdown modes (with SG used for heat removal). Thus, the CEOG models assume no significant plant configuration change occurs. Risks incurred are associated with increased unavailability of equipment and increased potential for plant trips and power upsets. In the CEOG applications for Allowed Outage Time (AOT) extensions, the averted risk of transitioning from Mode 1 (Full Power) operation to hot shutdown (with Steam Generators (SGs) used for heat removal) was included within the technical basis. The risk of transition from Mode 1 to Mode 3 (or Mode 4 with the RCS subject to SG heat removal) will be over a short period and are typically estimated to have a core damage probability on the order of 10^{-7} to 10^{-6} per transition.

The occurrence of additional events at shutdown has focused attention on effects of transitioning within shutdown states. Loss of inventory events associated with entry into hot shutdown and repair of equipment in hot and cold shutdown have resulted in potentially significant core damage precursors. Often, these precursors are associated with human errors such as plant system realignments and transitions which can reduce RCS inventory by diverting flow from the RCS and thus increase the potential for a core damage event.

In light of the above events, SONGS has expanded the initial shutdown model for the SONGS units to consider shutdown risks associated with SDC entry (e.g. flow diversion and drain down events addressed in IN-99-14) and LTOP relief valve challenges (Reference 14). SONGS has also included these models within the San Onofre Units 2 & 3 Safety Monitor. In this study, these models were used to both screen and assess the appropriateness of the existing TS required actions and the impact of altering the TS Required Action end state.

In the development of the current TS structure, cold shutdown was defined (with few exceptions) as the default end state to which the plant must ultimately transition following the failure to meet a required action in the TS. This state was specified based on the intuition that operation and maintenance of a nuclear plant in a cold shutdown state is safer than similar plant operations performed at higher temperature shutdown conditions (and at power). Recent probabilistic safety assessments of shutdown risk indicate that cold shutdown risks are acceptable. Oftentimes the lowest risk shutdown modes for performing equipment repairs (particularly for standby equipment) is <u>hot</u> shutdown, and in some instances, hot standby[1]. The particular risk state would be dependent upon the specific equipment availability and the time required for the repair/maintenance. As will be discussed in greater detail in Section 5.4, application of the SONGS shutdown model clearly indicates that when considering shutdown conditions, hot shutdown with the plant on steam generator heat removal provides an acceptable level of risk for a wide range of plant operational conditions. Furthermore, when considering risks of SDC entry and SDC operation, hot shutdown on SG heat removal is often a safer (lower risk) mode to maintain a plant than is SDC at either hot or cold shutdown.

3.3 BENEFITS OF END STATE CHANGES

As discussed above, many Required Action Statements direct the plant to maneuver into hot or cold shutdown. The review and evaluation of TS end state conditions performed in this report indicate that in many instances current Required Action Statement end states are actually risk adverse and prohibit the plant operating staff from taking lower risk operational alternatives when repairing inoperable equipment. It is the intent of this effort to modify those subject TSs to become risk informed. In so doing, the plant and the public will benefit by: (1) allowing reduced risk plant operation, (2) allowing increased flexibility in performing plant maintenance and (3) decreasing plant unavailability. Benefits of reduced risks are secured by allowing repairs made during shutdown to be performed in a resource rich environment and by minimizing forced mode transitions and consequent plant realignments. Increased maintenance flexibility and decreased plant unavailability results from allowing maintenance/repairs or plant

[1] In many instances completing the repair at power is the lowest risk alternative. This issue is not addressed within the scope of this report.

adjustments to be performed at a higher temperature mode (e.g. hot shutdown or, in limited cases, hot standby). Allowing operation in hot shutdown minimizes the need for plant realignments, such as entry into Low Temperature Overpressure Protection (LTOP) and Shutdown Cooling (SDC) and the associated surveillances required during the subsequent return to power.

Avoidance of SDC entry would reduce plant shutdown time on average by about 8-16 hours per evolution. This roughly corresponds to an averted cost of approximately $250K to $750K per required shutdown. This cost could be much larger if problems arise during plant heatup or required testing. In addition to reduced operational risks, increased reliance on a Mode 4 end state would allow the plant personnel to avoid unnecessary plant configuration changes and surveillances associated with SDC entry, while still affording the plant staff the opportunity to enter SDC should that be a more desirable end state from the perspective of equipment repair and maintenance.

4.0 RISK INFORMED END STATE REVIEW PROCESS

This present effort was limited in scope to the risk-informed identification of those end states contained in CEOG member TS Required Actions resulting from condition entries associated with one train or component out of service, whose modification to an alternate end state would either be risk neutral or result in an overall safety benefit. Consistent with the current TS philosophy, the recommended end state in the required action was taken to be a plant shutdown condition: either hot standby or hot or cold shutdown. That is, continued "at power" operation was not considered an alternate end state regardless of the risk. PRA evaluations are performed to establish the relative risks of plant maintenance in the various shutdown modes. Safety benefits of the hot standby/shutdown end state were seen to accrue from:

1. Allowing the plant to avoid unnecessary mode transitions during low risk maintenance evolutions and

2. Allowing operation of the plant in the shutdown state that affords greater redundancy and diversity of resources to be used for core and RCS heat removal.

Safety benefits were assessed following the general guidance presented in RGs 1.174 and 1.177 and their associated Standard Review Plans (SRPs).

As the risks associated with cold shutdown operation (with rare exceptions) are acceptable, it is not the intent of this effort to prevent the plant from entering Mode 5 should the plant staff desire to do so for operational needs or maintenance requirements. By implementing these changes, the plant will have the flexibility to simultaneously optimize risks associated with emergent work and reduce plant unavailability.

4.1 MODE DEFINITIONS

TS mode applicability is not addressed in this report. However, where appropriate, technical justification for continued plant operation in the proposed mode is presented.

Mode definitions used in this report are those used in Table 1.1-1 of Section 1.1 of the CEOG ISTS (Reference 1). The Improved Standard Technical Specifications defines six operational modes. These include 2 power Modes, 3 shutdown Modes and 1 refueling Mode (Mode 6). The Power modes include Mode 1 (power operation) and Mode 2 (Reactor Startup). The three shutdown modes are distinguished by RCS temperature and are termed hot standby (Mode 3), hot shutdown (Mode 4) and cold shutdown (Mode 5). Entry into Mode 5 is restricted to pressures consistent with the operational capability of the SDC system and RCS temperatures below 200 °F. This implies that while in Mode 5 the RCS coolant is subcooled. Thus LOCAs in this mode, should they occur, will proceed without attendant flashing and the initial blowdown inventory loss is minimized. The physical differences between Mode 3 and Mode 4 operation with steam generator heat removal, are subtle. Mode 3 operation may be accompanied with a wide range of RCS pressures (in some instances up to full system pressure) and RCS temperatures above 300 °F or so, based on the particular plant TS. Shutdown cooling operation cannot be accommodated within the restrictions of Mode 3 operation. Mode 4 spans the temperature range from the lower end of Mode 3 to the upper end of Mode 5 (200 °F). Mode 4 operation allows RCS cooling via either SG heat removal or SDC. Mode 4 entry may or may not require entry into Low Temperature Overpressure Protection (LTOP) procedures (plant specific). However, once the temperature of the LTOP setpoint is approached the proper adjustments are made. The LTOP system varies among CE PWRs. Many units rely on a Power Operated Relief Valve (PORV) readjustment to establish LTOP, while others utilize dedicated safety relief valves.

For purposes of this evaluation it is assumed that plant operation in Mode 4 with SG heat removal occurs while the plant RCS temperature is above the LTOP entry limit. On the other hand Mode 4 with SDC and Mode 5 operation will require that LTOP procedures be invoked. It was further assumed that Mode 5 operation was conducted with a normal RCS primary system configuration (i.e. SG nozzle dams not installed) and nominal RCS inventory.

4.2 END STATE REVIEW AND ASSESSMENT PROCESS

The End State Risk Informed Assessment effort consisted of the following steps:

(1) Identification of the target TSs for upgrade.

This effort consists of a review and screening of the ISTS and individual CEOG member TS LCOs to determine the candidate end states to be considered for modification. The evaluation considered all TSs with Mode 4 or Mode 5 end states. Some TSs were screened out as not being appropriate for change based on a preliminary risk assessment. The list of the selected TSs along with proposed changes to the end states is provided in Table 2-1.

(2) Risk informed assessment of the proposed TSs.

Risk assessments are performed for representative end states and LCO entry conditions using the SONGS units as representative plants. Risk insights gained from these evaluations are extrapolated to other PWR designs via use of sensitivity studies. Based on these studies the relative risks of plant operation/maintenance in the various shutdown modes may be established.

The risk basis for recommending a change to the defined TS end state is based on one or more of the following:

- A mode transition (e.g. 3 to 4, or 4 to 5) would pose a transition risk without realizing an associated decrease in longer term risk when operating in the target mode.
- Operation within the given LCO, in the recommended mode, poses an acceptably low overall risk. In most instances it will be shown that the recommended end state poses a lower overall plant operating risk than that which would be incurred by operating in the mode currently specified by the TS.

This risk reduction is typically attributed to either one or both of the following:

1. The recommended mode provides a greater degree of redundancy and diversity to ensure core cooling and RCS heat removal.
2. The equipment unavailabilities/inoperabilities associated with the failure to meet the LCO has a lower risk significance in the recommended mode.

A detailed discussion of the risk assessments performed is presented in Section 5.4.3.

(3) Consideration of Deterministic Issues and Defense In Depth.

The risk informed assessment considers issues associated with the proposed end state change by evaluating the impact of the modified LCO required action end state from the perspective of the plant design basis. It is the intent of this assessment to confirm that the shutdown modes defined in the proposed Required Actions maintains adequate Defense-In-Depth by demonstrating availability of functionally redundant systems in Mode 4, and/or showing that adequate margin exists to core damage and/or radiation release. The intent of the deterministic assessment is not to provide information to permanently change the plant design basis, but rather to identify that sufficient capability exists such that completion of a limited duration component repair operation may be conducted in a higher temperature mode (over that currently specified in the ISTS). Deterministic issues are discussed in Section 5.

5.0 ENGINEERING EVALUATION

This section describes the qualitative and quantitative assessments performed in the identification and assessment of CEOG member TS end state changes. Table 5.5-1 documents the list of TSs that were reviewed, the existing ISTS end state, the recommended end state and the supporting rationale for the recommendation.

5.1 COMPLIANCE WITH CURRENT REGULATIONS

The risk-informed assessment herein considers issues associated with the proposed end state change by evaluating the impact of the modified LCO required action end state from the perspective on the plant design basis. Evaluations presented in this report are in accordance with RG 1.174 and RG 1.177 for the treatment of risk informed changes to the plant Technical Specifications. This assessment confirms that the shutdown modes defined in the proposed Required Actions maintain adequate Defense-In-Depth by demonstrating capability of the plant to meet the intent of the plant design basis while operating in the proposed mode. In addition, Defense-in-Depth is assured by demonstrating margin to core damage and/or radiation release. Therefore, the proposed changes to required action end states are in compliance with all current regulations while meeting all license conditions.

The intent of the deterministic assessment is not to provide information to permanently change the plant design basis, but rather to identify that sufficient capability exists such that a short-lived, temporary component repair operation may be conducted in a higher temperature mode (over that currently specified in the plant TS). It is not the intent of this effort to prevent the plant from entering Mode 5 should the plant desire to do so for operational needs or maintenance requirements. Once implemented, these changes will afford the plant operator the ability to optimize equipment repairs in order to both reduce plant risks and reduce plant unavailability.

5.2 DEFENSE IN DEPTH (GENERAL)

Implementation of the proposed changes to the TS end states will improve the plant Defense-in-Depth capability by allowing the plant to minimize unnecessary configuration changes and to operate in a mode with increased resources for core and RCS heat removal. This conclusion is based on the detailed evaluation of the impact of the end state changes from a Defense-in-Depth perspective for each TS as documented in Section 5.5. A general discussion of the impact of the proposed changes on the plant Defense-in-Depth is provided below.

These technical specification changes request modifications to two types of LCOs. These are: (1) LCOs that are entered due to the INOPERABILITY of a single train of equipment, and (2) LCOs that are entered due to violation of a plant operational parameter. For the most part, these changes to the technical specifications seek modifications to many Action Statements that direct the operator to place the plant in Mode 5 following the continued inoperability of a single train of equipment. In all cases, the availability of the redundant train during the maintenance process ensures both an adequate level of Defense-in-Depth exists during the repair/maintenance process and that safety margins are maintained. In two instances associated with TS 3.3.5 (SONGS) and 3.3.6, redundancy of equivalent operable actuation signals was not required since the operator has ample time to diagnose and actuate the associated equipment. Where complex signal sequences were required, a recommendation was made to maintain equipment operability consistent with the ECCS-Shutdown TS.

TSs that involve violation of plant operational parameters include TSs 3.6.1, 3.6.4, 3.6.5 and 3.5.4. TS 3.6.1 involves containment inoperability resulting from excessive containment leakage (leakage in excess of L_a). Short term operation with the plant exceeding this leakage limit is acceptable since Mode 4 conditions adequately ensure Defense-in-Depth as a result of the lower potential for core damage events and the lower potential containment pressures, lesser radionuclide inventory, and stored energy contained within the RCS in this mode and that restrictions included in the proposed change reduce the potential of significant increases in leakage. Because of the importance of containment integrity, appropriate use of this end state condition will be carefully controlled via (a)(4) of the revised Maintenance Rule through implementation of the plant's Configuration Risk Management Program.

TS 3.6.4 and 3.6.5 involve limitations intended to support the Mode 1 containment design basis and the adequacy of environmental qualification limits on safety related equipment. In both Mode 4 and Mode 5, the core energy released during a core damage event would be much lower than in Mode 1, due to the rapidly decreasing decay heat. This decay heat is the same, whether in Mode 4 or Mode 5. In Mode 4, the plant is shutdown and RCS coolant temperatures are reduced to values in the neighborhood of at most 350 to 375 °F. At this level the stored energy contained within the RCS coolant, structure and fuel are well below that available for release to the containment during Mode 1 operation. This reduction in stored energy more than compensates for any credible potential increase in containment pressure or temperature beyond the Mode 1 design basis analysis limit. Thus, the potential for violation of the plant design basis containment limits is negligible. In addition, a loss of cooling event in Mode 4 would potentially progress slower than a loss of cooling event in Mode 5, steam generator inventory, is available in Mode 4 and may not be available in Mode 5. This additional inventory increases the time to core uncovery. This potentially slower progression in Mode 4 allows the operators additional time to prevent both core damage and release from containment.

TS 3.5.4 involves control of the boric acid concentration in the RWST. RWST inoperabilities due to boron concentration out of limits have negligible risk impact on the public while the plant is in a shutdown mode. Boron dilution concerns are mitigated by the fact that the plant is shutdown . Over-boration concerns are addressed by acknowledging the fact that the large LOCA event (which is the origin of the concern) is of very low probability. Also, the event progression is slower than at power (making operator misalignments less likely), and the concentrating process associated with the core boil-off is slower. It is also noted that the need for boration increases with reducing temperature. Thus, a Mode 3 shutdown end state for this TS is preferred.

5.3 SAFETY MARGINS (GENERAL)

Implementation of the proposed changes described in this change request should result in a net reduction in plant risk. In general, plant risks are reduced as a combined consequence of allowing plant operation in the resource rich environment (from the perspective of core and RCS heat removal), and that by not forcing the plant to cold shutdown for these TS required actions, plant realignment (and risks) associated with SDC entry may be avoided. The proposed recommendations for replacing the cold shutdown (Mode 5) required action with a recommendation to allow continued operation at hot shutdown (Mode 4) or hot standby (Mode 3) for a large number of TSs will also provide the plant operators the flexibility to optimize longer term equipment repairs in order to both reduce plant risks and reduce plant unavailability. Therefore, in the aggregate, this change involves an increase in safety, and not a reduction in plant safety margins.

Deterministically, plant safety margins are unaffected because the proposed change does not affect the plant design basis as governed by the DBA and transient analyses requirements set forth in the UFSAR. The proposed change is limited in scope to risk-informing those end state required actions (resulting from condition entries associated with one train or component out of service), whose modification to an alternate end state would either be risk-neutral or result in an overall safety benefit and a reduction in plant unavailability. Consistent with the current TS philosophy as required by 10CFR50.36, the recommended end state in the required action is taken to be a plant shutdown condition: either hot standby or hot or cold shutdown. The intent of the deterministic assessment herein is not to evaluate or provide information to support a permanent change of the plant design basis, but rather to identify that sufficient capability (and hence, sufficient safety margin) exists such that a short term temporary component repair outage may be conducted in a higher temperature mode than that currently specified in the plant TS (e.g. selection of Mode 4 versus Mode 5). Therefore, sufficient plant margins are maintained as a result of the proposed change to the end states.

For those situations where plant parameters are allowed to exceed design basis limits for extended periods, sufficient margin is afforded by the less challenging plant conditions during shutdown (i.e. rod insertion, lower stored energies in the RCS coolant, structures, and fuel, and lesser decay heat and volatile radionuclide content) so as to ensure an adequate level of safety is maintained.

5.4 EVALUATION OF RISK IMPACT

This section provides a detailed technical justification for the changes to the TS Required Actions recommended in Table 2-1. The TS changes are consistent with the recommendations of RG 1.174 and RG 1.177 and their associated SRPs.

The risk assessment supporting the TS change is divided into two sections. Section 5.4.2 provides a semi-qualitative discussion of transition and shutdown risks and the relative merits of plant operation in hot shutdown, as opposed to cold shutdown. Section 5.4.3 provides an example quantitative assessments of mode specific shutdown risks associated with a representative CE PWR (San Onofre Units 2 & 3). Results of this study are extrapolated to other PWRs via focused sensitivity studies. Analyses are performed using the San Onofre PRA shutdown model as an analytical basis. A summary discussion of the transition model used in the analysis is provided in Section 5.4.3.2.

The qualitative assessment provided below demonstrates that changing TS end states from Mode 5 on SDC to Mode 4 (or Mode 3) results in an increase in defense in depth for expected initiating events. For example, Table 5.4-2 shows that Mode 4 would have up to 6 systems (4 to 6, depending on plant design) available for providing cooling to the reactor, while Mode 5 would only have 4 systems (1-4, depending on plant design). The example quantitative assessment, including sensitivity cases, is used in this report to substantiate this qualitative assessment, and provides numerical results for the representative plant. However, the basis for the TS changes is the qualitative assessment and the defense in depth arguments presented. The overall result of this assessment is that each TS change represents an overall risk reduction or risk neutral change, since additional defense in depth is provided in the recommended end state and transition onto shutdown cooling is avoided.

In performing the risk assessment it is assumed that the entry into the shutdown mode under consideration is for a limited interval with the primary intent of that entry being to repair a non-functional component and return the plant to power.

To complete the risk assessment, sensitivity studies are used to establish the significance of model and data uncertainties, and to assess the applicability of the results to other PWR designs.

5.4.1 GENERAL ASSUMPTIONS

The risk impact of the Mode change is evaluated (qualitatively and quantitatively) subject to the following restrictions:

1. For purposes of this evaluation, it is assumed that plant operation in Mode 4 with SG heat removal occurs with LTOP and SDC not aligned. On the other hand, Mode 4 with SDC and Mode 5 operation will require that LTOP procedures be invoked. (Mode 4 analyses predict that entry into LTOP increases plant risk for inadvertent LOCA due to spurious opening of the LTOP valve.)

2. In assessing risk (qualitatively and quantitatively) it is assumed that the entry into the shutdown mode under consideration is for a short interval with the primary intent of that entry being to repair a non-functional component and return the plant to power as soon as practical.

3. Consistent with the current TS philosophy, the recommended end state in the required action was taken to be a plant shutdown condition: either hot standby or hot or cold shutdown. That is, continued "at power" operation was not considered an acceptable end state regardless of the risk.

4. TS mode applicability is not addressed in this report. However, where appropriate, technical justification for continued plant operation in the proposed mode is presented.

5. The risk results are based upon initial plant conditions following shutdown. As the time from shutdown increases, and the time to core damage from a potential loss of cooling event increases, the risk will decrease. The results shown are therefore conservative for plant shutdown greater than a few days. Comparisons between the risks in Mode 4 and Mode 5 are, however, still valid since the corresponding risk for each mode will decrease as the core power decreases.

6. It is assumed that the RCS remains at its nominal inventory and the RCS strength is not compromised (for example, via installation of nozzle dams).

7. Mode 5 operation does not consider reduced RCS inventory or reduced RCS integrity operating conditions. Mode risk comparisons are therefore conservative when one compares risks between Mode 4 and 5.

5.4.2 QUALITATIVE RISK ASSESSMENT

Plant risks at shutdown are conceptually similar to those that occur during power operation. However, the "shutdown" nature of the core ensures adequate reactivity control, reduces core heat addition, and generally the lower decay heat and lower initial stored energy results in more time for successful operator intervention. Qualitative risk comparisons between Mode 4 and Mode 5 operation are considered from the perspective of Critical Safety Functions and Risk Parameters (initiating events and mitigating systems).

5.4.2.1 Qualitative Assessment of Shutdown Mode Critical Safety Functions

Successful operation during shutdown requires that adequate means exist to maintain the following critical safety functions per NUMARC 91-06 (Reference 15):

- Core Decay Heat Removal
- Inventory Control
- Reactivity Control
- Containment Integrity Control
- Power Availability

A comparison of the Critical Safety Functions during Mode 4 and Mode 5 operation are discussed below.

a) Core Decay Heat Removal

CE plants utilize several means of accomplishing RCS heat removal during normal and post accident operation. These include:

1. Steam generator via motor or turbine driven Main Feedwater (MFW) pumps.
2. Steam generator via Motor Driven Auxiliary Feedwater (MDAFW) pumps.

3. Steam generator via use of motor driven condensate or startup pumps.
4. Steam generator via Turbine Driven Auxiliary Feedwater (TDAFW) pumps.
5. Steam generator via Diesel Driven AFW (FCS only).
6. Shutdown Cooling System (via use of LPSI pumps).
7. Shutdown Cooling System (via use of CS pumps).
8. Once through Core Cooling (OTCC) (via HPSI and PORVs).

During Mode 4 operation most plants have available Items 3, 4 and 6. Some CE plants also have the potential removal paths via MDAFW (Item 2) and one plant has available a diesel-driven AFW pump (Item 5). OTCC is also available for plants with PORVs. The availability of turbine driven pumps provides a diverse heat removal path not entirely dependent on AC power. Mode 5 heat removal is typically limited to Items 6 and 7. Use of CS pumps to backup LPSI pumps requires the RCS to be vented. This effectively prevents the use of TDAFW pumps since the SG can not be used to produce steam.

b) Inventory Control

Similar to heat removal, CE PWRs utilize several means of mitigating loss of RCS inventory control during shutdown. These include High Pressure Safety Injection (HPSI), Containment Spray (CS), Low Pressure Safety Injection (LPSI) and the Chemical and Volume Control System (CVCS) via the charging pumps. The inventory source for LPSI and HPSI is the RWST.[2] The LPSI system can either perform the RCS safety injection function to provide RCS inventory or perform shutdown cooling to provide for decay heat removal. The CS system also has dual functions of either providing RCS inventory control, or cooling the containment following an accident. Some PWRs include the capability of the CS pumps to backup the LPSI pumps for the purpose of SDC. Some CE PWRs include the capability to gravity-feed the water from the RWST to a depressurized RCS if power to the LPSI and HPSI system is unavailable and a large RCS vent path is available. Inventory sources and injection paths are typically controlled by shutdown configuration control programs and are not substantially different in Modes 4 and 5.

c) Reactivity Control

The primary purpose of the reactivity control safety function is to maintain adequate shutdown margin in the RCS and the spent fuel pool. A boration system is provided to ensure that adequate shutdown reactivity margin exists to bring the plant to cold shutdown conditions (Mode 5) with the worst Control Element Assembly (CEA) stuck out and the decay of all xenon poison.

These systems are also sufficient to mitigate possible return to power scenarios following a Main Steam Line Break (MSLB). The boration function can be performed by the charging pumps feeding the RCS from either the RWST or the Boric Acid Makeup (BAMU) tanks via the BAMU pumps, or in some instances, gravity feed. During accident scenarios, HPSI may also be used to borate the RCS via injection from the RWST.

For shutdown conditions considered in this report, it is assumed that the plant shutdown process was uneventful and all rods are inserted. Availability of all rods during shutdown avoids potential ATWS scenarios and provides added shutdown margin as compared with at-power transients.

[2] CE PWRs utilize several designations for this tank including RWT and Safety Injection Refueling Water Tank (SIRWT).

d) Containment Integrity Control

The containment integrity control safety function primarily focuses on ensuring containment integrity and limiting offsite exposure due to events leading to core damage. Containment heat removal systems are designed to cope with large, rapid, highly energetic releases of mass into the containment from full power operation. All CE PWRs with the exception of the Palo Verde units maintain containment heat removal capability via a combination of CS trains with associated heat exchangers and/or containment emergency fan coolers. CS provides a means for injecting water from the RWST to the containment through the spray headers to provide a containment pressure suppression mechanism and a vehicle for removing fission products from the containment atmosphere. In the recirculation mode, CS provides long term containment cooling by taking suction from the containment sump and discharge to the spray headers utilizing the SDC heat exchangers. Palo Verde units provide containment protection via two redundant Containment Spray Pumps. As a result of the low energy content in the RCS in Mode 4 (and even lower content in Mode 5) containment heat removal systems have ample margin to respond to and mitigate containment challenges with partial system operation.

e) Power Availability

The power availability safety function ensures that electric power is available during shutdown events to maintain cooling to the reactor core and spent fuel pool, to provide RCS inventory when needed, to achieve containment closure when required, and to support other important functions. AC and DC instrumentation and control power is required to support systems that perform critical safety functions during shutdown operations. Redundant offsite and onsite electrical power supplies are provided to support critical safety functions.

The electrical AC and DC power sources are designed to provide sufficient capacity, redundancy and reliability to ensure the availability of power to ESF systems so that the fuel, RCS and containment design limits are not exceeded during power and shutdown conditions. SDC operation is entirely dependent upon availability of AC power.

f) Summary

With the exception of the Turbine Driven Auxiliary Feedwater (TDAFW) Pump, equipment supporting critical safety functions is dependent on the availability of onsite or offsite AC power. (Note, while the turbine-driven MFW pump does not rely on power, it is not expected to be operable at low temperature "wet" steam conditions typical of Mode 4.) In addition, even though RCS heat removal via turbine and diesel driven AFW pumps may be established without AC power, DC power is required to operate SG level instrumentation to ensure this action is successful. However, the availability of the feedwater source provides many additional hours of core cooling which would otherwise be unavailable for a significant class of shutdown events.

In a pragmatic sense, core integrity is assured provided one means of heat removal is available to cool the core. Furthermore, the Mode 4 shutdown conditions that offer the greatest redundancy and diversity in providing core heat removal will exhibit the lowest risk. This concept will be explored further in the Section 5.4.2.2 and is approximately quantified in Section 5.4.3.

5.4.2.2 Qualitative Assessment of Shutdown Mode Initiating Events and Lower Mode Mitigating Systems

This section provides a qualitative assessment of the Modes 4 and 5 risks via comparing the likelihood of initiating events and availability of mitigating systems. Section 5.4.2.2.1 compares the differences between "at power" and shutdown operation (Mode 4 and Mode 5). Section 5.4.2.2.2 discusses Mode-dependent event mitigation capability. It is the intent of these discussions to qualitatively establish the acceptability of Mode 4 end states as the default action for most TSs where partial equipment availability is assured and a short-term repair is possible.

5.4.2.2.1 Shutdown Mode Initiating Events

In general, accidents that occur at shutdown will proceed in an analogous manner to accidents that occur at power operation, with the exception that control rods are initially inserted (i.e. an Anticipated Transient Without Scram Event (ATWS) is not possible), the initial stored energy in the fuel and RCS, and core power production are much less than at power. Hence, events proceed more slowly providing operators with longer times to take remedial actions. Consequently, shutdown events pose a lesser threat to the core and containment. Table 5.4-1 provides a summary comparison of the key at power initiating events with Mode 4 and Mode 5. The table also includes three columns which define whether or not the initiating event is considered in the SONGS PSA evaluation (Section 5.4.3).

Table 5.4-1
Comparison of "At Power" and "Shutdown" Initiating Events

Initiating Event	Event Considered "At Power"	Event Considered in Mode 4	Event Considered in Mode 5	Comment
ATWS	Y	N	N	Event not possible during shutdown.
Large LOCA	Y	Y	N	Frequency of event significantly lower for low pressure operational conditions. Lesser stored energy results in slower heatup, requiring less mitigation capability.
Medium LOCA	Y	Y	N	Alignment to SDC increases potential for Loss of Inventory events due to induced flow diversions.
Small LOCA	Y	Y	N	
Main Steam Line Break	Y	N	N	Large catastrophic main steam line breaks are not credible in shutdown modes. In Mode 4, small failures of steam lines are possible during TDAFW operation. No consequence for core melt except if SLB is an initiator for a Loss of feedwater event.
Steam Generator Tube Rupture	Y	Y	N	Risk of spontaneous steam generator tube rupture is less than at full power for Mode 4 low pressure operation. SGTRs are negligible when on SDC. SGTRs at shutdown proceed slowly, and the time required to transition to SDC is short.
Loss of Offsite Power	Y	Y	Y	Loss of offsite power event frequency is expected to be greater during shutdown due to increased switchyard activity and potentially less stable electrical grid.[d]
Loss of Load	Y	N	N	No load present in shutdown.
Loss of Vital Bus	Y	Y	Y	Event considered in all modes.
Loss of Component Cooling Water	Y	Y	Y[a]	For Modes 4 and 5 this event is considered within context of loss of SDC, as CCW is relied upon as the primary means (and in some plants the only means) for SDC heat removal.
Loss of Feedwater	Y	Y[b]	N	Loss of FW in shutdown modes varies based on an assumed FW source, type and operational mode. Considered in Modes 3 and 4.
Boron Dilution	Y	N	N	At power, boron dilution events are considered trip initiators. Slowly progressing event with ample time for operator action. Not considered a core damage scenario.[3] At shutdown, rapid boron dilution events are not considered due to high level of control of non-borated water sources.
Loss of Inventory	N	Y[c]	Y	Event results in loss of inventory during plant realignments associated with transitioning into SDC.
Loss of SDC	N	N	Y	Loss of SDC not considered in Mode 4 with SG HR. Events that lead to loss of SDC are considered in Modes 4 and 5

Notes:

(a) CCW is assumed to provide cooling to SDC HXs. The designation or this system may vary among plants.
(b) Both TD and MD AFW pump conditions analyzed.
(c) Considered during realignment from SG HR to SDC entry.

[3] Core damage due to introduction of an unborated water slug into the RCS is unlikely due to maintenance and pump restart procedures which ensure a borated water source.

(d) This assumes that in the lower temperature mode the plant may take advantage of the longer anticipated shutdown time to perform "scheduled" maintenance, potentially increasing switchyard activity. In addition the shutdown plant may result in a potentially less stable grid.

While the shutdown RCS is subject to many of the same accident initiating events as might occur at power, their frequency of occurrence is different and the event progression is typically slower. Events that are driven by energetic failures of the RCS (e.g. large LOCAs) are expected to be much reduced in probability due to the lower pressure operation associated with some of the shutdown modes. In addition, experience has shown that events associated with loss of power are more frequent due to potential for increased switchyard maintenance and lower grid stability. As can be seen from Table 5.4-1, the accident initiators during shutdown modes include: LOCAs, Steam Generator Tube Ruptures (SGTRs), Loss of Feedwater Events (LOFW), Loss of Offsite Power Events (LOOP), Loss of Shutdown Cooling (LOSDC), Loss of Inventory (LOI) and Loss of Component Cooling Event and Boron Dilution Events. These event classes are discussed in additional detail below.

<u>ATWS and Boron Dilution Events</u>

Events not considered in the Mode 4 or Mode 5 assessments include ATWS and core damage initiated via slow or rapid boron dilution. ATWS is precluded in this assessment as it is assumed the core has achieved an unremarkable shutdown with all rods inserted. Slow boron dilution events are typically not analyzed in "at power" PSAs due to the relatively long time required to initiate core damage, close control of unborated water sources and the availability of adequate nuclear instrumentation to trend approach to criticality following post-trip events. Slow boron dilution events have similarly not been considered as core damage initiation for shutdown conditions. Rapid boron dilution events may be postulated to occur as a result of maintenance on standby systems. Particular systems of concern would be the ECCS and other systems which are directly connected to the RCS. Boron concentration of water in these lines is assessed via maintenance procedures and may be sampled via the normal sampling system. In any event, the expected impact of any boron dilution incident would be similar in shutdown in Modes 4 and 5.

<u>LOCAs and SGTRs</u>

LOCAs and SGTRs are to a large extent pressure driven initiating events, and are expected to decrease in frequency as the RCS transitions from Modes 3 to 4 and are entirely negligible once SDC is entered. For most plants entry into Mode 4 results in RCS pressure restrictions which would decrease the random pipe failure frequency associated with these events. Should a SGTR event occurring Mode 4, the cooldown response to a SGTR event is significantly shortened and RWST inventory requirements are reduced in Mode 4. These features decrease the likelihood that a Mode 4 SGTR would result in core damage. As discussed below, the process of SDC entry increases the potential for events causing a decrease in RCS inventory due to inadvertent flow diversions. While these events are not defined as LOCA, extended flow diversions may result in core uncovery and fuel damage.

<u>LOOP and Loss of Vital Bus</u>

Loss of Vital Bus and the Loss of Offsite Power (LOOP) are important initiating events at all plant modes. Based on an (INEL) review of LOOP precursors at shutdown, shutdown modes will likely experience an increase in LOOP frequency. This was attributed to a decrease in grid stability and an increased potential of power loss due to maintenance-related human errors as switchyard activities and maintenance on switchyard components increase.

Loss of Feedwater Events

LOFW events are initiators in Modes 1 through 4. In Mode 1 the event is associated with a loss of main feedwater flow. Typically this category of initiating event has a frequency of occurrence of 1 to 3 per year. In shutdown modes (particularly in Mode 4) the event is associated with the loss of the auxiliary feedwater or emergency feedwater train. Following a loss of AFW/EFW the plant staff would attempt to either restore SG cooling or take the necessary steps to enter SDC. Since Mode 4 operation already requires entry conditions compatible with SDC (or nearly so), the process of establishing SDC can be readily implemented. Since Mode 5 operation implies SDC operation, LOFW during that mode is not a credible initiating event.

Loss of CCW

Loss of CCW is considered an initiating event in Mode 1. However, it is not directly considered an initiating event in Mode 4 or 5 due to the relative independence of AFW or CCW. In Mode 4 on SDC or in Mode 5 a loss of CCW can lead to a loss of SDC (as discussed below). In the shutdown modes, CCW (or equivalent) has two important functions: (1) Remove heat from the SDCS and transfer it to the ultimate heat sink via the SDC HX and (2) provide cooling to RCP seals. The impact of loss of the SDC HX heat removal capability would be to fail that RCS heat removal pathway. This is indirectly considered in the current PSA evaluation as a contributor to the loss of SDC event. CCW induced RCP seal failures are primarily of concern with continued pump operation. RCP seals in use at CE designed PWRs are robust and include multiple full pressure seal stages each capable of withstanding extended exposure to full RCP operational pressure at high RCS temperatures.

A limited loss of CCW may impact RCP seal cooling with RCPs in operation without affecting SDC heat removal. RCP seals used in CEOG PWRs have exemplary performance and have been shown to be robust to a wide range of upsets. Anecdotal information suggests that one CE PWR had run at power for a period of 45 minutes without significant degradation (Reference 16). Similar performance has been confirmed via tests. RCP tests performed on N-9000 designs (typical of many CE PWRs) indicate excellent seal performance following a 30 minute loss of CCW (Reference 17). These tests exposed the RCP seals to both high temperatures (~ 560 °F) and high pressures. Even at the upper temperature end of Mode 4, RCS temperatures are relatively low (< 400 °F) and provide only a negligible threat to the seals' elastomers. Furthermore, system pressure in Mode 4 is typically lower than normal operating pressure. Thus, seal performance should be robust to short duration CCW upsets. Cooling the RCS down to ~ 300 °F (or near SDC entry) would typically be sufficient to prevent degradation on the most susceptible seal stage and to minimize any potential leak for an event, should it occur. In Mode 4, restoration of SG cooling on a loss of SDC would be possible as a result of the long time available for operator action, and the low potential for a gross seal failure, modest resultant leak rates and the availability of ample mitigation resources, this scenario has not been explicitly included in the shutdown PSA.

Loss of Shutdown Cooling

Loss of Shutdown Cooling (LOSDC) may be caused by many factors, including failure of SDC pumps, failure of CCW or other cooling water pumps, failure of support systems, or a loss of offsite power. The frequency of occurrence for this type of event is on the order of the loss of feedwater event (loss of AFW in Mode 4), or greater than 1 per year. Following a loss of SDC, the plant staff would attempt to restore SDC via the standby pump, or a backup pump such as the Containment Spray pump (plant dependent), or take the necessary actions to heat up the RCS to restore SG cooling. If the RCS is vented, restoration of SG cooling may not be possible. Additionally, if the plant is originally in Mode 5, the operators may be reluctant to allow an un-controlled heatup to Mode 4 since operator training emphasizes that mode changes should be controlled. In Mode 4, restoration of SG cooling on a loss of SDC would be possible, since no RCS vent would be present, and an uncontrolled mode change would not be required to re-establish SG cooling.

Loss of Inventory

A Loss of Inventory (LOI) event can occur through a number of pathways, most likely associated with the alignment of SDC. As discussed in Section 3.1, an LOI can occur through an inadvertent lift of an LTOP valve, which would result in a release to containment. More common LOI events are diversion of SDC flow outside of containment, such as to the RWST. The most likely time for an LOI to occur is during the initial alignment of SDC, or when operating near the LTOP setpoint. The risk is therefore greatest during the transition onto SDC in Mode 4, and can be avoided by not requiring transition onto SDC. Many of the events described in Section 3.1 could have been avoided if this transition were not required for all shutdowns.

The frequency for an LOI event is generally higher than full power or Mode 4 LOCA and SGTR events. Generally, the estimated frequency for an LOI is around 1 in ten years. Following an LOI, plant staff would attempt to isolate the leak, which may include isolating SDC. Each of the events discussed in Section 3.1, was terminated by isolating the leak. Some leaks may be non-isolable, and would then require plant staff action to provide injection in a similar manner to full power LOCAs. If decay heat is low, CVCS may be sufficient to keep the core covered. Additionally, HPSI, LPSI or Containment Spray (plant dependent) backup to LPSI may be used. Gravity feed may be available, but is generally not credited in Mode 5, due to the need for a large RCS vent and potential problems with pressurizer surge line flooding.

A core damage event following an LOI outside of containment would be considered a bypass event (ISLOCA) event. Although the RCS energy would be much less than full power due to the lower decay heat, the event would release directly to atmosphere. This would be the equivalent to a shutdown LERF event.

5.4.2.2.2 Mitigating Systems In Lower Modes

The ability of the plant to respond to plant challenges in shutdown modes is largely dependent upon the diversity of the plant resources for core heat removal. As the plant transitions from Mode 3 to lower temperature shutdown modes, availability of mitigating systems also decreases and the dependencies of these systems on a power source becomes of increased importance. Expected availability of equipment in the various shutdown modes is summarized in Table 5.4-2.

Table 5.4-2 Typical Summary of Plant Systems Available in Shutdown Modes 3 to 5			
System	Modes		
	3 (Hot Standby)	4 (Hot Shutdown)	5 (Cold Shutdown)
MFW	(b)	(b)	-
Condensate	√	√	√
MDAFW	√	√	(g)
TDAFW (a)	√	√	(d), (g)
HPSI & PORV	√ (f)	√ (f)	(e)
SDC	(c)	√ (c)	√ (h)

(a) RCS heat removal not dependent on offsite power, (DC power supports SG level instrumentation).
(b) MD MFW may be available at some plants.
(c) Potential for SDC operation following event provided Mode changes to 4 or 5 implemented. SDC is optimal in Mode 4.
(d) TDAFW may be established following an event in Mode 5, however, heatup into Mode 4 conditions would be required. This may be restricted as an unplanned mode change and would be avoided by operating staff.
(e) OTCC may be accomplished via use of HPSI and LTOP system, however; guidance may not be in place and this recovery is not credited.
(f) Not available to SONGS Units 2 & 3, PVNGS Units 1, 2 & 3 and Waterford Unit 3.
(g) May be used to backup SDC providing RCS is not vented to support CS backup.
(h) CS pumps may be used to backup LPSI as an SDC pump provided RCS is vented.

5.4.2.2.3 Summary of Qualitative Assessment

In summary, for plant conditions that do not compromise the effectiveness of AFW, plant operation in Mode 4 typically offers the greatest robustness to plant upsets due to its greater diversity and redundancy of components or systems to effect RCS heat removal. These factors, coupled with the reduced initiating event frequencies for RCS LOCAs and SGTRs, result in anticipated plant risks that are similar to, or lower than Mode 5 risks, dependent on which mode of heat removal is selected in Mode 4 and if the RCS is vented in Mode 5. Section 5.4.3.4 provides an example quantification of these concepts.

5.4.2.3 Comparison of CEOG RCS Heat Removal Capabilities at Shutdown

Section 5.2.1.2 presented a discussion of representative plant capabilities available during shutdown Modes 3, 4 and 5. This section provides a comparison of shutdown mode entry conditions/restrictions and system availabilities among the CE PWRs. This information is summarized in Table 5.4-3 and discussed below.

5.4.2.3.1 Mode 4 Entry Conditions

Table 5.4-3 shows general agreement with Mode 4 entry conditions, reflecting a relatively common definition of the Mode 4 state. The FCS Technical Specifications are customized and have no formal definition for hot shutdown. One operational mode spans the entire region from low power to cold shutdown.

Of the plants with standardized Technical Specifications, entry into Mode 4 typically occurs between 300 °F and 350 °F. The Mode 4 pressure restrictions are less consistent among the units. Upper Mode 4 pressures are typically limited by the Reactor Vessel P-T curve, however these limits are variable among units and tend to allow potentially increased pressures, including pressures to near operating pressures. In two specific instances (Calvert Cliffs Unit 2 and San Onofre Units 2 & 3) the maximum Mode 4 pressures were identified as 170 psia and 400 psia respectively. Units with low pressure restrictions will ensure that LOCA and SGTR event frequencies are negligible. When pressure is maintained near operational levels, LOCA initiating event frequencies will be similar to that of normal operation, and SGTR initiating event frequencies may be higher. However, even without the high pressure restrictions, continued high pressure operation at low temperatures (while potentially allowed in some ISTS versions) is not an expected end state. Furthermore, once SDC is entered, LOCA and SGTR contributions become negligible. LTOP Operation is also available around 400 psia, while SDC Operation is available at 375 psia (300 psia for ANO). So although SDC alignment may not be performed while in Mode 4, SDC would be available as a backup for AFW in Mode 4 operation. This provides both redundancy and diversity for most loss of cooling events in Mode 4.

5.4.2.3.2 Feedwater Equipment

The ability to provide feedwater to the plant may be mode dependent. In hot standby, FW supply to the SGs may be provided by the Main Feedwater system. Main feedwater is supplied by turbine driven pumps for most CE PWRs. These pumps cannot be used for FW flow at conditions of reduced steam quality associated with Mode 4 (hot shutdown). Plants with Motor Driven MFW pumps are FCS and St Lucie Units 1 & 2. These plants may be able to utilize MFW in Mode 4 as well.

All CE units include at least 1 TD EFW pump, and 1 MD EFW (N.B. the EFW and AFW are alternate designations used to refer to the same functions). The only CE plant with 2 TD EFW (AFW) units is Calvert Cliffs. Availability of TD EFW is a mitigating factor with respect to plant upsets caused by loss of AC power. Turbine pumps provide a non AC power dependent RCS heat removal mechanism. DC power is required to enable instruments used for the SG heat removal process. This power source may be provided to the plant for a finite duration following a Station Blackout Event. Once battery power is depleted, heat removal via TDEFW is dependent upon operator strategies to "blind feed" the SG without causing a SG overfill condition.

5.4.2.3.3 Other Steam Generator Heat Removal Capability

All CE plants have alternate means of injecting feedwater into the SG. These means include either use of plant condensate pumps, startup FW pumps and/or other safety pumps.

5.4.2.3.4 Once Through Core Cooling (OTCC)

Core heat removal may also be accomplished by OTCC. CE plants with the exception of San Onofre Units 2 & 3, Waterford Unit 3 and Palo Verde Units 1, 2 & 3, are equipped by PORVs, or as in the case of ANO-2, the ECCS vent system. Plants without PORVs cannot implement OTCC prior to entry into Low Temperature Overpressure Protection (LTOP). Once LTOP is entered, OTCC may be possible via the LTOP system, however, unavailability of procedures may impede the system's application. OTCC is not credited in the SONGS base Modes 4 and 5 analysis presented in Section 5.4.3.

5.4.2.3.5 Shutdown Cooling Systems

All CE PWRs utilize LPSI pumps to provide SDC flow to the reactor. The alternate heat sink used varies among the units, as does the redundancy in these systems. All SDC systems require power for operation. About half of CE SDC systems may utilize CS pumps to backup LPSI pumps. While this adds to system redundancy, both pumps are dependent on AC power and their use as backup typically requires venting the RCS so that SG inventory (if available) would not be useful in delaying the accident progression.

Table 5.4-3
Comparison of CE Plant Design Features Relevant to End State Issues

	ANO-2	CC	FCS	MP2	PAL	PVNGS 1, 2 & 3	SONGS 2 & 3	SL 1	SL 2	WSES 3
Mode 4 conditions										
Entry RCS temp, deg F	300	< 300	515 – 210(1)	<300	-	350	350	325	325	350
When above LTOP conditions, are there limits or procedures that limit RCS pressure in Mode 4?	Yes (10)	Yes < 170 psia	Yes (10)	Yes (10)	Yes(10)	Yes (10)	Yes (10)	Yes(10)	Yes (10)	Yes (10)
Equipment										
# MD EFW pumps	1	1	1	2	2	1	2	2	2	2
# TD EFW pumps	1	2	1	1 (6)	1	1	1	1	1	1
# MD MFW pumps	0	0	3 (7)	0	0	0	0	2	2	0
# TD MFW pumps	2	2 (8)	0	2	2	2	2	0	0	2
O-T-C-C Capability (Feed and Bleed)										
OTCC via PORVs	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No
OTCC via LTOP(14)	Yes	Yes (4)	Yes	No	Yes	No	Yes	Yes	Yes (5)	No
Other SG Heat Removal Capability:										
Condensate pump	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes (9)	Yes (9)	Yes (3 pmps)
Other	Yes - 1 non-SR MD AFW pump	(11)	Yes – 1 diesel driven AFW pump	No	No	Yes (12)		No	No	Yes (13)
SDC Capability:										
LPSI pump	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CS pump	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No
Mode 5										
RCS vented to low pressure prior to using CS pump as backup for SDC?	below 75 psia	below 170 psia	NA	NA	-	No	Yes	NA	NA	NA

Notes:

(1) For Fort Calhoun, Mode 3 is Hot Shutdown, Mode 4 is Cold Shutdown, and Mode 5 is Refueling Shutdown	(2) Based on suction pipe on CS pumps rated at 200 psig
(3) Based on Pressurizer Safety Pressure	(4) Proceduralized Action
(5) PORVs used for LTOP	(6) One 200% capacity pump
(7) Three 50% capacity pump	(8) Two 60% capacity pumps
(9) Condensate pumps will feed the SG at SG pressures below 600 psig	(10) Based on plant P-T curves.
(11) Cross-connect between EFW pump motors for Units 1 & 2	(12) 1 non-safety motor-driven AFW pump (Class power)
(13) 1 motor-driven, non-safety AFW pump	(14) OTCC may be established using HPSI & LTOP valve for some heat removal sequences.

5.4.3 QUANTITATIVE RISK ASSESSMENT

This section along with Sections 5.4.4 and 5.4.5 provide a quantitative representation of the risks of Core Damage associated with both continued plant operation in the shutdown modes and transition risks between modes. The analyses are performed using SONGS Units 2 & 3 as a representative CEOG PWR. Selection of SONGS Units was considered conservative for this application since these units cannot credit OTCC as an alternate heat removal path during Mode 4. It was further assumed for conservatism that TDAFW would not be credited in Mode 4. Inclusion of either or both of these features would further improve the plant Mode 4 response over that expected during Mode 5.

The scope of evaluation was to provide a quantitative assessment of the risks associated with mode transition and the comparative risks of "short term" continued operation in Modes 3, 4 and 5. The intent of these evaluations is to demonstrate the impact of equipment redundancy and diversity on the risk of shutdown operations so that a realistic risk informed view of plant risk in shutdown modes may be developed.

The SONGS analyses in Modes 3, 4 and 5 were performed subject to the following:

1. OTCC (Feed and Bleed) not considered in any SDC Mode.
2. TDAFW will not be implemented for accidents in Mode 4 and is unavailable for accidents initiated in Mode 5.
3. Mode 3 does not credit potential for use of MFW.

In general, the assumptions reflect both plant design issues (Items 1 & 3) and plant expectations for San Onofre (Item 2).

5.4.3.1 Methodology

The quantitative risk evaluations employed the upgraded transition modes and shutdown modes risk models included in the SONGS Units 2 & 3 Safety Monitor. The transition modes model applies to Modes 2, 3 and 4 (on AFW), while the shutdown modes model applies to Modes 4 (SDC), 5 and 6. The transition modes model was based upon a modified version of the SONGS at power model, adjusted as discussed in the assumptions section below. These adjustments account for the mode specific features and initiating event challenges.

The shutdown modes model is based upon the SONGS 2 & 3 shutdown PRA. This PRA has been used since 1994 for analysis of outage risk. The model was converted and added to the SONGS Safety Monitor model in 1997-8. The shutdown model includes the following specific initiating events:

- <u>Loss of SDC events</u>: This fault tree development includes loss of the running SDC train, loss of power, Loss of HVAC and Loss of Cooling Water.
- <u>Loss of Offsite Power</u>: This includes sequences for both a plant centered LOOP and Grid LOOP.
- <u>Loss of RCS or Fuel Pool Inventory</u>: This includes misalignments during SDC entry, failure to isolate a draining activity, and other loss of RCS inventory events.

The shutdown and transition mode models use the same system and top logic fault tree model as was developed for the SONGS power PRA. Additional fault tree models were needed to complete the shutdown PRA, and were developed using the same method, quality, and level of completeness as used in the full power model. These models are maintained and updated with the full power model, as described in the PRA Quality section of this report.

Model Assumptions

As discussed previously, the SONGS model conservatively neglects the availability of the TDAFW to provide FW to the SG while the plant is in Mode 4. Additional assumptions included in the SONGS model are as follows:

1. The SONGS Shutdown analysis for Mode 5 assumed the RCS was vented to atmosphere so that one CS pump would be initially available to backup SDC. For plants with low pressure CS piping, venting the RCS ensures RCS repressurization cannot occur and is required since CS suction piping is designed for low pressure operations (See also Item 2).

2. For many CE PWRs, the CS suction piping is low pressure piping, and is assumed not available in Mode 4, since both Mode 4 entry and SDC entry conditions are both well above the CS suction piping design.

3. Additional assumptions included in the SONGS shutdown and transition risk models are as follows:

    a. Pressurizer Safety Valve lift probability is reduced by a factor of ten (10) in Modes 2 & 3 and set to zero in Mode 4. This reduction is based on the lower PSV challenge potential posed by transients initiated in the shutdown mode.

    b. ATWS frequency is set to zero in Modes 3, 4 and 5.

    c. Loss of Inventory frequency is increased by a factor of 10 in Mode 4 to account for valve misalignments during SDC entry.

    d. Mode 4 loss of PCS/MFW frequency is increased to result in a yearly running failure for AFW.

    e. Loss of Offsite Power (LOOP) initiating frequency is increased for Modes 3, 4 and 5 by a factor of 3.45. The increased LOOP IEF is based on the results of an INEL study which attributes the increased shutdown Loss of Offsite Power to the potential for increased switchyard maintenance and the decrease in grid stability associated with a plant shutdown.

    f. Turbine/Reactor Trip frequency is set to zero for Modes 3 and 4, as no power is produced during shutdown.

    g. The failure to start probability for the running motor driven AFW pump, (assumed to be MP-504 for SONGS), is set to zero, along with the discharge valve active failures to the two SGs for Mode 4 (AFW).

    h. Probability of non-recovery of MFW is set to 1.0, while probability of non-recovery of condensate is set to 0.006 for Modes 3 and 4.

    i. All LOCA, Steam Line Break (SLB), and SGTR frequencies are reduced by a factor of 20 in Mode 4. This factor is approximate and reflects plant operation at lower RCS pressures.

j. Loss of Component Cooling Water (CCW) initiating event frequency is set to zero in Modes 3 and 4 (AFW). These models rely on SG for heat removal. LOCCW will require plant depressurization and either heat removal via SDCs or via natural circulation (as RCPs will be tripped). The probability of these events leading to core damage is negligible, as the low RCS temperatures and pressures associated with Mode 4 operation are not conducive to RCP seal failure, and RCPs are not required for SG heat removal.

k. Probability of non-recovery of offsite power in 60 minutes is reduced to 0.1, based on a 2 hour minimum recovery time in Modes 3 and 4.

l. Conditional probability of loss of offsite power due to reactor trip is set to zero in Modes 3 and 4 as the plant is already in a shutdown mode.

m. Turbine driven AFW pump [(MP-140) for SONGs model] is not credited in Modes 4 and 5. This upwardly biases Mode 4 risks with respect to Mode 5 risks and is considered a conservative assumption.

n. Loss of Power Conversion System (PCS)/MFW frequency is increased by a factor of 4 in Mode 2.

o. Success criteria (i.e. inventory makeup requirements and operator action times) are based on calculations of RCS and SG inventory of boil off assuming nominal decay heat rates at various times after reactor shutdown (scenario dependent).

5.4.3.2 Transition Risks

Plant transitions expose the plant to additional operational risk. These risks are typically accumulated in a short time frame. The increased risks from plant transition arise from the impact of the plant transition on increasing plant trip and loss of power event frequencies, and by errors occurring during valve and system realignments required by some transitions. The most common plant transitions are from full power to the shutdown modes. These risks have been estimated using CEOG transition risk methodology to be on the order of 10^{-6} for an uncomplicated shutdown. This transition risk is important in making a decision whether to continue plant operation or shut down to repair a component.

In addition to transition risk from power to a shutdown mode, transitions between shutdown modes and between operating configurations are also important. Based on a review of shutdown procedures, the transition risk from Mode 3 to Mode 4 as it affects AFW is relatively transparent and is judged to be low. However, entering SDC creates new risks associated with flow diversion from the RCS. These risks are dominated by misalignment of SDC or an LTOP relief valve lift, on the order of 10^{-2} to 10^{-3} per event. These events are generally significant, of short duration, and are important during the initial alignment of SDC. To a lesser extent, they are significant when heating up to return to SG cooling prior to returning to power. However, extended operation near the LTOP setpoint in SDC mode would represent a longer duration risk, but slightly smaller risk impact. Such situations have been the subject of several NRC Information Notices (See Section 3.1).

5.4.3.3 External Events

This report considers the relative risks of plant operation in shutdown Modes 3, 4 and 5. External event challenges will impact loss of power (such as seismic events) and may result in localized challenges to plant equipment (such as fires and floods). As discussed above, the Mode 4 PRA model used for this analysis does not credit the TDAFW pump. The effect of this conservatism is discussed in the sensitivity cases. Without credit for the TDAFW pump, one would expect a similar risk from external events in both Mode 4 and Mode 5. A long term loss of power or loss of offsite power, resulting from a fire or seismic event, would affect the MDAFW pumps in a similar manner to the SDC pumps. The SDC requirement of CCW and other support systems would make SDC slightly more vulnerable than AFW, since SDC and its support systems rely on electrical power for heat removal. The AFW system includes the TDAFW pump which may be operated for a time without electrical power. The ability of the TDAFW to provide "long-term" heat removal is dependent on the ability of the plant staff to utilize the TDAFW pump following the loss of SG level indication.

When the TDAFW pump is credited, then the vulnerability of Mode 4 operation to external events would be less than Mode 5 operation. Additionally, with lower decay heat during shutdown, the Mode 4 vulnerability will be less than full power.

Based on the above discussion, it can be concluded that the risk due to external events in Mode 4 is either lower or about the same as Mode 5 operation.

The SONGS PRA evaluation presented in Section 5.4.3 includes consideration of dominant risks associated with fire and seismic events. Qualitatively, the major impact of external events is to disable a large variety of mitigating safety equipment. The risks associated with the equipment disabled from these events will depend on the equipment location and protective barrier placement, and dependencies of the equipment on support systems such as power. Thus, from a pragmatic sense, plant safety is largely tied to issues of redundancy and diversity. For CE PWRs, Mode 4 offers the greatest variety of equipment. Thus, the susceptibility to the loss of all heat removal capability is lower than it would be in Mode 5, where the plant is entirely dependent upon motor driven pumps and strongly dependent on the energy removal systems connecting the RCS to the plant's ultimate heat sink.

5.4.3.4 Assessment of Mode Dependent Plant Risks

As discussed in Section 5.5, in aggregate, the impact of the proposed TS change will either be risk neutral or result in a reduction in plant risk. Therefore, the risk acceptance criteria associated with increases in CDF and LERF, which are provided in Regulatory Guide 1.174, are inherently met.

The risk profile of the various modes can best be understood by relating the plant risk to the dominant risk initiators and plant recovery capability (See Figure 5-1). Mode 3 is the first shutdown mode encountered as the plant is transitioned to a shutdown state. As Mode 3 is entered the TDMFW pump becomes unavailable. This results in a sharp (~2E-5/yr) increase in the plant CDF. The impact of the mode change on all other initiating event core damage contributions is small (~20% of the at-power CDF) and primarily reflects the impact of control rod insertion on the elimination of ATWS events from the plant initiating event challenges. As the RCS temperature is decreased to 350 °F (300 °F for ANO), Mode 4 is entered. The primary difference between the Mode 3 and Mode 4 SG heat removal states is the RCS thermal-hydraulic condition (temperature and pressure). Pressure restrictions, such as those associated with SONGS procedures, result in a decrease in the contribution of LOCA and SGTR to core damage. The lower core decay heat associated with Mode 4 results in increased operator performance due to increases in the overall time available for the operator to complete specific actions. The net impact of these effects is to decrease the CDF by ~ 2 E-5/yr. In this mode the dominant risk comes from loss of FW, contributing about 80% of the total CDF. Mode 4 risks are lower than Mode 3 risks since either AFW or SDC may be used in Mode 4.

Entry into SDC from an initial Mode 3 state would be delayed by the need to first maneuver the plant to Mode 4. However, when in Mode 4, plant capability to operate in either SDC or SG heat removal modes is available and proceduralized. Analyses also show that the risks of the two Mode 4 plant operational states (AFW backed up by SDC; or SDC backed up by AFW), are relatively close, however the risk becomes somewhat larger once SDC is entered. This is caused by the following:

- A backup cooling mode is not available when on SDC, but is available when on AFW cooling. So in Mode 4, AFW, when AFW is lost, the operators can either switch to SDC or provide SG Cooling using condensate or other means. But when on Mode 4 SDC, the operators could switch to AFW on a loss of SDC, but are less likely to use condensate cooling since the initiating event was not a loss of SG cooling.

- Loss of RCS inventory is modeled as more likely when SDC cooling is initially aligned, since a misalignment can result in an RCS diversion. Additionally, a pressure spike or LTOP setpoint drift can cause an LTOP lift (See for example, Reference 14).

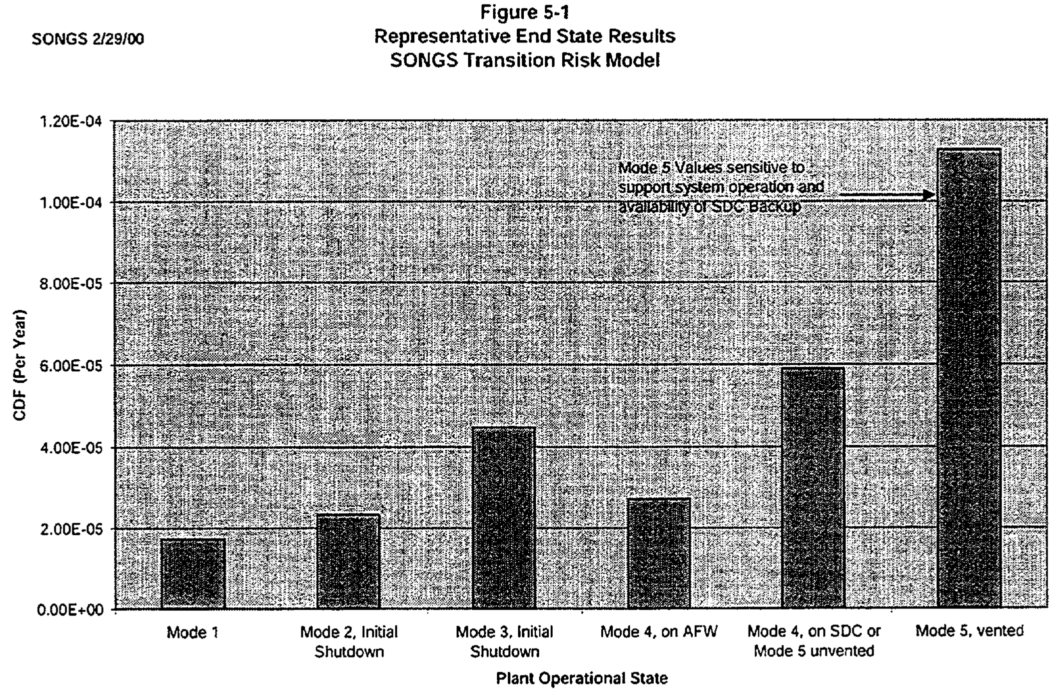
Once Mode 5 is entered, the ability of the SG to remove heat from the RCS is reduced since SG cooling is not initially available without either boiling the RCS or raising the RCS pressure and temperature. Furthermore, for some PWRs, this action of raising RCS temperature/pressure on a loss of SDC would be considered an uncontrolled mode change, and would be avoided by plant personnel. This may result in a delay in using AFW SG cooling on a loss of SDC, thus resulting in a higher operator failure rate for this action.

However, provided the RCS is not vented in Mode 5 and SG inventory is available, the risks of plant operation in Mode 5 would be close to that of operating in Mode 4 on SDC. Shutdown cooling operation involves realigning the plant to allow the LPSI pumps to be used within SDC. Many CE PWRs also have the ability to use CS pumps as backup to the LPSI, for the purpose of shutdown cooling. For many of these plants, once it has been decided to use CS to backup the SDCS, an RCS vent path to the atmosphere is necessary to ensure that pressurization events do not threaten the CS piping. The venting process results in the loss of effective use of the SG for heat removal, since a pressure/temperature increase in the RCS is not possible. The risks of this operational mode are much greater than for Mode 4 (See Figure 5-1, Mode 5, vented).

For example, at San Onofre, the CCW/SWC systems are vital for heat removal during shutdown cooling and hence their loss would impact the plant's ability to remove energy via SDC operation. This would significantly increase the risk of Mode 4, SDC or Mode 5 operation. Similarly, since AFW is the primary heat removal capability in the upper end of Mode 4, loss of AFW/EFW pump would increase the risk of residing in Mode 4 unless SDC is entered. The significance of the AFW inoperability to Mode 4 risks would be associated with the level of redundancy and diversity in the plant FW systems.

A review of the TSs of interest indicates that, when TS inoperability does not directly impact a shutdown heat removal component, the relative mode risks presented in Figure 5-1 will be applicable. As discussed above, unavailability of components of the RCS heat removal systems would significantly impact relative and absolute plant risks.

Figure 5-1
Representative End State Results
SONGS Transition Risk Model



5.4.4 SENSITIVITY STUDIES

Sensitivity studies were performed to evaluate the impact of other CE plant design features and other variabilities in the transition and shutdown models, and to provide a basis for extrapolating representative plant results to other PWRs. Sensitivity studies accounted for the inclusion of additional mitigating features including:

1. Availability of MFW in Modes 3 and 4.
2. Availability of TDAFW in Mode 4.
3. Feed and Bleed Capability.

Two additional sensitivity studies were performed to investigate:

4. The impact of the SONGS plant electrical cross-ties model.
5. The impact of CS pump backup for Shutdown Cooling in Mode 5 vented.

Three parametric studies were also performed:

6. LOOP frequency was: a) increased by a factor of 10 for Modes 3, 4 and 5, and, b) kept the same as full power compared to an increase by a factor of 3.45 used in the base case analysis (See Section 5.4.3.1).
7. Probability of non-recovery of offsite power in 60 minutes was: a) increased by a factor of 2 to 0.20 and, b) decreased by a factor of 2 to 0.05 - compared to the 0.1 value used in the base case analysis (See Section 5.4.3.1).
8. Sensitivity to LOCA IEF factors on Mode 4 AFW operation.

These cases are discussed below:

1) MFW Available in Modes 3 & 4

Several CE PWRs have motor driven MFW pumps and therefore have the ability to provide MFW in Mode 4 operation. This feature was not credited in the SONGS model. A sensitivity study was performed to assess the added benefit of this.

The assessment assumed the availability of MFW in the shutdown modes. While the SONGs base analysis did not credit MFW, the SONGS Modes 3 and 4 model credits emergency condensate (condensate pumps bypassing the MFW pumps) in its full power and transition modes model. The sensitivity study, giving additional credit for MFW in Modes 3 and 4, shows little difference in the results. The overall impact of crediting MFW is to reduce the CDF in either mode by about 10%. The magnitude of this benefit was limited since the MFW and Condensate are highly dependent on common support systems. Thus, additional MFW credit provides little additional Defense-in-Depth.

In conclusion, plants with motor driven MFW pumps, plants with MFW pumps that will continue to run in Modes 3 and 4 for a long time, or immediately following shutdown where sufficient steam is available to operate steam-driven MFW pumps, are adequately represented by the base case results. Therefore the conclusion that Mode 4 is the lowest risk mode for most end states remains valid.

2) Availability of TDAFW in Mode 4

The SONGS Mode 4 model does not credit the TDAFW Pump operation in Mode 4. This feature was chosen as a <u>conservative</u> modeling assumption. The SONGS procedures <u>do not</u> prohibit the use of the TD pump in Mode 4, and this pump would be available if the operators increased SG steam pressure to the pump. A Mode 4 shutdown case was run with the TDAFW pump available. Results of this sensitivity study show that availability of TDAFW will produce a large (>90%) decrease in Mode 4 AFW CDF. However, the Mode 4 SDC operation risk is only slightly decreased, since the availability of AFW following a loss of SDC is dominated by operator action.

Plants with availability of TDAFW pumps or equivalent in Mode 4, i.e. 3 independent AFW pumps operating in Mode 4, are represented by the base case results.

3) Feed and Bleed Capability

The availability of RCS feed and bleed varies among CE PWRs. CE plants with power levels > 3400 Mwt have been designed without PORVs. This includes SONGS Units 2 & 3, Waterford Unit 3 and PVNGS Units 1, 2 & 3. All earlier designed units have PORVs (or an equivalent system) that would be potentially available to depressurize the RCS following Loss of FW events. To assess the significance of the PORV as a mitigation feature in shutdown, the feed and bleed credit (also known as once through core cooling) was reviewed for the SONGS shutdown mode cutsets. The results indicate that additional credit for Feed and Bleed provides little additional risk reduction in Mode 5. In Modes 3 and 4, it is estimated that the addition of Feed and Bleed capability would lower the CDF results by less than 10%, since a majority of the recoverable cutsets would also fail Feed and Bleed.

In conclusion, plants with Feed and Bleed capability have additional features in Mode 4 which contribute to a lower Mode 4 risk and consequently, their performance is bounded by the base case results. A summary of the sensitivity results are presented in Table 5.4-4.

4) Impact of SONGS Units 2 & 3 Crosstie Capability

SONGS is a two unit site, with cross-tie capability between the units for loss of offsite power. Removal of that function would provide a more representative CDF and LERF for single unit sites and sites without cross ties or alternate AC capability.

Analyses considering the removal of the plant cross-tie assumption indicate that the risk (as measured by CDF/LERF) is not significantly affected in any modes. Mode 1 and 2 risks rise about 20% and Mode 3, 4 and 5 rise less than 10%. The smaller impact of the cross-tie in shutdown modes is due to the longer time available for offsite power recovery in Modes 3, 4 and 5, due to decreased inventory boiloff rates. Thus, plants without Alternate AC (AAC) or crosstie capability may expect to experience greater plant risks. Plants with alternate AC capability may accrue a greater benefit than that noted for the SONGS units. In either case the benefit will be uniform across the shutdown modes.

In conclusion, plants without alternate AC power supplies available are well represented by the base case results.

5) CS Pump not available in Mode 5

SONGS has 2 CS pumps available to serve as backup to the LPSI pumps for Mode 5 SDC operation. About half of the CE plants are designed with the ability for CS pumps to be realigned and used as a SDC pump. To accomplish this realignment, the RCS must be vented to atmosphere to ensure that the spray system piping will not be over-pressurized. The SONGS PRA analysis only credited operation of 1 CS pump, though both are normally available. Since the CS piping is rated at less than SDC cooling entry pressures, these pumps are not considered available in Mode 4. These pumps are dependent on the same support systems that provide LPSI support. In this sensitivity study, the CS backup was not credited and Mode 5 risks were re-evaluated. The results of this study show that Mode 5 CDF risk is increased by about 10-20% over the base case results when the RCS is vented in Mode 5.

Plants that have only 2 SDC pumps available, without backup, may have increased Mode 5 risks due to the unavailability of AFW in Mode 5 operation and no Mode 4 increase. Thus, the conclusion that Mode 4 risks would be less than Mode 5 risks remains unchanged and Mode 4 is still regarded the lowest risk mode for typical plant end states.

6) Loss of Offsite Power (LOOP) Initiating Event (IE)

Several sensitivity cases were evaluated for LOOP modeling for this analysis. The first two cases involved the assumption that the LOOP initiating event is increased in all shutdown modes by a factor of 3.45. Two cases were run, one with LOOP increased by a factor of 10 and another with LOOP not increased for shutdown.

In both cases, the CDF results for all Modes 3, 4 and 5 changed between 5% and 30% when LOOP is increased by 10 (versus 3.45) and decreased between 2% and 12% when LOOP is left at the Mode 1 assumed frequency. In both cases, the most sensitive mode is Mode 4 (AFW). Even with the changes, Mode 4 AFW remains the lowest risk plant operational state for both cases.

In conclusion, the assumption that Mode 4 risks would be less than Mode 5 risks remains unchanged and Mode 4 is still regarded the lowest risk mode for typical plant end states.

7) Loss of Offsite Power Non-recovery

Similar to sensitivity cases discussed in 6, the LOOP non-recovery probability was varied from the assumed transition model results. The full power model uses a non-recovery probability of 0.37 for 1 hour following a LOOP. Since more time is available to recover offsite power (preventing core damage) following reactor shutdown, the transition model uses a 0.1 non-recovery probability. Two sensitivity cases were run, with this event set to 0.2 and 0.05, respectively. In both cases, the CDF results did not vary more than about 10% for any plant operational state.

In conclusion, the assumption that Mode 4 risks would be less than Mode 5 risks remains unchanged and Mode 4 is still regarded the lowest risk mode for typical plant end states.

8) LOCA Initiating Events in Mode 4 AFW

The Transition Model used by SONGS assumes the LOCA Initiating Events are decreased by a factor of 20 (from Mode 1 full power) for Mode 4 AFW. This sensitivity case analyzed Mode 4 AFW with the LOCA IEs decreased by 2 instead of 20. Based on this analysis, the Mode 4 AFW results increase by approximately 20% if this is assumed. Even with these results, the Mode 4 AFW risk is less than Mode 4 SDC and Mode 5 CDF results.

In conclusion, the assumption that Mode 4 risks would be less than Mode 5 risks remains unchanged and Mode 4 is still regarded the lowest risk mode for typical plant end states.

Sensitivity Studies - Conclusion

These sensitivity studies were performed to evaluate the impact of other CE plant design features and other variabilities in the transition and shutdown models. The results of the sensitivity studies is summarized in Table 5.4-4. In all cases discussed above, the Mode 4 AFW risks continue to be the lowest risk plant operational state.

Many of the sensitivity cases were developed to test the assumptions discussed in 5.4.3. The results show that Mode 4 AFW is most sensitive to the assumption that the TD AFW pump is not available and that LOCAs are reduced by a factor of 20. In the first case, since the model assumes no credit for the TD AFW Pump, any credit would correspondingly reduce the risk. For example, if a 0.5 failure probability were assumed, the Mode 4 AFW risk would be reduced by about ½ compared to the baseline. In the second case, it is expected the LOCA IEs would be reduced once the RCS pressure is reduced, but the exact reduction is uncertain. Although we would not see much of a risk reduction if a factor greater than 20 were used, if Mode 1 IE frequencies were assumed, we would see approximately a 20% increase in the CDF risk. Other sensitivity cases would not affect the results as significantly.

Mode 5 results are not as sensitive to the variables selected for the sensitivity studies. This is mainly due to the variables selected being based upon the transition model assumptions, and not the shutdown model assumptions. For Mode 5, the dominant assumptions would be operator non-recovery probabilities and cutsets containing failure of both component cooling water trains. The model variables that greatly affect the Mode 5 results do not generally affect the Mode 4 AFW results.

Sensitivity cases could be developed with combinations of the sensitivity cases in Table 5.4-4. However, since the conclusion for each of these is that the representative calculation remains valid and that Mode 4 AFW is the lowest risk mode, combination sensitivity studies would also show this result.

The conclusion of the sensitivity analysis, that Mode 4 AFW is the lowest risk plant operation state, is reasonably certain and the PRA results support the plant defense in depth characteristics discussed in the Qualitative Risk Assessment Section 5.4.2.

Table 5.4-4
Results of Shutdown Mode Sensitivity Studies

Sensitivity Parameter	Modifications to base model	Conclusion
1a. Availability of MFW in Mode 3	Assume MD FW available	Mode 3 risks decrease by 10%
1b. Availability of MFW in Mode 4	Assume MD FW available	Mode 4 risks decrease by 10%
2. Other Heat Removal Capability TDAFW	Add TDAFW Recovery to Mode 4	Mode 4 risks (AFW) decrease by 90%
3. Effect of PORVs for Feed and Bleed	Assume High Pressure Plant Damage States Recoverable	Mode 3,4 risks decrease by 10%
4. Effect of EDG Cross-tie	Remove X-Tie/AAC Capability	Risks in all shutdown modes increased by 10%
5. CS pump not available in Mode 5	CS removed as backup (RCS vented)*	Mode 5 risks increased by > 50%
6a. LOOP IE	Increase by 10 (versus 3.45) for Modes 3-5	Modes 3-5 Risk increases between 5% and 30%
6b. LOOP IE	Leave IE as assumed for Mode 1 PRA	Modes 3-5 Risk decreases between 2% and 12%
7a. LOOP non-recovery	Assume non-recovery equals 0.2 (versus 0.1)	Modes 3-5 Risk increases less than 10%
7b. LOOP non-recovery	Assume non-recovery equals 0.05 (versus 0.1)	Modes 3-5 Risk decreases less than 10%.
8. LOCA IE	Assume LOCA IEF reduced by 2 instead of 20 for Mode 4 AFW	Mode 4 AFW Risks increase by 20%.

* Note if CS is removed as a backup, and the RCS is not vented, the plant risk will be typical of that of plant operation in Mode 4 on SDC.

5.4.5 UNCERTAINTY ANALYSIS

Mode 4 PRA results are similar to Mode 1 PRA results, with LOCAs being less important, and loss of SG cooling being more important. The cutsets are dominated by mechanical/electrical failures, with few Human Error Probabilities (HEPs) in the dominant cutsets. The most important HEP is failure to recover offsite power, which as discussed above in Section 5.4.4, is based upon the most limiting time for initial entry into Mode 4. The Mode 4 cutset review shows that the condensate system is typically failed on most cutsets that fail all of AFW and SDC. For example, failure of a DC train fails condensate and two of the standby trains (AFW and SDC). The result is that the operator action for failure of condensate is unimportant, as seen in Table 5.4-4 above.

Based on the Mode 4 cutsets results, and the sensitivity cases above, the uncertainty of the Mode 4 results is expected to be similar to Mode 1 results with an error factor in the range of 3-5.

The Mode 5 results show a combination of cutsets containing mechanical/electrical failures and HEPs. The HEPs include failure to start standby equipment, failure to recover offsite power, and isolate a loss of inventory. The first two of these HEP types, similar to the Mode 4 results, are based upon the Mode 5 entry conditions and are expected to decrease as decay heat decreases. There is no single HEP that dominates the results, with approximately 10 HEPs contributing greater than 1% of CDF. Additionally, the Importance Analysis of Mode 5 PRA results shows a much larger number of basic events that can result in a very high risk in comparison to the Mode 4 results.

Based upon these results, and the sensitivity cases above, the uncertainty results are expected to be larger for Mode 5 than for Mode 4.

5.4.6 *LARGE EARLY RELEASE FREQUENCY (LERF)*

The Quantitative Assessment did not calculate or compare Large Early Release Frequency (LERF) for several reasons. During "at power" operation (Mode 1) the large early radioactive releases are a result of (1) energetic containment failure due to a high pressure RCS following a core damage event, (2) a containment bypass event (such as a SGTR with a stuck open secondary valve, or ISLOCA) and (3) a core damage event occurring in the presence of an unisolated containment. The likelihood of LERF contributors resulting from to Mode 4 operation is very low. This observation is a result of the combined impact of the lower initial energy level, reduced initial fission product inventory and decay heat load in Mode 4. These features serve to provide the operator time to respond to serious plant upsets and consequently contribute to delaying the core melt progression and reducing radiation releases. The impact of the initial shutdown condition on LERF event classification is discussed below for these three category of events.

Energetic Containment Failures

From a LERF perspective shutdown initiated events that result in in-containment fission product releases will not have enough energy to result in an energetic containment failure. These events were the primary LERF contributors that were not also bypass events. Typically RCS energetics is limited by the lower core decay heat and the lesser LTOP pressure setpoints.

Containment Bypass Events

Qualitatively, radioactive releases from containment can be compared for the various end states as well as to Mode 1. For Mode 4 AFW operation, release from containment would be dominated by initial or induced SGTR events. These events are much less likely than at full power, since at shutdown both the RCS and secondary pressures are generally much lower than at full power. Additionally, core damage due to a SGTR event would be less likely, since transitioning onto SDC would be likely as the initial RCS conditions are already at or near SDC entry. SGTR flowrates would also be much reduced due to rapid approach to SDC entry. ISLOCA events, such as backflow from the RCS into the LPSI system, would be considered unlikely due to the low RCS initial pressure. So in general, LERF due to SGTR or ISLOCA would be considered much lower than at full power.

Radioactive release during Mode 4 on SDC or Mode 5 would be dominated by a Loss of Inventory event outside of containment (See 5.4.2.2.1). This event is one of the more likely core damage events in Mode 4 SDC or Mode 5. This event would result in the draining of the RCS resulting in a loss of SDC and an eventual core damage event. As discussed above, the radioactive release during an LOI event bypassing the containment, would be much less than a Mode 1 bypass event. In general, due to the likelihood of this event, and the direct release from containment, radioactive release during Mode 4 SDC or Mode 5 is considered more likely than Mode 4 AFW operation. Furthermore, the most serious of these events would be a flow diversion bypass which would typically be the result of plant misalignments during the SDC entry process itself. By avoiding SDC entry this failure mechanism will be eliminated.

Loss of Containment Isolation

This early release mode applies when a core damage event occurs in the presence of an unisolated containment. Radioactive release due to an open containment would be less likely in Mode 4 with SG heat removal than in any other operational mode due to its lower CDF. However, the likelihood of loss of containment isolation is low in Modes 1 through 4 and the contribution of this early release mechanism is small even in Mode 1 (typically less than 10^{-7} per year).

Thus, while shutdown events can result in radiation releases to the environment, their releases are typically not large and early. Consequently, shutdown PRAs, such as that developed for the SONGS Shutdown PRA, do not calculate LERF.

5.5 SPECIFIC TECHNICAL SPECIFICATION ASSESSMENTS

In performing the Defense-in-Depth assessment, it is assumed that the purpose of the TS Required Action to enter shutdown is to complete a short duration repair of the component under consideration.

This section provides a summary of the basis for the change of each of the risk-informed TS end state changes proposed. The format of each of the subsequent subsections will be as follows:

- i) Description
- ii) Plant Applicability
- iii) Limiting Condition for Operation
- iv) Licensing Basis for LCO
- v) Condition Requiring Entry into End State
- vi) Proposed Modification to End State Required Actions
- vii) Basis for Proposed Change
- viii) Defense-in-Depth Considerations
- ix) Tier 2 Restrictions

This section provides an integrated discussion of the risk and deterministic issues, focusing on specific technical specifications. In performing these assessments it is assumed that the required Mode 4 end state entry is for the temporary repairs of inoperable equipment so that the plant may be returned to service without incurring additional risks and costs associated with establishing a cold shutdown condition. In instances where the proposed end state change is not applicable to all CE units, it is identified within item (ii). The risk justification for Mode 4 end state entry is based on qualitative and quantitative analyses presented in Section 5.4.

All TSs are subject to the restriction that when the inoperability involves a degradation of the TS SG heat removal capability, with no concurrent inoperability of the SDC system, the required plant end state should be Mode 4 on Shutdown Cooling.

5.5.1 T.S. 3.1.9 (SONGS) BORATION SYSTEMS - OPERATING

The boration systems are required to ensure that adequate shutdown reactivity margin exists to bring the plant to cold shutdown with the worst CEA stuck out and the decay of all xenon poison. The systems are also intended to mitigate possible return to power scenarios following an MSLB. The ISTS is silent on boration systems. The SONGS TS 3.1.9 on boration systems requires that during the modes of applicability, two boration paths that are to remain available are: (1) the RWST and its feed to the charging pumps, and (2) one or both BAMU tanks with their respective feed paths to the charging pumps.

Plant Applicability

ANO-2, Millstone 2, SONGS 2 & 3, St Lucie 1 & 2, Waterford 3

Limiting Condition for Operation (LCO)

Two RCS boron injection flow paths shall be OPERABLE in Modes 1, 2, 3 and 4, with the contents of the Boric Acid Makeup (BAMU) tanks in accordance with the LCO. Two boration paths that are to remain available are: 1) the RWST and its feed to the charging pumps, and 2) one or both BAMU tanks with their respective feed paths to the charging pumps.

Licensing Basis for LCO

The boration systems are required to ensure that adequate shutdown reactivity margin exists to bring the plant to Mode 5 with the worst CEA stuck out and the decay of all xenon poison. The systems are also intended to mitigate possible return to power scenarios following an MSLB or RCP restart.

Condition Requiring Entry into End State

If a boration path is unavailable for more than 72 hours, then the plant must proceed to Mode 3. If the path cannot be restored within the next 7 days, then the plant must proceed to Mode 5.

Proposed Modification for End State Required Actions

Modify action statement to allow Mode 3 operation during the time one train of the boration system is inoperable.

Basis for Proposed Change

Risk importance of the boration system is low. For PRA applications, the CVCS injection functions are modeled only for small-small LOCA, SGTR and ATWS. In shutdown modes ATWS events are precluded. In the event a loss of redundancy of charging pumps occurs, the impact on plant risk will be very small since boration (and injection) may be provided by the alternate train capability or other injection equipment (e.g. HPSI pumps).

During shutdown, the SDM is controlled to ≥ [4.5%] $\Delta K/K$ (via an alternate TS). Thus, a return to criticality will be precluded.

Defense-in-Depth Consideration

From a design basis perspective, borated makeup water has low importance for the shutdown modes. CE plants are designed and operated to ensure adequate shutdown margins.

During the time interval the impaired train of boration is being repaired, the operable boration train provides adequate control for the plant shutdown margin. It should further be noted that from a shutdown margin perspective, that when MTC is negative, increased boration is required at lower temperatures. For plant conditions with a negative MTC, at similar boron concentration levels, Mode 3 should have greater SDM than Mode 4. Either mode would have greater shutdown margin than Mode 5.

Availability of the redundant boration train ensures the plant Defense in Depth is maintained. During operational periods when MTC < 0, the Mode 3 end state is also the end state with the least demand on the remaining train of boration.

Tier 2 Restrictions

None.

5.5.2 T.S. 3.5.4 REFUELING WATER STORAGE TANK

Boration issues are also addressed in TS 3.5.4 Condition A (RWST). One function of the RWST, as defined in the ISTS bases, is to serve as a source of borated water for Emergency Core Cooling System (ECCS) injection. The minimum boric acid concentration is controlled to ensure adequate shutdown margin and the maximum boric acid concentration is controlled to prevent precipitation of boric acid during large LOCA recirculation cooling. Therefore, in order to comply with accident analysis assumptions the RWST water must meet restrictive boron concentration limits. These limits are based on Mode 1 plant design basis analyses, which involve very low likelihood events and include assumptions that are not applicable to a shutdown reactor. In particular, the minimum boron concentration is based on an all rod out assessment. Upon entry into Mode 3, the plant has been shutdown and the core is sub-critical.

From a design basis perspective, borated makeup water has low importance for the shutdown modes and is designed with conservatively large shutdown margins. The RWST water specification ensures large Shutdown Margins (SDMs) will exist (up to 9% SD margin) with all rods stuck out.

Following a large LOCA, Emergency Operating Instructions (EOIs)* direct the operator to implement a hot side/cold side injection mode of core cooling. By utilizing this technique within a predetermined time frame following a LOCA, potential boric acid precipitation from the core could be averted. The time required to implement this action varies from 4 hours to > 30 hours and is based on a limiting Mode 1 LOCA. In Mode 4, a LOCA event would proceed more slowly and the decreased core heat load would retard the boric acid concentration process. Thus, in this mode additional time is available for the operator action. Furthermore, the likelihood of having a LOCA in which boron precipitation is a concern is negligible over the time interval.

Since anticipated deviations in the RWST boric acid concentrations are expected to be small and the ability to correct this deficiency is expected to be readily available, the requirement for entry into shutdown Modes 4 or 5 is unnecessary.

Plant Applicability

All

Limiting Condition for Operation (LCO)

The RWST shall be OPERABLE in Mode 1, 2, 3 and 4.

Licensing Basis for LCO

In Mode 1, 2, 3 and 4, the RWST OPERABILITY requirements are dictated by the ECCS and CS OPERABILITY requirements. Since both the ECCS and the CS must be OPERABLE in Modes 1, 2, 3 and 4, the RWST must be OPERABLE to support their operation.

Core cooling requirements in Mode 5 are addressed by LCO 3.4.7, "RCS Loops - Mode 5, Loops Filled," and LCO 3.4.8, "RCS Loops - Mode 5, Loops Not Filled."

The RWST is needed in Modes 1 through 4 to provide a borated water source for ECCS injection. The TS specifically requires that the RWST liquid must meet volume, temperature and boron concentration limits to comply with accident analysis assumptions. With all rods inserted the boron concentration limits quoted in the TS are very conservative. Note that the RWST is not formally required for ECCS injection in

* EOI – Emergency Operating Instructions is an alternate designation for EOPs (Emergency Operating Procedures).

Mode 5 per TSs, but may be useful in Mode 5 as part of a shutdown risk management program. It should be noted that at SONGS, a boration flow path (either from RWST or BAMU) must be operable in Mode 5 per LCO 3.1.10.

The RWST supplies two ECCS trains by separate, redundant supply headers. Each header also supplies one train of the CS System. A motor operated isolation valve is provided in each header to allow the operator to isolate the usable volume of the RWST from the ECCS after the ESF pump suction has been transferred to the containment sump following depletion of the RWST during a LOCA. A separate header is used to supply the Chemical and Volume Control System (CVCS) from the RWST. Use of a single RWST to supply both trains of the ECCS is acceptable since the RWST is a passive component, and passive failures are not assumed to occur coincidentally with the Design Basis Event during the injection phase of an accident. Not all the water stored in the RWST is available for injection following a LOCA; the location of the ECCS suction piping in the RWST will result in some portion of the stored volume being unavailable.

Condition A of this LCO ensures that:

a. The RWST contains sufficient borated water to support the ECCS during the injection phase and that

b. The reactor remains sub-critical following a LOCA. Improper boron concentrations could result in a reduction of SDM or excessive boric acid precipitation in the core following a LOCA.

c.

Post LOCA boron precipitation concerns diminish in Modes 3 and 4 since: (1) inventory/boric acid injection into the RCS is reduced due to the less severe inventory depletion and a (2) lesser rate of injection is required to mitigate the LOCA. (3) Post-LOCA reactivity concerns are diminished since SDM is larger in Mode 3 and 4 (than in Mode 1) due to the prior insertion of control rods.

Condition Requiring Entry into End State

When the Refueling Water Storage Tanks are INOPERABLE in Modes 1, 2, 3 and 4 due to boron concentration not being within limits and not corrected within 8 hours.

Proposed Modification for End State Required Actions

Modify bases to allow for Mode 3 end state when boron concentration is outside of the operating band for a period greater than 8 hours and to create a new action (e.g. 3.5.4 D.2) to maintain the current end state for other inoperabilities.

Basis for Proposed Change

The RWST is considered an injection source for HPSI, LPSI and CVCS (the latter also considers BAMU) for all modes for LOCAs (large, medium, small and small-small), SGTR and other transients in which pressurizer safeties lift and fail to re-close. This change addresses the condition when the RWST is inoperable due to the boron concentration being outside the TS limits. Once in a shutdown mode, inoperability of this type would most likely not have any impact on plant safety, when best estimate conditions are considered. This change does not address the event that the RWST is truly unavailable. In that case, the loss of functionality would lead directly to core damage in cases in which ECCS injection is required and not otherwise recovered.

Ideally, boron concentration anomalies in the RWST should be corrected while the plant is at power. Once a shutdown has commenced, continued operation in Mode 3 results in an increased risk above that incurred by plant operation. However, since the time expected to correct this anomaly is small (< 1 day) the incremental risk of Mode 3 operation is negligible < 1×10^{-7}. Since the primary concern with RWST boron concentration arises from the large LOCA event and the event is of very low probability, the impact from marginally high or low concentrations has a negligible risk impact.

This TS modification provides for a Mode 3 operation end state for conditions associated with RWST boron concentration out of limits. Mode 3 provides a safe shutdown mode for completing necessary actions to correct the malfunction. By completing adjustments in Mode 3, additional mode transitions and their associated risks are averted.

Defense-in-Depth Consideration

RWST inoperabilities due to boron concentration out of limits have negligible impact on plant risk. Boron dilution concerns are mitigated by the fact that the plant is shutdown making a return to recriticality unlikely. The slower event progression associated with a LOCA shutdown will afford the plant staff with the opportunity to utilize other boric acid sources to makeup for lower RWST concentrations.

Over-boration concerns are addressed by acknowledging the fact that the large LOCA event (which is the origin of the concern) is of very low probability, the event progression is slower than that at power, so that added time exists to implement hot side/cold side injection, and operator misalignments are less likely. The boric acid concentrating process associated with the core boiloff is slower due to the reduced makeup requirements. Therefore, the proposed TS end state change does not affect the plant Defense-in-Depth.

Tier 2 Restrictions

None.

5.5.3 T.S. 3.3.5 (SONGS) ESFAS INSTRUMENTATION – RECIRCULATION ACTUATION SIGNAL (RAS)

Several TSs relating to actuation signal generation currently require that upon the inability to restore the affected signal within the allotted outage time, the plant must transition to Mode 5.

The Engineered Safety Feature Actuation System (ESFAS) provides automatic actuation of the Engineered Safety Features. The ESFAS is designed so that at least two channels must be able to trip in order for ESFAS to actuate. Most of the ESFAS functions are required to be operable only in Modes 1 through 3. The end state for these functions is therefore Mode 4, which is acceptable. In the SONGS TS, the Recirculation Actuation Signal (RAS) is required be operable in Mode 4 as well, so the current end state for this ESFAS function is Mode 5. As a consequence of this TS the operator must be prepared to bring the plant to Mode 5 when:

1. The plant staff fails to place an inoperable RAS channel in trip or bypass within 1 hour or,
2. The plant staff fails to restore an inoperable channel to operable prior to entering Mode 2 following the next Mode 5 entry.

The present issue concerns the recommendation to allow the plant to be placed in Mode 4 operation without an operational RAS. NUREG-1432 already identifies the applicable Modes for RAS instrumentation as only Modes 1, 2 and 3. This recommendation reflects the understanding that RAS is less likely in Mode 4 due to lower LOCA probability in Mode 4 and that adequate instrumentation is available to alert the operator to the need for a manual switchover of safety injection from the injection to the recirculation mode and that due to lesser expected RWST discharge, ample time is available for operators to accomplish the switchover. Therefore, Mode 4 is an acceptable TS end state.

<u>Plant Applicability</u>

ANO-2, SONGS 2 & 3, Waterford 3

<u>Limiting Condition for Operation (LCO)</u>

Four ESFAS trip and bypass removal channels for each function in Table 3.3.5-1 shall be OPERABLE in Modes specified in that Table.

<u>Licensing Basis for LCO</u>

ESFAS provides automatic actuation of the Engineered Safety Features, which are required for accident mitigation. At least two channels must be able to trip in order for ESFAS to actuate. The ISTS requires that the ESFAS functions (including RAS) are required to be operable only in Modes 1 through 3. The end state for these functions is therefore Mode 4, which is acceptable. The TS of three CE PWRs requires that the Recirculation Actuation Signal (RAS) must be operable in Mode 4 as well, so for those plants the current end state for inoperable RAS instrumentation is Mode 5.

<u>Condition Requiring Entry into End State</u>

The Required Actions of the TS are entered upon:

1. Failure to place an inoperable RAS channel in trip or bypass within 1 hour, or
2. Failure to restore an inoperable channel to operable prior to entering Mode 2 following the next Mode 5 entry.

Proposed Modification for End State Required Actions

Allow the plant to remain in Mode 4 until the inoperable RAS channel is restored to service. Mode 4 entry is required in 12 hours.

Basis for Proposed Change

The RAS function is modeled in the PRA for all safety injection functions that require recirculation operation. However, because of the decreased likelihood of a LOCA IE in this mode (i.e. when RCS pressure is reduced) and the availability of a redundant RAS channel, a quantitative evaluation of the risk importance of this condition was not explicitly performed. Also, should a LOCA occur in Mode 4, more time would be available until the switchover to recirculation would need to begin. Therefore, even with one train of RAS unavailable, sufficient time would exist for manual actions to be taken in the event of RAS failure.

Maintaining the plant in Mode 4 provides several advantages to the plant operating staff. Mode 4 operation ensures that the plant is shutdown, and is at a low temperature (< 350 °F). In addition, Mode 4 operation provides a resource-rich environment to ensure continued RCS heat removal and protection from both LOCA and non-LOCA plant upsets (See Section 5.4). While not specifically required, low temperature operation is often associated with a low pressure operation. As a result of the Mode 4 plant conditions, loss of cooling/loss of inventory events are characterized by lower initial fuel temperatures and a lower fuel decay heat generation rate. Consequently, core damage transients initiated from Mode 4 are expected to proceed at a slower rate than a similar event occurring at power. The impact of the Mode 4 end state change on various instrumentation TSs under consideration for change is discussed below.

Defense-in-Depth Consideration

RAS is implemented prior to depletion of the water in the RWST by aligning the sump in the containment to recirculate the water in the containment. The purpose of the RAS signal is to ensure a smooth switchover from the ECCS injection mode of operation to the ECCS recirculation mode of operation. RAS is particularly important for a LOCA occurring during Mode 1, when typically 2 HPSI, 2 LPSI and 2 CS pumps are used to send water into the containment. When all standby equipment injects water from the RWST, the RAS will actuate in about 20 minutes and automatic actions to open/close valves for recirculation will commence.

In Mode 4, only 1 HPSI pump and 2 CS pumps are required by the TS. (This arrangement may vary dependent on plant operations.) With the minimum TS arrangement, water injection rates into the containment will be reduced and RAS will be delayed.

NUREG-1432 lists applicable Modes for RAS instrumentation as only Modes 1, 2 and 3. This recommendation to remove the Mode 4 applicability for the RAS reflects the understanding that RAS is less likely in Mode 4 due to lower LOCA probability in Mode 4 and that adequate instrumentation is available to alert the operator for manual switchover of safety injection from the injection to the recirculation mode with ample time available to accomplish the switchover. Therefore, Mode 4 is an acceptable TS end state, and does not affect the plant Defense-in-Depth. The current designation for the affected units is inconsistent with ISTS philosophy.

Tier 2 Restrictions

None. While reduced RCS pressure operation is not required, operation at lower RCS pressures reduces the potential for LOCA and limits the initial flashing and inventory loss in the event of a LOCA.

5.5.4 T.S. 3.3.6 (SONGS) ESFAS LOGIC AND MANUAL TRIP

Safety Injection Actuation Signal (SIAS) and Containment Isolation Actuation Signal (CIAS)

ESFAS provides automatic actuation of the Engineered Safety Features, which are required for accident mitigation. Trip signals from the four bistable channels are processed through a set of six matrix logic circuits to determine if two valid signals exist. If a two-of-four coincidence is detected, four actuation logic circuits are actuated, which in turn actuate four ESFAS initiation circuits. A set of two manual trip circuits is also provided, which uses the actuation logic and initiation logic circuits to perform the trip function. Many of the ESFAS functions are required to be operable only in Modes 1 through 3. Table 3.3.6-1 in the SONGS 2 & 3 TS, indicates Mode 4 applicability for the Initiation logic, Actuation Logic and Manual trip for SIAS, CIAS, Containment Cooling Actuation Signal (CCAS) and RAS. Mode 5 may be required to be entered when one manual trip circuit, initiating logic circuit, or actuation logic circuit is inoperable for RAS, SIAS, CIAS or CCAS for more than 48 hours. The applicability of these functions to Mode 4 varies among utilities. For example, APS does not require CS actuation signal (any function) in Mode 4. This signal actuates containment heat removal and radiation control.

The primary objective of the ESFAS logic and Manual Trip in Mode 4 is to provide a SIAS to the operable HPSI train and CIAS to ensure containment isolation. For TS 3.5.3, ECCS–Shutdown, to be met, the Manual Trip and Actuation Logic associated with that train of HPSI must be available in Mode 4. No other Mode 4 restrictions are required. By including the actuation logic in Mode 4, the effort in establishing HPSI injection following a LOCA or other inventory loss event is minimized. Similarly, by requiring one CIAS manual trip and actuation relay group to be operable, the plant operating staff does not have to operate every containment penetration manually following an event that may lead to radiation releases to the containment. It is therefore recommended that the Mode 4 LCO for the SIAS and CIAS include only a requirement for a manual trip and actuation logic function.

Containment Cooling Actuation System (CCAS)

As discussed above, the ESFAS logic and Manual trip TS includes a Mode 4 requirement for the CCAS. In general, the CCAS is used to automatically actuate the containment heat removal systems (containment recirculation fan coolers) to prevent containment overpressurization during a range of accidents which release inventory to the containment, including large break LOCAs, small break LOCA, Main Steam Line Break or Feedwater Line Breaks inside containment. This signal is typically actuated by high containment pressure. Analyses of Mode 4 post-LOCA containment responses indicate that the lower energy content associated with the Mode 4 RCS coolant will result in a reduced containment challenge when compared with Mode 1 post-LOCA containment responses. Based on the lower stored energy in the RCS and lesser core heat generation, short term containment pressure following a LOCA or MSLB would be much less than the current design containment strength. Ample instrumentation is available to the operator to diagnose the onset of the event and to take appropriate mitigating actions (actuation of the containment fan coolers and/or sprays) prior to a potential containment threat. Consequently, operability of this actuation signal in Mode 4 is not required. The equivalent function Containment Spray Actuation Function (CSAS) is currently not required in the TS for Palo Verde Units 1, 2 and 3.

Recirculation Actuation Signal (RAS)

As discussed above, the ESFAS logic and Manual trip TS includes a Mode 4 requirement for the RAS. Following a LOCA, the RAS is used to automatically perform the switchover from the SI mode of heat removal to the sump recirculation mode of heat removal. RAS must be implemented prior to depletion of the water in the RWST by aligning the containment emergency sump to recirculate the water in the containment. RAS is especially important during operating Mode 1, when HPSI (2), LPSI (2) and CSP (2) pumps are available and used upon ESFAS to send water into the RCS. At the RAS function setpoint, there is about 20 minutes to open/close valves for recirculation. In Mode 4, ECCS required injection may be reduced to only 1 HPSI pump (and then only when the plant is above LTOP conditions) and 2 CS pumps per the TSs. Since the time to initiate RAS is based on depletion of the RWST via all injection sources, when the lesser Mode 4 TS requirements are met, water will be injected at a much slower rate in Mode 4 than in Mode 1. Hence RAS times in Mode 4 are expected to be considerably longer than those associated with Mode 1. Regardless, following a LOCA the instrumentation available to the operator is sufficient to alert the operator to the need for switchover to recirculation.

Plant Applicability

All CE PWRs except Palisades

Limiting Condition for Operation (LCO)

Six channels of ESFAS Matrix Logic, four channels of ESFAS Initiation Logic, two channels of Actuation Logic and two channels of Manual Trip shall be OPERABLE for SIAS, CIAS, CCAS, RAS, CSAS, MSIS, EFAS-1 and EFAS-2. LCO is applicable in Modes 1, 2 and 3 for all functions for all components and in Mode 4 for initiation logic, actuation logic and manual trip for SIAS, CIAS, CCAS and RAS (Specific applicability of CCAS or equivalent systems (e.g. CSAS) may vary among utilities).

Licensing Basis for LCO

ESFAS provides automatic actuation of the Engineered Safety Features, which are required for accident mitigation. Trip signals from the four bistable channels are processed through a set of six matrix logic circuits to determine if two valid signals exist. If a two-of-four coincidence is detected, four actuation logic circuits are actuated, which in turn actuate four ESFAS initiation circuits. A set of two manual trip circuits is also provided, which uses the actuation logic and initiation logic circuits to perform the trip function. Many of the ESFAS functions are required to be operable only in Modes 1 through 3. The end state for these functions (CSAS, MSIS, EFAS-1, EFAS-2) is therefore Mode 4. RAS must be operable in Mode 4 as well. In addition, manual actuation capability must be provided in Mode 4 for SIAS, CIAS, and CCAS, so the manual trip, actuation logic and initiation logic circuits for these signals must be operable. (Manual actuation may also be required for RAS.)

Condition Requiring Entry into End State

Condition F of the TS is entered when:

1. One manual trip circuit, initiating logic circuit, or actuation logic circuit inoperable for RAS, SIAS, CIAS or CCAS for more than 48 hours (Conditions A, B & D).

or,

2. Two initiating logic circuits in the same trip leg for RAS, SIAS, CIAS or CCAS inoperable for more than 48 hours (Condition C).

Proposed Modification for End State Required Actions

Since the SIAS and CIAS signals perform numerous actions, manual trip and actuation for these signals should be retained in Mode 4. In particular, the operability of a single train of HPSI is required in Mode 4. Therefore, the associated actuation circuit and manual trip circuit for SIAS should be maintained available so that automatic lineup of HPSI can be established following a LOCA. Both isolation valves in the appropriate containment penetrations are required to be operable during Mode 4. However, the large number of actions required to isolate these penetration, given an event, indicates that an extended unavailability of CIAS is not desired. No change is being requested for TS 3.5.3, ECCS-shutdown.

The proposed change is to modify Mode 5 end state required action to allow component repair in Mode 4 of all functions of the CCAS and RAS initiation/logic function of the SIAS and CIAS. Entry into Mode 4 is proposed at 12 hours.

Basis for Proposed Change

Due to the lesser probability of a LOCA during Mode 4 operation a qualitative risk assessment was performed. The risk bases for this change are:

1. The low anticipated LOCA frequency in Mode 4, coupled with the knowledge that: (a) the redundant channel remains operable, (b) longer times are available for implementing operator actions associated with Mode 4 LOCA events and, (c) repair activities are expected to be of short duration, and thus exposure to a potential initiating event requiring system action is small, and

2. The overall risk of plant operation in Mode 4 is either equal to or less than equivalent risks of operation in Mode 5 (See Section 5.4.3.4).

Defense-in-Depth Consideration

The following sections provide a discussion of deterministic issues associated with the recommended changes to plant TSs as well as the bases for concluding that that the proposed TS change does not affect the plant Defense-in-Depth.

Safety Injection Actuation Signal (SIAS) and Containment Isolation Actuation Signal (CIAS)

ESFAS provides automatic actuation of the Engineered Safety Features, which are required for accident mitigation. Many of the ESFAS functions are required to be operable only in Modes 1 through 3. Table 3.3.6-1, indicates Mode 4 applicability for the Initiation Logic, Actuation Logic and Manual trip for SIAS, CIAS, CCAS and RAS[4]. Mode 5 must be entered when one manual trip circuit, initiating logic circuit, or actuation logic circuit is inoperable for RAS, SIAS, CIAS or CCAS for more than 48 hours. Two primary objectives of the ESFAS logic and Manual Trip in Mode 4 are to provide a SIAS to the operable HPSI train and CIAS to ensure containment isolation. In order to retain Defense-in-Depth, no change is being requested for the ECCS - Shutdown (TS 3.5.3) TS. Thus, the Manual Trip[4] and Actuation Logic associated with the TS operable train of HPSI must also be available in Mode 4 to establish HPSI injection following a LOCA or other inventory loss event. Analogously, to maintain Defense-in-Depth, one CIAS manual trip and actuation relay group should be operable in Mode 4 (not train specific). This will ensure that the plant operating staff does not have to manually actuate every containment isolation.

Containment Cooling Actuation System (CCAS)

As discussed above, the ESFAS logic and Manual trip TS includes a Mode 4 requirement for the CCAS. The CCAS is used to automatically actuate the containment heat removal systems (containment recirculation fan coolers and/or CS). Analyses of Mode 4 post-LOCA containment responses indicate that the lower energy content associated with the Mode 4 RCS coolant will result in a significantly reduced containment challenge when compared with Mode 1 post-LOCA containment responses. This provides ample opportunity for the operator to diagnosis the containment challenge and take appropriate mitigating actions. Therefore, operability of this actuation signal in Mode 4 is not required.

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[4] For SONGs, RAS currently requires Mode 4 capability for the Matrix Logic Function and not the Manual Trip Function.

Recirculation Actuation Signal (RAS)

As discussed above, the ESFAS logic and Manual trip TS includes a Mode 4 requirement for the RAS. Following a LOCA, the RAS is used to automatically perform the alignment from the SI mode of heat removal to the sump recirculation mode of heat removal. RAS must be implemented prior to depletion of the water in the RWST by aligning the containment emergency sump to recirculate the water in the containment. RAS is especially important during a Mode 1 large LOCA, when HPSI (2), LPSI (2) and CSP (2) are used to send water into the containment. A LOCA occurring in Mode 4 will deplete the RWST more slowly as a result of less available equipment and reduced energy in the RCS.

In Mode 4, ECCS required equipment may be reduced to only 1 HPSI pump (and then only when the plant is above LTOP conditions) and 2 CS pumps per the TSs. Furthermore, when the RCS is depressurized, the likelihood of a LOCA in Mode 4 is considerably reduced over that in Mode 1. Water will be injected at a much slower rate in Mode 4 than in Mode 1 since the time to initiate RAS is based on depletion of the RWST via all injection sources during a large LOCA. Hence, RAS times in Mode 4 are considerably longer than those associated with Mode 1. Regardless, following a LOCA, the instrumentation available to the operator is sufficient to alert the operator to the need for manual switchover to recirculation.

<u>Tier 2 Restrictions</u>

None.

5.5.5 T.S. 3.3.8 (DIGITAL) CONTAINMENT PURGE ISOLATION SIGNAL[5]

The Containment Purge Isolation Signal (CPIS) provides automatic or manual isolation of any open containment purge valves upon indication of high containment airborne radiation. TS for Modes 1 through 4 allow plant operation with the containment mini-purge valves open. These valves receive closure signals on SIAS and CIAS. A CPIS is not required for (nor is it credited for) Mode 1 design basis accidents. During normal plant operation, the containment purge is used in Modes 1 through 4 only for instances of unusual buildup of containment radiation levels due to operating leakage.

Following an accident, unavailability of the CPIS in Mode 4 would prevent automatic generation of the containment purge isolation signal. Without automatic isolation, the operator must manually isolate the containment purge. Since Mode 4 core damage events will evolve more slowly than similar events at Mode 1, the operator has adequate time and plant indications to identify and respond to an emergent core damage event and secure the containment purge. For accidents initiated at power, confirmation of isolation of the containment purge system is included in the plant's Emergency Operating Instructions (EOIs) or (EOPs). Thus, limited duration operation in Mode 4 without the CPIS poses no significant risk to the health and safety of the public.

Plant Applicability

SONGS 2 & 3

Limiting Condition for Operation (LCO)

Two CPIS channels shall be OPERABLE in Modes 1, 2, 3 and 4, during CORE ALTERATIONS, and during movement of irradiated assemblies within containment.

Licensing Basis for LCO

The CPIS is a backup to the CIAS systems in Modes 1, 2, 3 and 4 and will close the containment purge valves in the event of high radiation levels resulting from a primary leak in the containment.

CPIS provides automatic or manual isolation of any open containment purge valves upon indication of high containment airborne radiation. For Modes 1 through 4, only the containment mini-purge valves may be open. These valves receive closure signals on SIAS and CIAS. CPIS is not required for (nor is it credited for) design basis accidents. It would be used in Modes 1 through 4 only for instances of unusual buildup of containment radiation levels due to operating leakage.

Condition Requiring Entry into End State

CPIS [Manual Trip Actuation Logic], or one or more required channels of radiation monitors is inoperable and the required actions associated with the TS AOT or Completion Time (CT) have not been met.

Proposed Modification for End State Required Actions

Modify Mode 5 end state required action to allow component repair in Mode 4. Entry time into Mode 4 is proposed at 12 hours.

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[5] Also known as Containment Purge Isolation Actuation Signal (CPIAS).

Basis for Proposed Change

The actions of CPIS are not considered in the PRA, since ESFAS functions are credited for containment isolation under accident conditions. As a result of the plant shutdown condition and the associated fission product decay and lower fuel energy content, the threat of a core damage event leading to a large early release of fission products to the containment in Mode 4 is lower than in Mode 1. In addition, the threat of core damage in Mode 5 is greater than or equal to the threat of core damage in Mode 4 if RCS is vented. Differences between LERF impacts of Mode 4 operation and Mode 5 operation should be negligible due to the combined impact of the lower potential for radiological release challenges (lower CDF), reduced radiological source term (post shutdown), and high potential for event mitigation in both modes.

When entry into SDC may be averted by remaining in Mode 4 on SG heat removal, additional risk benefits are realized by averting the risks associated with the alignment of the SDCS.

Regardless of the status of the CPIS system, Mode 4 operation typically provides a lesser (or equivalent) level of risk (e.g. CDF) than in Mode 5. Since shutdown Modes 4 and 5 are subject to similar shutdown events and have similar fission product inventories and decay heats, radiation releases, their LERF behaviors would also be equivalent.

Defense-in-Depth Consideration

In the plant design basis, CPIS is not required or credited for isolating the containment purge during core damage scenarios. Unavailability of one channel of CPIS in Mode 4 eliminates one channel for the generation of the containment purge isolation signal. However, automatic channels to isolate the purge continue to be available via the other CPIS channel and, in some instances, the CIAS (if maintained available in Mode 4). Without automatic isolation, the operator must manually isolate the containment purge. Since core damage events initiating in Mode 4 will evolve more slowly than similar events at Mode 1, the operator has adequate time and plant indications to identify and respond to an emergent event and secure the containment purge prior to significant offsite release. Thus, sufficient Defense-in-Depth is retained when the end state mode is modified from Mode 5 to 4.

Tier 2 Restrictions

No tier 2 restrictions are necessary. However, when utilizing this option, it is recommended that when the CPIS is disabled, the operating staff should be alerted and operation of the containment mini-purge should be restricted. Consideration should be given to maintain availability of CIAS during the CPIS Mode 4 repair.

5.5.6 T. S. 3.3.9 (DIGITAL) CONTROL ROOM ISOLATION SIGNAL (CRIS)[6]

The CRIS initiates actuation of the Emergency Radiation Protection System and terminates the normal supply of outside air to the control room to minimize operator radiation exposure. The CRIS includes two independent, redundant subsystems, including actuation trains. Each train employs two separate sensors. One sensor detects gaseous activity. The other detects particulate and iodine activity. Since the two sensors detect different types of activity, they are not considered redundant to each other. However, since there are separate sensors in each train, the trains are redundant. If the bistable monitoring either sensor indicates an unsafe condition, that train will be actuated (one-out-of-two logic). The two trains actuate separate equipment. Actuating either train will perform the intended function. Control room isolation also occurs on a Safety Injection Actuation Signal (SIAS).

Plant Applicability

Calvert Cliffs 1 & 2, PVNGS 1, 2 & 3, Waterford 3

Limiting Condition for Operation (LCO)

One channel of CRIS shall be operable. The channel consists of manual trip, actuation logic, and radiation monitors for iodine/particulates and gases.

Licensing Basis for LCO

The CRIS Functions must be OPERABLE in Modes 1, 2, 3 & 4 [5, 6], [during core alterations], and during movement of irradiated fuel assemblies to ensure a habitable environment for the control room operators. The Bases for the LCO on the CRIS are discussed below for each Function:

a. Manual Trip

   The LCO on Manual Trip backs up the automatic trips and ensures operators have the capability to rapidly initiate the CRIS Function if any parameter is trending toward its setpoint. One channel must be operable. This considers that the Manual Trip capability is a backup and that other means are available to actuate the redundant train if required, including manual SIAS.

b. Airborne Radiation

   Both channels of Airborne Radiation detection in the required train are required to be operable to ensure the control room isolates on either high iodine and high particulates, or high gaseous activity.

c. Actuation Logic

   One train of Actuation Logic must be operable, since there are alternate means available to actuate the redundant train, including SIAS.

The CRIS, in conjunction with the Control Room Emergency Air Cleanup System (CREACS), maintains the control room atmosphere within conditions suitable for prolonged occupancy throughout the duration of any DBA.

[6] Also designated CRRS, CREFAS, and CRIP by various CEOG plants.

Condition Requiring Entry into End State

Both channels of CRIS are inoperable [and one CREACUS train is not realigned to the emergency mode within one hour]. A channel consists of Actuation Logic, Manual Trip, and particulate/iodine and gaseous radiation monitors.

Proposed Modification of End State Required Actions

For SONGS, a new Condition C is proposed which requires the plant to be in Mode 4 in 12 hours when Condition A is not met. For plants without this conditional action, it is recommended that either the SONGS action be included in the TS and change modes accordingly, or the existing TS be modified to change the Mode 5 end state required action to allow component repair in Mode 4. Entry time into Mode 4 is 12 hours.

Basis for Proposed Change

For example, since this system responds to radiation releases from fuel, adequate in-plant radiation sensors (for example, Containment High Area Radiation Monitors, CHARMs) are available to identify the need for CR isolation or Shield Building (SB) filtration (if appropriate). Furthermore, in Mode 4, the transient will unfold more slowly than at power and sufficient time exists for the operator to take manual action to realign the CREACUS. A Mode 4 end state allows SG heat removal and it may avert mode-transition risks associated with potential system alignment errors from actions required for SDC entry. Thus, the end state is low risk and any benefit associated with operating the plant in Mode 5 is negligible.

Defense-in-Depth Consideration

Redundant actuation logic is available in Mode 4. During shutdown, events unfold slowly and with lesser severity with regard to fission product releases so that the operator will have adequate time to take protective actions.

Tier 2 Restrictions

None. It would be prudent to minimize unavailability of SIAS and alternate shutdown panel and/or remote shutdown capabilities during Mode 4 operation with CRIS unavailable.

5.5.7 T. S. 3.3.9 (ANALOG) CHEMICAL VOLUME CONTROL ISOLATION SIGNAL (CVCSIS)

The CVCS Isolation Signal provides protection from radioactive contamination, as well as personnel and equipment protection in the event of a letdown line rupture outside containment. Each of the two actuation subsystems will isolate a separate letdown isolation valve in response to a high pressure condition in either the West Penetration Room or Letdown Heat Exchanger Room. Two pressure detectors in each of these rooms feed the four sensor subsystems. On a two-out-of-four coincidence, both actuation subsystems will actuate.

Plant Applicability

Calvert Cliffs 1 & 2

Limiting Condition for Operation (LCO)

Four channels of West Penetration Room/Letdown Heat Exchanger Room pressure sensing and two Actuation Logic channels shall be operable.

Licensing Basis for LCO

The CVCS Isolation Signal provides protection from radioactive contamination, as well as personnel and equipment protection in the event of a letdown line rupture outside containment.

Condition Requiring Entry into End State

The Mode 5 end state entry (Condition D) is required when:

1. One Actuation Logic channel is inoperable, or
2. One CVCS isolation instrument channel is inoperable for a time period in excess of the plant AOT/CT (48 hours).

Proposed Modification of End State Required Actions

Modify Condition B of TS to accommodate a Mode 4 end state when the required actions are not completed in the specified time.

Basis for Proposed Change

The CVCS Isolation Signal is redundant to the Safety Injection Actuation Signal for letdown line breaks outside containment. In addition, an excess flow check valve is located in containment just downstream of the regenerative heat exchanger, which isolates letdown when flow exceeds 200 gpm.

Transition to low a temperature state requires the use of the CVCS. Thus, by the time the plant is placed in Mode 4, the system has successfully operated to adequately borate the RCS. In Mode 4 the letdown flows are low. Consequently, there is adequate time to identify the need for CVCS isolation and for the operator to terminate letdown and secure charging.

Inoperability of the CVCSIS has no impact on plant CDF in any operational mode. CVCS isolation consists of closing the appropriate valve. This is undesirable at power, since letdown isolation will result. The absence of letdown flow will significantly decrease the charging flow temperature due to the absence of the regenerative heat exchanger preheating, causing unnecessary thermal stress to the charging nozzle. Therefore, the preferred action is to restore the valve function to operable status.

Plant core damage potential will be generally lower in Mode 4 than in Mode 5 due the increased redundancy and diversity of core heat removal mechanisms. Furthermore, when SDC entry may be avoided, transition risks associated with SDC alignment errors may be averted. LERF probability during these shutdown modes (Modes 4 and 5) is relatively small due to:

(1) The lower level of radionuclide inventory in the RCS,
(2) The slower nature of the Mode 4/5 severe accident event progression and
(3) Increased time for operator actions and mitigation strategies.

Defense-in-Depth Consideration

With one CVCSIS channel inoperable, the system will provide its function via its redundant channel. Transition to a low temperature state requires use of the CVCS. Thus, by the time the plant is placed in Mode 4 the system has successfully operated to adequately borate the RCS. In mode 4 the letdown flows are low. Consequently, the operator has adequate time to identify the need for CVCS isolation and for the operator to terminate letdown and secure charging.

Tier 2 Restrictions

None.

5.5.8 T.S. 3.3.10 (ANALOG) SHIELD BUILDING FILTRATION ACTUATION SIGNAL (SBFAS)

The SBFAS is required to filter the air space between the containment and shield building during a Loss of Coolant Accident (LOCA).

Plant Applicability

Millstone 2

Limiting Condition for Operation (LCO)

Two channels of SBFAS automatic and two channels of Manual Trip shall be operable.

Licensing Basis for LCO

The SBFAS is required to actuate the filter in the air space between the containment and shield building during a Loss of Coolant Accident (LOCA), as discussed in FSAR, Chapter 15. The bases acknowledge that in Mode 5 the probability of a LOCA is greatly diminished and there is ample time to respond manually to a LOCA event.

Condition Requiring Entry into End State

Shutdown condition B of TS 3.3.10 requires transition to Mode 5. This Required Action is to be taken when one Manual Trip or Actuation Logic channel is inoperable for a time period exceeding the TS AOT/CT (48 hours).

Proposed Modification of End State Required Actions

Modify Mode 5 end state required action to allow component repair in Mode 4.

Basis for Proposed Change

Inoperability of the SBFAS has no impact on plant CDF in any operational mode. Plant core damage potential will be generally lower in Mode 4 than in Mode 5 due the increased redundancy and diversity of core heat removal mechanisms. Furthermore, when SDC entry may be avoided, transition risks associated with SDC alignment errors may be averted. Large Early Release Probability (LERP) during these shutdown modes (Modes 4 and 5) is relatively small due to: (1) the lower level of radionuclide inventory in the RCS, (2) the slower nature of the Modes 4 and 5 severe accident event progression and (3) increased time for operator actions and mitigation strategies.

Defense-in-Depth Consideration

With one SBFAS channel inoperable, the system may still provide its function via its redundant channel. These systems provide post-accident radiation protection to on-site staff and/or public. Since these systems respond to radiation releases from fuel, adequate in-plant radiation sensors (Containment High Area Radiation Monitors, CHARMs) are available to identify the need for CR isolation or SB filtration (if appropriate). Furthermore, in Mode 4, the transient will unfold more slowly than at power and sufficient time exists for the operator to take manual action.

Tier 2 Restrictions

None.

5.5.9 T.S. 3.4.6 RCS LOOPS – MODE 4

This TS requires that two loops or trains consisting of any combination of RCS cooling loops or SDC trains shall be operable and at least one loop or train shall be in operation. A means (either via use of one RCS loop or one SDC train) must be provided to provide forced flow in the RCS for decay heat removal and to circulate boron. LCO action 3.4.6 A addresses the condition when the 2 SDC trains are inoperable. In that condition, the ISTS recognizes that Mode 5 SDC operation is not possible and continued Mode 4 operation is allowed until the condition may be exited. Condition B is concerned with the unavailability of forced circulation in two RCS loops and the inoperability of one train of SDC. Upon failure to satisfy the LCO, the current ISTS drives the plant to Mode 5.

The particular change sought in this TS is to adjust Condition B to reflect the risk of plant operation in Mode 5 with a defective SDCS (i.e. one train inoperable) and two RCS loops inoperable. It is recommended that heat removal be conducted in Mode 4 using either the available SDC train or, if available, the steam generators with RCS/core heat removal driven by natural convection flows. Plant natural circulation tests performed at San Onofre Unit 2 & 3 (Reference 18) indicate that natural circulation heat transfer will be an effective means of heat transfer and will ensure adequate core boration. Insights from these tests have been incorporated into plant EOIs and EOPs. Specifically, defined operator actions have been included to limit the probability of inadvertent positive reactivity addition after an extended period by requiring natural circulation prior to Reactor Coolant Pump (RCP) restart. Furthermore, as already noted in the ISTS bases, if unavailability of RCS loops is due to single SDC train unavailability, staying in a state with minimal reliance on SDC is preferred (Mode 4) due to increased diversity in RCS heat removal modes.

<u>Plant Applicability</u>

All

<u>Limiting Condition for Operation (LCO)</u>

Two loops or trains consisting of any combination of RCS loops and SDC trains shall be operable and at least one loop or train shall be in operation while in Mode 4.

<u>Licensing Basis for LCO</u>

The purpose of this LCO is to require that at least two loops or trains, RCS or SDC, be OPERABLE in Mode 4 and one of these loops or trains be in operation. The LCO allows the two loops that are required to be OPERABLE to consist of any combination of RCS and SDC System loops. Any one loop or train in operation provides enough flow to remove the decay heat from the core with forced circulation. An additional loop or train is required to be OPERABLE to provide redundancy for heat removal.

In Mode 4, RCS circulation is considered in the determination of the time available for mitigation of the accidental boron dilution event. The RCS loops and SDC trains provide this circulation.

RCS Loops - Mode 4 have been identified in the NRC Policy Statement as important contributors to risk reduction.

The response of the RCS without the RCPs or SDC pumps depends on the core decay heat production and the length of time that the pumps are stopped. As decay heat diminishes, the effects on RCS temperature and pressure diminish. Without cooling by forced flow, higher heat production will cause the reactor coolant temperature and pressure to increase at a rate proportional to the decay heat production. Because pressure can increase, the applicable system pressure limits (pressure and temperature (P/T) limits or LTOP limits) must be observed and forced SDC flow or heat removal via the SGs must be re-established prior to reaching the pressure limit.

Condition Requiring Entry into End State

Condition B of the TS requires that with one required SDC train inoperable and two required RCS loops inoperable for 24 hours, the plant be maneuvered into Mode 5. The short completion time and the low temperature end state reflect the importance of maintaining these paths for heat removal.

Proposed Modification for End State Required Actions

When RCS loops are unavailable due to inoperability of one train of SDC, and at least one SG heat removal path can be established, modify TS to change the end state from Mode 5 to Mode 4 with RCS heat removal accomplished via the steam generators.

Basis for Proposed Change

The basis for changing the Condition B End State for the unavailability of an SDC train, is as follows:

1. Mode 4 operation poses overall lower risk of Core Damage and large early Radiation Release than does Mode 5 (See section 5.4.3.4). This is particularly true since the SDC system is impaired.

2. In Mode 4 RCS and SG conditions may be maintained such that failure of the remaining SDC train may be more readily backed up by natural circulation heat removal through one or more SGs.

Natural circulation capability of typical CE PWRs (See for example SONGS 2 & 3, Reference 18) has been confirmed by tests.

For one train of SDC inoperable, PRA assessments confirm that Mode 4 operation with SG heat removal available will be a lower risk end state than operating in Mode 4 SDC or Mode 5 when the SDC is impaired.

When in Mode 4, plant capability to operate in either SDC or SG heat removal modes is available and proceduralized. PSA analyses presented in Section 5.4 show that the risks of the two Mode 4 plant operational states (AFW backed up by SDC; or SDC backed up by AFW), are relatively close, but the risk becomes larger once SDC is entered. This is caused by the following:

- A backup SG cooling method (AFW) may not be available when on SDC, but a backup method is available when on AFW cooling. When operating in Mode 4 with SG heat removal via AFW and AFW is lost, the operators can either switch to SDC or provide SG cooling using condensate or other means. But when operating in Mode 4 with SDC, the operators could switch to AFW on a loss of SDC, but they are less likely to do so since the initiating event was not a loss of SG cooling.

- Loss of RCS inventory is modeled as being more likely during the process of SDC alignment. This loss of inventory may result from a valve misalignment that creates an RCS diversion. Flow diversion paths created during SDC alignment may bypass containment. Additionally, a pressure spike or LTOP setpoint drift can cause an LTOP lift which also creates a loss of RCS inventory.

Once Mode 5 is entered, the risk may increase since SG Cooling is not initially available without either boiling the RCS or raising the RCS pressure and temperature. This action of raising RCS temperature/pressure on a loss of SDC would be considered an uncontrolled mode change, and would be initially avoided by plant personnel. This may result in a delay in using AFW SG cooling on a loss of SDC, thus resulting in a higher operator failure rate for this action. Once the RCS is reduced to atmospheric pressure, the RCS would be vented to atmosphere to allow operation of the CS pumps to back-up the SDC pumps (which for CE PWRs are the LPSI pumps). This action is not risk beneficial for many CE PWRs since venting may be necessary to ensure that pressurization events do not threaten the CS suction piping. However, the venting process results in the loss of effective use of the SG for heat removal, since a pressure increase in the RCS is not possible.

Defense-in-Depth Consideration

It is recommended that heat removal be conducted in Mode 4 using either the available SDC train or, if available, via the steam generators with RCS/core heat removal driven by natural circulation*. This condition provides additional redundancy since plant natural circulation tests performed at San Onofre Unit (Reference 18) indicate that natural circulation heat transfer during early shutdown will be an effective means of heat transfer and will ensure adequate core boration. Insights from these tests have been incorporated into generic CEOG Emergency Procedure Guidelines (EPGs) and plant EOPs and EOIs. Specifically, defined operator actions have been included to limit the probability of inadvertent positive reactivity addition after an extended period by requiring natural circulation prior to RCP restart.

Risk assessments confirm that Mode 4 operation with SG heat removal available would result in a lower risk end state than operating in Mode 4 SDC or Mode 5 with an impaired SDC system. Therefore, the proposed TS end state change does not affect the plant Defense-in-Depth.

Tier 2 Restrictions

None.

* Inoperability of RCPs is assumed to be the cause of the TS entry.

5.5.10 T.S. 3.6.1 CONTAINMENT

Containment Systems TSs are primarily focused on ensuring containment integrity and limiting offsite exposures due to events leading to core damage. The TS addresses this by:

1. Ensuring containment leakage is controlled and limited,
2. Ensuring containment heat removal (and atmospheric iodine removal) systems are available and operational and,
3. Limiting the peak containment pressure and temperature challenges to the plant by restricting the plant initial conditions consistent with the plant design basis analyses.

The requirements stated in the LCO define the performance of the containment as a fission product barrier. Specifically, LCO 3.6.1 requires that the containment allowable leakage rate, L_a, be limited in accordance with 10CFR50 Appendix J. Other LCOs place additional restrictions on containment air locks and containment isolation valves. The integrated effect of these TSs is to ensure that the containment leakage is well controlled within limits that assure that the post accident whole body and thyroid dose limits of 10CFR100 are satisfied following a Maximum Hypothetical Accident (MHA) initiated from full power. Inability to meet this leakage limit renders the containment inoperable.

Inoperability of the containment during Mode 4 has been traditionally based on the same inoperability restrictions associated with Mode 1 operation. That is, leakage rates in excess of permissible "at power" values would require plant transition to Mode 5. Design basis accidents of concern for containment leakage include LOCAs and CEA Ejection accidents. Containment leakage limits are governed by the Maximum Hypothetical Accident (MHA) associated with 10CFR100.11 siting criteria and GDC-19 which limit offsite and control room doses respectively). Containment operability is defined as maintaining total leakage within specified limits such that operator doses in the Control Room and individual general public doses at the Exclusion Area Boundary (EAB) and in the Low Population Zone (LPZ) are limited to design basis values. An important aspect of this process is that these limits are based upon at-power LOCA conditions with "at power" core radioactivity inventories and volumetric leakages associated with design basis peak containment pressure. The TS applies this restriction to Mode 4 condition on the general basis that a Design Basis Accident (DBA) in Mode 4 "could cause a release of radioactive material to the containment" and also the notion that core damage events in Mode 5 are of lower probability and therefore no such restriction is required. In fact, application of the Mode 1 TS to Mode 4 conditions is an extremely conservative assumption since the plant has been shutdown and the RCS energetics are much lower than at full power.

The applicability of the same TS 3.6.1 requirement to Mode 4 is rooted in tradition rather than consideration of risks. Accidents initiated from Mode 4 are far less challenging to the containment than those initiating from Mode 1. The lower energy content in Mode 4 results in containment pressures and potential leakage that are much lower than that associated with Mode 1 releases. Furthermore, by having the plant in a shutdown condition in advance, fission product releases following an MHA would be significantly reduced. Modifying the current ISTS end state for repair of the containment impairment is acceptable based on the short duration the plant is expected to be in Mode 4 and the fact that the core damage threat and thus containment failure threat in Mode 4 is either less than or about equal to the equivalent Mode 5 risk. Entrance into this TS is not intended to suggest the acceptability of long term gross containment leakages.

<u>Plant Applicability</u>

All

Limiting Condition for Operation (LCO)

Containment shall be OPERABLE in Modes 1, 2, 3 and 4.

Licensing Basis for LCO

In Modes 1, 2, 3 and 4, a DBA could cause a release of radioactive material into containment. In Mode 5, the TS assumes that the probability and consequences of a DBA are reduced due to the pressure and temperature limitations of this Mode. Therefore, it is assumed that the containment is not required to be OPERABLE in Mode 5 to prevent leakage of radioactive material from containment.

Containment integrity is required to limit releases of radioactive materials to the environment. Design Basis Accidents of specific concern are LOCAs, MSLBs and CEA Ejection accidents. Containment operability is dependent on maintaining total leakage within specified limits. Note that these limits are based upon at-power LOCA conditions with design basis peak containment pressure.

Condition Requiring Entry into End State

Containment is declared to be inoperable due to excessive leakage (including leakage from airlocks and isolation valves) for a time period greater than one hour.

Proposed Modification for End State Required Actions

Modify TS to allow Mode 4 to become a designated end state for correcting containment impairments for conditions where the containment leakage is excessive due to reasons other than the inoperability of two or more CIVs in the same flow path.

Basis for Proposed Change

Containment "leakage" at or near design basis levels is not explicitly modeled in the PRA. The PRA implicitly requires that containment "gross" integrity must be available to ensure adequate NPSH for ECCS pumps. In the Level 2 model, containment "leakage" is not considered to contribute to Large Early Release. Were accidents to occur in Mode 4, resulting containment pressures would be significantly less than the DBA conditions. Hence, leakage would be further reduced. While in Mode 4, the probabilities of LOCA and MSLB are reduced from Mode 1 levels.

Section 5.4.3.4 indicates that the implied licensing basis assumption that Mode 5 is inherently of lower operational risk than in Mode 4 is not supported by risk evaluations. Mode 5 risks are either about equal to and likely greater than equivalent risks in Mode 4 and therefore produce radiation releases to containment on par with those of Mode 4. Furthermore, plant shutdown actions that require entry into SDC introduce the potential for increased risks including LOCAs both inside and outside containment. Thus, based on these PRA insights, it appears that remaining in Mode 4 (vs. Mode 5) while the containment excess leakage condition is corrected is an appropriate action. This end state would maintain more mitigation systems available to respond to any event that could lead to a loss of RCS inventory or decay heat removal. Furthermore, in Mode 4 the SIAS and CIAS will be available to aid the operator in responding to events that threaten the reactor and/or containment integrity.

The proposed change addresses inoperability of the containment during Mode 4 due to leakage rates in excess of permissible values. Containment conditions following a LOCA in Mode 4 would result in containment pressures somewhat higher (on the order of 10 psi) than in Mode 5. Since the applicability of this change is limited to isolable penetrations that are not fully non-functional and penetrations not included within TS 3.6.2 and 3.6.3, only small changes in containment integrity are considered and there is no impact on LERF.

Defense-in-Depth Consideration

The requirements stated in the LCO define the performance of the containment as a fission product barrier. Specifically, this LCO requires that the containment leakage rate, be limited in accordance with 10CFR50 Appendix J. Other LCOs place additional restrictions on containment air locks and containment isolation valves. The integrated effect of these TSs is to ensure that the containment leakage is well controlled within limits that assure that the post accident whole body and thyroid dose limits of 10CFR100 are satisfied following a Maximum Hypothetical Event initiated from full power. Inability to meet this leakage limit renders the containment inoperable.

The applicability of the TS 3.6.1 requirement to Mode 4 is rooted in tradition rather than consideration of risks. Accidents initiated from Mode 4 are far less challenging to the containment than those initiating from Mode 1. The lower energy content in Mode 4 results in containment pressures and potential leakage approximately one half of that associated Mode 1 releases. Furthermore, by having the plant in a shutdown condition in advance, fission product releases are significantly reduced. Thus, while leakage restrictions should be maintained, Mode 4 leakage in excess of that allowed in Mode 1 can be safely allowed for a limited time sufficient to effect repair of the leak and return the plant to power operation. Additionally, Mode 4 on SGHR (vs. Mode 5) would maintain more mitigating systems available to respond to loss of RCS inventory or decay heat removal events and therefore reduce the overall public risk. In Mode 4, SIAS and CIAS will be available to aid the operators in responding to events that threaten the reactor and/or containment integrity. Therefore, the proposed TS end state change does not affect the plant Defense-in-Depth.

Tier 2 Restrictions

Limitation on containment leakage is still required. This is accomplished in this proposed change by limiting applicability of the TS to conditions where CIVs or air locks are essentially functional (although may be formally Inoperable) and have the capability to perform their containment isolation function. Conditions where containment isolation capability cannot be met will continue to result in a Mode 5 end state. This division is based on consideration of defense-in-depth. Temporary operation of the plant in Mode 4 (as opposed to Mode 5) with an "impaired" containment is not a risk significant action.

5.5.11 T.S. 3.6.2 CONTAINMENT AIR LOCKS

Operability of the containment air locks is defined so as to ensure that leakage rates (defined in TS 3.6.1) will not exceed permissible values. The containment isolation valves and air locks form part of the leakage boundary. For systems that communicate with the containment atmosphere, two redundant isolation valves are provided for each line that penetrates containment. For systems that do not communicate with the containment atmosphere, at least one isolation valve is provided for each line. Similarly, with regard to containment air locks, the air lock is fitted with redundant seals and doors, one located on each side of the air lock. These TSs are entered when containment leakage is within limits, however, some portion of the containment isolation function is impaired (e.g. one valve in a two valve path inoperable or containment purge valves have leakage in excess of Tech Spec limits). The issue of concern in these TSs is the appropriate action/end state for extended repair of an inoperable air lock where only one or both air locks doors are not functional.

Plant Applicability

All

Limiting Condition for Operation (LCO)

[Two] containment air lock[s] shall be OPERABLE Modes 1, 2, 3 and 4.

Licensing Basis for LCO

In Modes 1, 2, 3 and 4, a DBA could cause a release of radioactive material to containment. In Modes 5 and 6, the probability and consequences of a DBA are reduced due to the pressure and temperature limitations of these Modes. Therefore, the containment air locks are not required in Mode 5 to prevent leakage of radioactive material from containment. The requirements for the containment air locks during Mode 6 are addressed in LCO 3.9.3, "Containment Penetrations."

Containment integrity is required to limit releases of radioactive materials to the environment. Design Basis Accidents of specific concern are LOCAs and CEA Ejection accidents. Containment operability is defined as maintaining total leakage within specified limits. Note that these limits are based upon at-power LOCA conditions with design basis peak containment pressure.

Condition Requiring Entry into End State

Entry into a Mode 5 end state is required when:

1. One or more containment air locks with one containment air lock door inoperable or,
2. One or more containment air locks with containment air lock interlock mechanism inoperable, or
3. One or more containment air locks inoperable for other reasons,
4. And the required action not completed within the specified AOT/CT.

Proposed Modification for End State Required Actions

Modify TS to accommodate Mode 4 end state within the Condition D required Action. Mode 4 entry is proposed at 12 hours.

Basis for Proposed Change

Changes to this TS are sought for conditions when containment leakages is not expected to exceed that allowed in TS 3.6.1. Thus, the TS inoperability under consideration does not have an adverse impact on plant CDF or LERF.

The risk of core damage in Mode 4 is similar to or lower than that of Mode 5. Mode 4 (vs. Mode 5) would maintain more mitigating systems available to respond to loss of RCS inventory or decay heat removal events. Also, in Mode 4, SIAS and CIAS will be available to support the operators in responding to events that threaten the reactor and/or containment integrity. Consequently, the potential radiation challenge to the containment will also be lower. Thus no risk benefit will be gained by performing the repair in Mode 5.

Defense-in-Depth Consideration

Operability of both the containment air locks is inferred in TS 3.6.2. Operability ensures that leakage rates (defined in TS 3.6.1) will not exceed permissible values. The containment air locks form part of the leakage boundary. Each containment air lock is fitted with redundant seals and doors, one located on each side of the air lock. This TS is normally entered when containment leakage is within limits, and some portion of the containment isolation function is impaired. The issue of concern in these TSs is the appropriate action/end state for extended repair of an inoperable air lock.

Except for a limited number of equipment combinations, associated with unavailability of AFW train or SG heat removal, the risk of core damage in Mode 4 operation is similar to or lower than that of Mode 5. Consequently, the potential radiation challenge to the containment will also be lower. For all conditions when Mode 4 operation is otherwise recommended, no risk benefit will be gained by performing the containment leakage repair (or resolving a containment leakage issue) in Mode 5.

Tier 2 Restrictions

None that relate directly to the containment air lock TS. Mode end state for repair should consider availability of SG heat removal equipment.

5.5.12 T.S. 3.6.3 CONTAINMENT ISOLATION VALVES

Operability of the containment isolation valves ensures that leakage rates will not exceed permissible values. The containment isolation valves and air locks form part of the leakage boundary. For systems that communicate with the containment atmosphere, two redundant isolation valves are provided for each line that penetrates containment. For systems that do not communicate with the containment atmosphere, at least one isolation valve is provided for each line. Similarly, with regard to containment air locks, the air lock is fitted with redundant seals and doors, one located on each side of the air lock. This LCO is entered when containment leakage is within limits, but, some portion of the containment isolation function is impaired (e.g. one valve in a two valve path inoperable or containment purge valves have leakage in excess of Tech Spec limits). The issue of concern in this TS is the appropriate action/end state for extended repair of an inoperable CIV when one Containment Isolation Valve in a single line is inoperable.

Plant Applicability

All

Limiting Condition for Operation (LCO)

Each containment isolation valve shall be OPERABLE in Modes 1, 2, 3 and 4.

Licensing Basis for LCO

In Modes 1, 2, 3 and 4, a DBA could cause a release of radioactive material to containment. In Mode 5, the probability and consequences of DBAs are reduced due to the pressure and temperature limitations of these Modes. Therefore, the containment isolation valves are not required to be OPERABLE in Mode 5.

Containment integrity is required to limit releases of radioactive materials to the environment. The containment isolation valves form part of the leakage boundary. For systems that communicate with the containment atmosphere, two redundant isolation valves are provided for each line that penetrates containment. For systems that do not communicate with the containment atmosphere, at least one isolation valve is provided for each line. Design Basis Accidents of specific concern are LOCAs, MSLBs and CEA Ejection accidents.

Condition Requiring Entry into End State

A required action to maneuver the plant into Mode 5 will occur when one or more penetration flow paths exist with one or more containment isolation valves inoperable [except for purge valve leakage and shield building bypass leakage not within limit] and the affected penetration flow path cannot be isolated with the prescribed AOT/CT.

Proposed Modification for End State Required Actions

Modify Condition G of SONGS TS (and their equivalents) to accommodate a Mode 4 end state when the required actions defined by Conditions A, B, C, D, E and F are not completed in the specified time. Mode 4 entry is proposed at 12 hours.

Basis for Proposed Change

Remaining in Mode 4 (vs. Mode 5) while the deficient condition is corrected would maintain more mitigation systems available to respond to any event that could lead to a loss of RCS inventory or decay heat removal. Thus, the risk of plant operation in Mode 4 is no greater than that for Mode 5 (and should be considerably lower). Also transition risks associated with SDC entry may be avoided. Additionally, in Mode 4, SIAS and CIAS will be available to aid the operators in responding to events that threaten the reactor and/or containment integrity.

Containment conditions following a LOCA in Mode 4 would result in containment pressures only slightly higher than in Mode 5. Since the containment leakage is small and the plant is shutdown allowing for significant the radionuclide decay, no increase in LERF is expected.

Defense-in-Depth Consideration

The containment isolation valves form part of the leakage boundary. For systems that communicate with the containment atmosphere, two redundant isolation valves are provided for each line that penetrates containment. For systems that do not communicate with the containment atmosphere, at least one isolation valve is provided for each line. This TS would probably be entered when containment leakage is within limits, but, some portion of the containment isolation function is impaired (e.g. one valve in a two valve path inoperable or containment purge valves have leakage in excess of Tech Spec limits). The issue of concern in these TSs is the appropriate action/end state for extended repair of an inoperable CIV when the overall isolation capability of the associated flow path remains functional.

As discussed in Section 5.4.3.4, except for a limited number of equipment combinations, the risk of core damage in Mode 4 is similar to or lower than that of Mode 5. Consequently, the potential radiation challenge to the containment will also be lower. For all conditions when Mode 4 operation is otherwise recommended, no risk benefit will be gained by performing the containment leakage repair (or resolving a containment leakage issue) in Mode 5.

Tier 2 Restrictions

None.

5.5.13 T.S. 3.6.4 CONTAINMENT PRESSURE

The upper limit on containment pressure in this LCO is based on Mode 1 design basis analyses. In the event of large double ended guillotine break of the RCS piping or secondary piping inside containment, the initial conditions of the containment are such that the containment pressure would not exceed the design limit. The design analyses ensure that the containment is designed in such a manner that it is robust to a wide range of design basis and beyond design basis events. The robustness of the containment arises from the requirement that the containment be designed to respond to accidents while remaining well within the structural material elastic response capabilities. This effectively maintains the containment design pressure about a factor of 2 or more below the minimum containment failure pressure. For example, the SONGS 2 & 3 containment design pressure is 60 psig, whereas its median rupture pressure is calculated to be 175 psig (SONGS 2 & 3 IPE, Reference 19). Containment pressure challenges at the design base pressure level have a negligible potential of threatening containment integrity. Additional conservatism is provided in the containment challenge analysis which selects the large break to maximize the peak containment loading and minimize the impact of passive and active heat removal mechanisms to control containment pressure. The containment initial pressure is the starting point for the containment pressure challenge analysis.

As discussed previously, Mode 1 analyses have traditionally been used to bound Mode 4 behaviors and thus, Mode 4 TS applicability has also been subsumed in the Mode 1 TS. However, the Mode 1 and Mode 4 conditions that would drive such a containment challenge are far different. Specifically, the Mode 4 energy release is far less than would be possible during a Mode 1 RCS or secondary pipe breach. Consequently, containment loadings will fall well below the containment design pressure associated with a full power MSLB. Mode 4 peak pressure transients will produce containment pressure challenges well below the typical containment design capability, which is again well below the containment failure limit. Since the expectation of containment pressure variations is small and the margin to minimal challenge is large, a Mode 4 limit on this parameter is unnecessary.

The vacuum lower limit on containment pressure is typically set by the plant design basis and ensures the ability of the containment to withstand an inadvertent actuation of the CS system. This issue is of particular concern to plants with steel shell containment designs.

Plant Applicability

All

Limiting Condition for Operation (LCO)

Containment pressure shall be controlled within limits during Modes 1, 2, 3 and 4.

Licensing Basis for LCO

The maximum pressure limit is based on Mode 1 DBA and applied to Modes 1, 2, 3 and 4, where a DBA could cause a release of radioactive material to containment. In maintaining containment pressure within limits it is necessary to ensure initial conditions assumed in the accident analysis are maintained. The LCO is applicable in Modes 1, 2, 3 and 4.

In Mode 5, the probability and consequences of a DBA are reduced due to the pressure and temperature limitations of this Mode. Therefore, maintaining containment pressure within the limits of the LCO is not required in Mode 5.

The upper limit on containment pressure is based on design basis accident assumptions to ensure that post-accident pressure does not exceed design limits.

A negative pressure limit is also established to protect the containment from under-pressure failure due to inadvertent CS actuation. The maximum vacuum (minimum pressure) is based on initial containment temperature and pressure and temperature of the spray water. For example, an inadvertent spray actuation event initiated at the maximum permissible vacuum would not cause the containment pressure to decrease below the design limit of 5 psi below external pressure.

Condition Requiring Entry into End State

A Mode 5 end state is required to be initiated (Condition B) when the containment pressure is not within limits and the condition is not corrected within one hour.

Proposed Modification for End State Required Actions

Modify Condition B of TS to accommodate a Mode 4 end state when the required actions are not completed in the specified time. Mode 4 entry is proposed at 12 hours.

Basis for Proposed Change

Initial containment pressure at the start of an event is not explicitly modeled. In Mode 4, LOCAs and other accidents would pose a much reduced challenge to the containment. PRAs are primarily concerned with the impact of the containment challenges on containment "gross" integrity. Typically, containment failure pressures are greater than twice the containment design pressure. The SONGS 2 & 3 containment design pressure is 60 psig, whereas its median rupture pressure is calculated to be 175 psig (SONGS 2 & 3 IPE). Thus, minor variations in containment initial pressure will result is a similarly small change to the resulting containment challenge. Since the margin to failure is large, no LERF impact will result from Mode 4 initial containment pressures in excess of "Mode 1" TS limits. This is particularly true since Mode 4 conditions are associated with low RCS energetics

As discussed in Section 5.4.3.4, Mode 4 operation results in plant risks that are expected to be either equal to or less than similar Mode 5 operational risks. Furthermore, remaining in Mode 4 with SG heat removal would also allow the operator to avoid the risks associated with SDC entry.

Control on containment pressure during all operating modes is based on not exceeding permissible limits on containment pressure in the case of an accident. Maximum containment pressures vary from plant to plant. A design basis event initiated from Mode 4 conditions will result in maximum pressure challenges well below the containment design limits. Thus temporary reductions or increases outside of bounds of the LCO will not challenge containment integrity.

In-containment vacuum conditions will not compromise containment integrity for plants with pre-stressed or reinforced concrete containment. Plants with steel containment control the impact of CS actuation via use of vacuum breakers. Risk impact on Mode 4 operation of the plant with containment pressures significantly below the TS lower limit is expected to be low, as is the likelihood of inadvertent CS actuation.

Defense-in-Depth Consideration

Mode 1 analyses have traditionally been used to bound Mode 4 behaviors and thus, Mode 4 TS applicability has been subsumed in the Mode 1 TS. However, the Mode 1 and Mode 4 conditions that would drive such a containment challenge are far different. Specifically, the Mode 4 energy release is far less than would be possible during a Mode 1 RCS or secondary pipe breach. Consequently, containment loadings will fall well below the containment design pressure. Representative analyses suggest the Mode 4 peak pressure transients will produce containment pressure challenges that are well below the containment design capability, which is again well below the containment failure limit. Since the expectation of containment pressure variations is small and the margin to minimal challenge is large, a Mode 4 upper limit on containment initial pressure has negligible risk importance.

The lower limit on containment pressure is typically a result of containment depressurization studies and ensures the ability of the containment to withstand an inadvertent actuation of the CS system. This issue is of particular concern to plants with steel shell containment designs. Plant susceptibility to this condition is entirely dependent on containment initial humidity and temperature and not significantly different in Modes 4 or 5. For example inadvertent spray actuation injecting 40 °F water into a containment with a containment temperature of 120 °F and a relative humidity of 100% will result in a containment pressure decrease of 3.5 psi, regardless of initial mode*. Since the initial pressure variability is physically limited to small changes and margin exists between the minimum containment design pressure capability and the expected Mode 4 and 5 pressure challenge, correction of the containment pressure condition in Mode 4 is an acceptable alternative to performing this activity in Mode 5. Therefore, the proposed TS end state change does not affect the plant Defense-in-Depth.

Tier 2 Restrictions

None. For plants with steel shell containments, if lower limit pressure specification is violated, confirm operability of the vacuum breakers. For all plants, when entering this action statement for violation of low containment pressure limit for a period projected to exceed one day secure one containment spray pump.

* SONGS assessment indicates that margin exists with their current LCO limit such that, under most limiting conditions (-0.3 psig TS lower limit), inadvertent actuation of CS will not decrease the containment pressure to below - 4.2 psig (Reference 20). The design basis lower limit for SONGS is - 5.0 psig.

5.5.14 T.S. 3.6.5 CONTAINMENT AIR TEMPERATURE

The upper limit on containment temperature is based on Mode 1 design basis analyses for containment structures and equipment qualification. In the event of large double ended guillotine break of the RCS piping or secondary piping inside containment, the initial condition imposed by this LCO is such that the containment temperature would not exceed design value. As discussed previously, the Mode 4 energy release is far less than would be possible during a Mode 1 RCS or secondary pipe breach. Consequently, Mode 4 post-accident containment temperatures will fall well below the containment temperature limit employed in the plant design basis. Since containment temperature variations are expected to be limited to small variations from the technical specification value and the margin to minimal challenge is large, short duration operation in Mode 4 outside of the containment maximum temperature limit will not erode plant Defense-in-Depth.

<u>Plant Applicability</u>

All

<u>Limiting Condition for Operation (LCO)</u>

Containment average air temperature shall be ≤ 120 °F in Modes 1, 2, 3 and 4.

<u>Licensing Basis for LCO</u>

In Modes 1, 2, 3 and 4, a DBA could cause a release of radioactive material to containment. In Mode 5, the probability and consequences of a DBA are reduced due to the pressure and temperature limitations of these Modes. Therefore, maintaining containment average air temperature within the limit is not required in Mode 5.

The containment temperature limit is based on design basis accident assumptions to ensure that post-accident temperatures do not exceed the design limit.

<u>Condition Requiring Entry into End State</u>

Condition B of this TS requires a Mode 5 shutdown when containment temperature is not within limits and is not corrected within specified AOT/CT.

<u>Proposed Modification for End-State Required Actions</u>

Modify condition B of TS to accommodate a Mode 4 end state with a 12 hour entry time.

<u>Basis for Proposed Change</u>

Initial containment temperature at the start of an event is not explicitly modeled in the PRA and has no direct impact on plant CDF or LERF. The Mode 4 end state is recommended based on the low risk of Mode 4 operation (See Section 5.4.3.4) and the potential to avoid unnecessary mode transitions.

Control on containment temperature during all operating modes is based on not exceeding calculated limits on containment temperature in the case of an accident. A design basis event during Mode 4 will result in temperatures well below the design value. Thus temporary increases outside of bounds of the LCO would not be expected to challenge containment integrity. Mode 4 operation also provides a diverse and redundant environment for ensuring core and RCS heat removal and low plant operational risks (See Section 5.4.3.4).

Defense-in-Depth Consideration

The upper limit on containment temperature is based on Mode 1 design basis analyses for containment structures and equipment qualification. In the event of large double ended guillotine break of the RCS piping or secondary piping inside containment, the initial condition imposed by this LCO is such that the containment temperature would not exceed design value. As discussed previously, the Mode 4 energy release is far less than would be possible during a Mode 1 RCS or secondary pipe breach. Consequently, Mode 4 post-accident containment temperatures will fall well below the containment temperature limit employed in the plant design basis. Since potential operational containment temperature variations are small and the margin to minimal challenge is large, a Mode 4 limit on this parameter is unnecessary. Therefore, the proposed TS end state change does not affect the plant Defense-in-Depth.

It should be noted that high temperature in Mode 4 is not expected due to the lower operating temperature of the RCS and steam generators. In practice, the appropriate end state to perform repairs should consider the health and safety of plant personnel working within the containment.

Tier 2 Restrictions

None.

5.5.15 T.S. 3.6.6 CONTAINMENT COOLING SYSTEMS

Containment cooling is required to ensure both long term containment integrity and sump cooling. Containment cooling TSs include LCO 3.6.6. - Containment Spray and Cooling Systems, LCO 3.6.6A - Credit taken for Iodine Removal by Containment Spray, LCO 3.6.6B - Credit not taken for Iodine Removal by Containment Spray.

The design basis of the Containment Spray (CS) and cooling systems varies among the CE units. Most CE plants credit the CS and cooling systems for containment pressure and temperature control and one of the two systems for radio-iodine removal. In these plants typically, one train of CS is sufficient to effect radio-iodine control and one train of CS and one train of fan coolers is sufficient to effect containment pressure and temperature control. The Palo Verde units are designed with only the CS system (containing full capacity redundant CS pumps) which it credits for both functions.

Design and operational limits (and consequently the TSs) are established based on Mode 1 analyses. Traditionally, these analyses and limits are applied to Modes 2, 3 and 4. Mode 1 analyses bound the other modes and confirm the adequacy of the containment cooling system to control containment pressure and temperature following limiting containment pipe breaks occurring at any mode. However, the resulting TS requirements become increasing conservative (and restrictive) as the lower temperature shutdown modes are traversed. Plants that do not require containment cooling in Mode 4 include St. Lucie Units 1 & 2 and Palo Verde Units 1, 2 & 3. SONGS Units 2 & 3, ANO 2 and St. Lucie do not require sprays to be operable in Mode 4.

Inability to complete the repair of a single train of cooling equipment in the allotted AOT will require transition to Mode 5. This end state transition was originally based on the expectation of very low Mode 5 risks when compared to alternate operating states. Mode 4 is generally the more robust (and lower risk) of the operating modes. Furthermore, when considering the Mode 4 containment challenge, the lower stored energy and decay heat of the reactor coolant system support the proposed use of a less robust cooling and radionuclide removal capability. Based on representative plant analyses performed in support of PRA containment success criteria, containment protection may be established via use of a single fan cooler as documented in the SONGS 2 & 3 IPE (Reference 19). Qualitatively, a similar conclusion could be drawn for one train of CS. Consequently, in Mode 4 one train of containment coolers or one train of CS assures adequate heat removal capability. Furthermore, for plants that credit CS for iodine removal, accidents initiated in Mode 4 may be adequately mitigated via one operable spray pump.

<u>Plant Applicability</u>

ANO 2, Calvert Cliffs 1 & 2, Ft Calhoun, SONGS 2 & 3, Waterford 3

<u>Limiting Condition for Operation (LCO)</u>

Two CS trains and two containment cooling trains shall be OPERABLE in Modes 1, 2, [and] [3 and 4]. The time required for Mode 5 entry varies from 30 to 36 hours for one component of the containment cooling system out of service. For SONGS Units 2 & 3 unavailability of one or more CS train(s) will require the plant to transition to Mode 4 in 84 hrs.

<u>Licensing Basis for LCO</u>

The TS notes that in Modes 1, 2, 3 and 4, a DBA could cause a release of radioactive material to containment and an increase in containment pressure and temperature, requiring the operation of the CS and containment fan coolers.

Containment cooling is required to remove heat from the containment following a design basis accident. Fan coolers/sprays also participate in the removal of airborne fission products from the containment environment and thereby influence containment out leakage. Two trains of containment cooling, considering the worst single failure, provide sufficient cooling to control containment pressure and temperature following an accident.

In Mode 5, the probability and consequences of a DBA are reduced due to the pressure and temperature limitations of this Mode. Thus, the CS and Containment Cooling systems are not required to be OPERABLE in Mode 5.

Condition Requiring Entry into End State

Condition C requires Mode 5 entry when the affected train is not returned to service within the TS AOT/CT. For SONGS 2 & 3 only, conditions 3.6.6.1 B and 3.6.6.1 F require Mode 4 entry within 84 hours.

Proposed Modification for End State Required Actions

Modify condition B & F of TS to accommodate a Mode 4 end state. Entry time requirements are as follows:

Inoperability	Required Actions
CSS one train	Mode 4 – 84 hrs
Cont. Coolers two trains	Mode 4 – 36 hrs

Basis for Proposed Change

PRAs consider containment cooling from the perspectives of ensuring long term containment integrity and establishing the environment for ensuring adequate NPSH exists for the ECCS and spray pumps when the systems are operated in a recirculation mode. Representative severe accident analyses conducted for SONGS 2 & 3 demonstrate that only a single Containment Cooling (CC) train (i.e. 25% cooling capacity) is sufficient to prevent containment failure and ensure adequate ECCS pump NPSH loss for a Large LOCA initiated from Mode 1.

Modification of the end state of this TS to allow a Mode 4 end state for conditions when one CC train is inoperable is a risk beneficial action in that it allows plant operation in a condition where the plant has increased redundancy and diversity of core heat removal equipment without compromising Defense-in-Depth. Furthermore, in Mode 4, SIAS and CCAS will be available to support the operators in responding to events that threaten the reactor and/or containment integrity.

Defense-in-Depth Consideration

Design and operational limits are established based on Mode 1 analyses. Traditionally, these analyses and limits are applied to Modes 2, 3 and 4. Mode 1 analyses bound the other modes and confirm the adequacy of the containment cooling system to control containment pressure and temperature following limiting containment pipe breaks occurring at any mode. However, the resulting TS requirements become more conservative (and restrictive) as the lower temperature shutdown modes are traversed.

Inability to complete the repair of cooling equipment in the allotted AOT currently will require transition to Mode 5. This end state transition was originally based on the expectation of very low Mode 5 risks when compared to alternate operating states. Mode 4 is generally the more robust (and lower risk) of the operating modes. Furthermore, when considering the Mode 4 containment challenge, the lower stored energy and decay heat support the use of a less robust cooling and radionuclide removal capability. Based on representative plant analyses performed in support of PRA containment success criteria, containment integrity may be ensured via use of a single fan cooler. Qualitatively similar conclusions could be drawn for one train of CS. Consequently, in Mode 4 one train of containment coolers or one train of CS assures adequate heat removal capability. Furthermore, iodine removal by CS, accidents initiated in Mode 4 may be adequately supported via one operable spray pump. Therefore, 84 hrs requested to transition to Mode 4 with one CS train inoperable allows additional time to restore the inoperable CS train and is reasonable when considering that the driving force for a release of radioactive material from the RCS is reduced in Mode 3.

The requested 36 hrs to transition to Mode 4 with both trains of Containment Cooling inoperable is reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems. It also recognizes that at least one train of CS is available as a backup system.

Availability of SIAS and CCAS in Mode 4 also supports the operators in responding to events that threaten the reactor and/or containment integrity. Hence, modification of the end state of this TS to allow a Mode 4 end state allows plant operation in a condition of increased redundancy and diversity of core heat removal equipment without compromising Defense-in-Depth.

Tier 2 Restrictions

None.

5.5.16 T. S. 3.6.11 SHIELD BUILDING

The shield building is a concrete structure that surrounds the steel containment vessel. Between the containment vessel and the shield building inner wall is an annular space that collects any containment leakage that may occur following a Loss of Coolant Accident (LOCA). This space also allows for periodic inspection of the outer surface of the steel containment vessel.

<u>Plant Applicability</u>

Millstone 2, St Lucie 1 & 2, Waterford 3

<u>Limiting Condition for Operation (LCO)</u>

Shield Building OPERABILITY must be restored within 24 hours. If the shield building cannot be restored to OPERABLE status within the required Completion Time, the plant must be brought to Mode 5 within 36 hours.

<u>Licensing Basis for LCO</u>

Shield building OPERABILITY is required in Modes 1, 2, 3 and 4 when a Main Steam Line Break, LOCA, or Control Element Assembly Ejection Accident could release radioactive material to the primary containment atmosphere. Radioactive material may enter the shield building from the primary containment following a LOCA. Maintaining shield building OPERABILITY ensures that the release of radioactive material from the primary containment atmosphere is restricted to those leakage paths and associated leakage rates assumed in the accident analysis.

Following a LOCA, the Shield Building Exhaust Air Cleanup System (SBEACS) establishes a negative pressure in the annulus between the shield building and the steel containment vessel. Filters in the system then control the release of radioactive contaminants to the environment. Shield building OPERABILITY is required to ensure retention of primary containment leakage and proper operation of the SBEACS.

The LCO takes into consideration the limited leakage design of the containment and the low probability of a DBA occurring during the transition from Mode 1 to Mode 5.

<u>Condition Requiring Entry into End State</u>

A Mode 5 end state is required to be initiated when Shield building is inoperable for more than 24 hours.

<u>Proposed Modification of End State Required Actions</u>

Modify Mode 5 end state required action to allow component repair in Mode 4 with a 12 hour Mode 4 entry requirement.

<u>Basis for Proposed Change</u>

Shield Building "leakage" at or near containment design basis levels is not explicitly modeled in the PRA. The PRA implicitly requires that containment "gross" integrity must be available to ensure adequate NPSH for ECCS pumps. In the Level 2 model, containment "leakage" is not considered to contribute to Large Early Release even without a Shield Building. Were accidents to occur in Mode 4, resulting containment pressures would be significantly less than the DBA conditions and the Shield Building would be available to further limit releases. While in Mode 4, the probabilities of LOCA and MSLB are reduced from Mode 1 levels. When Condition A of this TS can no longer be met, the plant must be shutdown and transitioned to Mode 5.

Section 5.4.3.4 indicates that the implied licensing basis assumption that Mode 5 is inherently of lower operational risk than in Mode 4 is not supported by risk evaluations. Mode 5 risks are either about equal to and likely greater than equivalent risks in Mode 4 and therefore produce radiation releases to containment on par with those of Mode 4. Furthermore, plant shutdown actions that require entry into SDC introduce the potential for LOCAs and RCS flow diversions. Thus, based on these PRA insights, remaining in Mode 4 (vs. Mode 5) while the Shield Building leakage condition is corrected is an appropriate action. This end state would maintain more mitigation systems available to respond to any event that could lead to a loss of RCS inventory or decay heat removal. Furthermore, in Mode 4 the SIAS and CIAS will be available to aid the operator in responding to events that threaten the reactor and/or containment integrity.

Inoperability of the Shield Building during Mode 4 implies leakage rates in excess of permissible values. Containment conditions following a LOCA in Mode 4 would result in containment pressures only marginally higher than in Mode 5. Since leakage from containment is controlled via TS 3.6.1, and no major leak paths are unisolable, there is no contribution to an increased LERF.

Defense-in-Depth Consideration

The requirements stated in the LCO define the performance of the Shield Building as a fission product barrier. Specifically, this LCO requires that the containment design leakage rate, L_a is limited in accordance with 10CFR50 Appendix J. In addition, this TS places restrictions on containment air locks and containment isolation valves. The integrated effect of these TSs is to ensure that the containment leakage is well controlled within limits that assure that the post accident whole body and thyroid dose limits of 10CFR100 are satisfied following a Maximum Hypothetical Event initiated from full power. Inability to meet Shield Building and Containment leakage limits renders the containment inoperable.

The applicability of the TS 3.6.1 requirement to Mode 4 is rooted in tradition rather than consideration of risks. Accidents initiated from Mode 4 are far less challenging to the containment than those initiating from Mode 1. The lower energy content in Mode 4 results in containment pressures and leakage approximately one half of that associated with Mode 1 releases. Furthermore, by having the plant in a shutdown condition in advance, fission product releases are significantly reduced. Thus, while leakage restrictions should be maintained in Mode 4, leakage in excess of that allowed in Mode 1 should be allowed to effect repair of the leak and return the plant to power operation. Additionally, Mode 4 (vs. Mode 5) would maintain more mitigating systems available to respond to loss of RCS inventory or decay heat removal events. In Mode 4, SIAS and CIAS will be available to aid the operators in responding to events that threaten the reactor and/or containment integrity. Therefore, the proposed TS end state change does not affect the plant Defense-in-Depth.

Tier 2 Restrictions

None. Shield building inoperability should not result in "large" radiation release pathway (See TS 3.6.1).

5.5.17 T.S. 3.7.5 AUXILIARY FEEDWATER SYSTEM

The AFW system supplies feedwater to the steam generators to remove decay heat from the RCS upon the loss of normal feedwater supply. The AFW pumps take suction through separate and independent suction lines from the Condensate Storage Tank (CST) and pump to the steam generator secondary side via separate and independent connections to the MFW piping inside containment. The steam generators function as a heat sink for core decay heat. The heat load is dissipated by releasing steam to the atmosphere from the steam generators via the Main Steam Safety Valves (MSSVs) or Atmospheric Dump Valves (ADVs). If the main condenser is available, steam may be released via the steam bypass valves and recirculated to the CST.

The AFW System varies among CE PWRs. For SONGS the AFW consists of two motor driven AFW pumps and one steam turbine driven pump configured into three trains. Each motor driven pump provides 100% of AFW flow capacity; the turbine driven pump provides 100% of the required capacity to the steam generators as assumed in the accident analysis. The pumps are equipped with independent recirculation lines to prevent pump operation against a closed system. One pump at full flow is sufficient to remove decay heat and cool the unit to SDC system entry conditions.

The steam turbine driven AFW pump receives steam from either main steam header upstream of the Main Steam Isolation Valve (MSIV). Each of the steam feed lines will supply 100% of the requirements of the turbine driven AFW pump. The turbine driven AFW pump supplies a common header capable of feeding both steam generators, with DC powered control valves actuated to the appropriate steam generator by the Emergency Feedwater Actuation System (EFAS).

The design basis of the AFW system is to supply water to the steam generators to remove decay heat and other residual heat, by delivering at least the minimum required flow rate to the steam generators at pressures corresponding to the lowest MSSV set pressure.

Plant Applicability

All

Limiting Condition for Operation (LCO)

[Three] AFW trains shall be OPERABLE in Modes 1, 2 and 3, and Mode 4 when steam generator is relied upon for heat removal.

The LCO is modified by a Note indicating that only one AFW train, which includes a motor driven pump, is required to be operable in Mode 4. This is because of reduced heat removal requirements, the short period of time in Mode 4 during which AFW is required, and the insufficient steam supply available in Mode 4 to power the turbine driven AFW pump.

Licensing Basis for LCO

This LCO requires that three AFW trains be operable to ensure that the AFW system will perform the design safety function to mitigate the consequences of accidents that could result in overpressurization of the reactor pressure coolant boundary.

In Modes 1, 2 and 3, the AFW System is required to be OPERABLE and to function in the event that the MFW is lost. In addition, the AFW System is required to supply enough makeup water to replace steam generator secondary inventory, depleted as the unit cools to Mode 4 conditions.

In Mode 4, the AFW System may be used for heat removal via the steam generators.

In Mode 5, the steam generators are not normally used for decay heat removal, and the AFW System is not required.

AFW is required for steam generator heat removal when MFW is not available. In Modes 1, 2 and 3, all three AFW pumps are required to be operable. In the Mode 4 base risk analysis of Section 5.4, the turbine-driven AFW pump is assumed to be unavailable due to low steam pressure.

In the SONGS Units 2 & 3 TSs, both motor-driven pumps are required to ensure that at least one train is available, given a single failure. However, in Mode 4, SONGS TS 3.7.5 states that only one pump is required.

Condition Requiring Entry into End State

1. One steam supply to turbine driven AFW pump inoperable, or
2. One AFW train inoperable [for reasons other than the above condition], or
3. Two AFW trains with two motor driven pumps inoperable, or
4. Two AFW trains with one motor driven pump and one steam driven pump inoperable and equipment not returned to service within the associated AOT/CT.

Proposed Modification for End State Required Actions

Mode 4 with heat removal via the SDC system with an 18 hour entry requirement.

Basis for Proposed Change

For cases in which both motor-driven pumps are available, remaining in Mode 4 should be a lower risk condition than continuing to Mode 5 because more diversity of heat removal and injection sources remain available. With impaired SG heat removal capability, and a fully operational SDC system, core heat removal via SDC is the preferred mode of heat removal when in the shutdown modes. NUREG-1432 also allows staying in Mode 4 if RCS heat removal requirements are fully met by the use of SDC trains. SDC on Mode 4 is preferred to Mode 5 since AFW remains a proceduralized backup (albeit impaired).

The eighteen hour time frame provides sufficient time for the plant staff to enter Mode 4 and place the plant in SDC. This time requirement is consistent with the current ISTS required action.

Defense-in-Depth Consideration

The AFW system provides feedwater to the steam generators to remove RCS decay heat upon loss of normal feedwater supply. The typical AFW system consists of 3 pumps (one turbine-driven and two motor-driven). One pump at full flow is sufficient to remove decay heat and cool the plant to SDC system entry conditions. The proposed modification to the end state of the TS to Mode 4 without reliance on SG heat removal is consistent with NUREG-1432 which allows staying in Mode 4 if RCS heat removal requirements are fully met by the use of SDC trains. Unavailability of AFW pumps limits the usefulness of SG heat removal. Hence SDC operation in Mode 4 under the TS conditions provides sufficient Defense-in-Depth for RCS heat removal.

Tier 2 Restrictions

None.

5.5.18 T.S. 3.7.7 COMPONENT COOLING WATER SYSTEM

The CCW* system provides cooling to various critical components in the RCS and also provides heat removal capability for various plant safety systems, both at power and on SDC. The appropriate actions to be taken in the event of inoperabilities of the CCW system depend on the particular system function being compromised and the existence of backup water supplies.

In the event of a DBA, one train of CCW is required to provide the minimum heat removal capability assumed in the safety analysis for systems to which it supplies cooling water. The CCW system provides heat removal capability to the containment fan coolers, CS and SDC. In addition, CCW provides cooling to the Reactor Coolant Pumps. Other safety components may be cooled via CCW component flow paths. From an end state perspective, upon loss of part of the CCW, the plant should transition to a state where reliance on the CCW system is least significant. For San Onofre Units 2 & 3, loss of one CCW train will degrade the plant's capability to remove heat via the affected SDC heat exchanger. Thus, once on SDC, an unrecovered failure of the second CCW train poses a significant potential for core damage. Provided component cooling is available to the RCPs, a Mode 4 end state with the RCS on SG heat removal is preferred to the Mode 5 end state on SDC heat removal.

For plants with redundant sources of SDC cooling, the inability of the CCW system to perform its function may be less significant in Mode 5 than identified in this assessment. In such circumstances a Mode 5 end state may be preferred to a Mode 4 with heat removal via natural circulation of primary coolant and SG heat removal. Such a situation may be required when RCP cooling is lost with SDC heat removal.

<u>Plant Applicability</u>

All CE PWRs except ANO 2.

<u>Limiting Condition for Operation (LCO)</u>

Two CCW trains shall be OPERABLE in Modes 1, 2, 3 and 4.

<u>Licensing Basis for LCO</u>

In Modes 1, 2, 3 and 4, the CCW System is a normally operating system that must be operable to perform its post accident safety functions, primarily RCS heat removal by cooling the SDC heat exchangers.

In Mode 5, the OPERABILITY requirements of the CCW System are determined by the systems it supports.

At least one CCW train must be operable to remove decay heat loads following a design basis accident. CCW is also used to provide heat removal during normal operating and shutdown conditions. Two 100% trains of CCW are provided to ensure adequate CCW flow assuming the worst single failure.

<u>Condition Requiring Entry into End State</u>

One CCW train inoperable and not returned to service in TS AOT/CT.

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* Terminology for cooling systems vary among CE plants. Appendix C summarizes the various plant cooling water systems designations.

Proposed Modification for End State Required Actions

Modify Condition B of TS to accommodate a Mode 4 end state with a 12 hour entry requirement.

Basis for Proposed Change

CCW is modeled in the PRA for all modes. In Mode 5, many plants rely on CCW or its equivalent system (See Table C-2) to support SDC. So, the one operable CCW train (in conditions in which the other train is inoperable) must continue to function. Operation in Mode 4 with the Steam Generators available provides a decay heat removal path that is not dependent on CCW except for RCP cooling. The risk significance of the CCW system is dependent upon the diversity, redundancy and dependencies of the backup systems which are available to support SDC. While design basis accidents are less likely and less severe in Mode 5, more mitigating systems are available in Mode 4 to respond to an event. As discussed earlier, the risk of plant operation in Mode 4 is less than or similar to that for Mode 5. In addition, by avoiding SDC entry, transient risks associated with valve misalignments may be averted.

Defense-in-Depth Consideration

The CCW system provides cooling to various critical components in the RCS and also provides heat removal capability for various plant safety systems, both at power and on SDC. The appropriate actions to be taken in the event of inoperabilities of the CCW system depend on the particular system function being compromised and the existence of backup water supplies.

In the event of a DBA, one train of CCW is required to provide the minimum heat removal capability assumed in the safety analysis for systems to which it supplies cooling water. The CCW flow provides heat removal capability to the containment fan coolers, CS and SDC. In addition, CCW flow provides cooling to the Reactor Coolant Pumps. Other safety components may be cooled via CCWS component flowpaths. From an end state perspective, upon loss of part of the CCWS, the plant should transition to a state where reliance on the CCWS is least significant. For San Onofre Units 2 & 3, loss of one CCW train will degrade the plant's capability to remove heat via the SDC heat exchanger. Thus, once on SDC, an unrecovered failure of the second CCW train poses a significant potential for core damage. Provided component cooling is available to the RCPs, a Mode 4 end state with the RCS on SG heat removal is preferred to the Mode 5 end state with RCS on SDC heat removal.

For plants with redundant sources of SDC HX cooling, the inability of the CCWs to perform its function may be less significant in Mode 5 than identified in this assessment. In such circumstances a Mode 5 end-state may be preferred to a Mode 4 with heat removal via natural circulation of primary coolant and SG heat removal. Such a situation may be required when loss of CCW results in loss of cooling to RCP seals.

The proposed Mode 4 TS end state results in plant conditions where the reliance on the CCW system is the least significant. Also, as shown previously, the risk of plant operation in Mode 4 is less than or similar to that for Mode 5. Hence, sufficient Defense-in-Depth is retained when the end state is modified from Mode 5 to Mode 4.

Tier 2 Restrictions

For conditions where CCW flow is lost to the RCP seals, reactor shutdown is required and the RCS Loops operating TS is entered. Limited duration natural circulation operation is acceptable, but extended plant operation in the higher Mode 4 temperatures may degrade RCP seal elastomers. Mode 5 operation ensures adequately low RCS temperatures so that any RCP seal challenges would be avoided. Prior to entry into Mode 5 due to loss of CCW to RCP seals, the redundant CCW train should be confirmed to be operable and backup cooling water systems should be confirmed for emergency use. SG inventory should be retained to assure a diverse and redundant heat removal source if CCW should fail.

5.5.19 T.S. 3.7.8 SERVICE WATER SYSTEM/SALT WATER COOLING SYSTEM/ESSENTIAL SPRAY POND SYSTEM/AUXILIARY COMPONENT COOLING WATER[7]

This TS covers systems that provide a heat sink for the removal of process heat and operating heat from the safety-related components during a transient or DBA. The present discussion is based on SONGS 2 & 3 designation of Salt Water Cooling (SWC) System. The primary function of the SWC system is to remove heat from the CCW system. In this manner the SWC system also supports the SDC system. In some plants the SWC system or its equivalent provides emergency makeup to the CCW system and may also provide backup supply to the AFWS. For many plants including San Onofre Units 2 & 3, loss of one SWC system train will degrade the plant's capability to remove heat via the affected SDC heat exchanger. A Mode 4 end state with the RCS on SG heat removal is preferred to Mode 5 with RCS on SDC heat removal.

<u>Plant Applicability</u>

All

<u>Limiting Condition for Operation (LCO)</u>

Two SWC trains shall be OPERABLE in Modes 1, 2, 3 and 4 (SONGS 2 & 3).

<u>Licensing Basis for LCO</u>

In Modes 1, 2, 3 and 4, the SWC System is a normally operating system, which is required to support the OPERABILITY of the equipment serviced by the SWC system and required to be OPERABLE in these Modes.

In Mode 5, the OPERABILITY requirements of the SWS are determined by the systems it supports.

At least one SWC train must be operable to remove decay heat loads following a design basis accident. SWC is also used to provide heat removal during normal operating and shutdown conditions. Two 100% trains of SWC are provided, which provides adequate SWC flow assuming the worst single failure.

<u>Condition Requiring Entry into End State</u>

One SWC train inoperable and not restored to operability in TS AOT/CT.

<u>Proposed Modification for End State Required Actions</u>

Modify Condition B of TS to accommodate a Mode 4 end state with a 12 hour entry requirement on SGHR.

<u>Basis for Proposed Change</u>

When the plant is in Mode 5, SWC is required to support Shutdown Cooling. So, the one operable SWC train (in conditions in which the other train is inoperable) must continue to function. Operation in Mode 4 with the Steam Generators available provides a decay heat removal path that is not dependent on SWC. While design basis accidents are less likely and less severe in Mode 5, more mitigating systems are

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[7] Terminology for cooling systems vary among CE plants. Appendix C summarizes the various plant cooling water systems designations.

available in Mode 4 to respond to an event. As shown earlier, the risk of plant operation in Mode 4 is less than or similar to that for Mode 5.

Defense-in-Depth Consideration

The SWC system provides a heat sink for the removal of process and operating heat from the safety-related components during a transient or DBA. The primary function of the SWC system is to remove heat from the CCWS. In this manner the SWC system also supports the SDCS. In some plants the SWC system provides emergency makeup to the CCW system and may also provide backup supply to the AFWS. For many plants including San Onofre Units 2 & 3, loss of one SWC train will degrade the plant's capability to remove heat via the SDC heat exchanger. A Mode 4 end state with the RCS on SG heat removal is preferred to Mode 5 with RCS on SDC heat removal.

The proposed Mode 4 TS end state results in plant conditions where the reliance on the SWC system is the least significant. Also as shown previously, the risk of plant operation in Mode 4 is less than or similar to that for Mode 5. Hence, sufficient Defense-in-Depth is retained when the end state is modified from Mode 5 to Mode 4.

Tier 2 Restrictions

None.

5.5.20 T. S. 3.7.9 ULTIMATE HEAT SINK[8]

The Ultimate Heat Sink (UHS) system provides a heat sink for the removal of process and operating heat from the safety-related components during a transient or DBA. The primary function of the UHS system is to remove heat from the CCW system. In this manner the UHS system also supports the SDC system. In some plants the UHS system provides emergency makeup to the CCW system and may also provide backup supply to the AFW system. For many plants, loss of one UHS system train will degrade the plant's capability to remove heat via the affected SDC heat exchanger. A Mode 4 end state with the RCS on SG heat removal is preferred to Mode 5 with RCS on SDC heat removal.

Plant Applicability

All CE PWRs except SONGS 2 & 3.

Limiting Condition for Operation (LCO)

Two UHS trains shall be OPERABLE in Modes 1, 2, 3 and 4.

Licensing Basis for LCO

In Modes 1, 2, 3 and 4, the UHS System is a normally operating system, which is required to support the OPERABILITY of the equipment serviced by the SWS and required to be OPERABLE in these Modes.

In Mode 5, the OPERABILITY requirements of the UHS are determined by the systems it supports.

At least one UHS train must be able to operate to remove decay heat loads following a design basis accident. UHS is also used to provide heat removal during normal operating and shutdown conditions. Two 100% trains of UHS are provided to ensure adequate UHS flow assuming the worst single failure.

Condition Requiring Entry into End State

One UHS train inoperable and not restored to operability in TS AOT/CT.

Proposed Modification for End State Required Actions

Modify Condition B of TS to accommodate a Mode 4 end state with a 12 hour entry requirement.

Basis for Proposed Change

When the plant is in Mode 5, UHS is required to support Shutdown Cooling. So, the one operable UHS train (in conditions in which the other train is inoperable) must continue to function. Operation in Mode 4 with the Steam Generators available provides a decay heat removal path that is not dependent on UHS. While design basis accidents are less likely and less severe in Mode 5, more mitigating systems are available in Mode 4 to respond to an event. As shown earlier, the risk of plant operation in Mode 4 is less than or similar to that for Mode 5.

Defense-in-Depth Consideration

The UHS system provides a heat sink for the removal of process and operating heat from the safety-related components during a transient or DBA. The primary function of the UHS system is to remove

[8] Calvert Cliffs designates the system as the Salt Water System; SWCS is the ultimate heat sink at SONGS Units 2 & 3.

heat from the CCW system. In this manner the UHS system also supports the SDC system. In some plants the UHS system provides emergency makeup to the CCW system and may also provide backup supply to the AFW system. For many plants, loss of one UHS train will degrade the plant's capability to remove heat via the SDC heat exchanger. A Mode 4 end state with the RCS on SG heat removal is preferred to Mode 5 with RCS on SDC heat removal.

The proposed Mode 4 TS end state results in plant conditions where the reliance on the UHS system is the least significant. Also as shown previously, the risk of plant operation in Mode 4 is less than or similar to that for Mode 5. Hence, sufficient Defense-in-Depth is retained when the end state is modified from Mode 5 to Mode 4.

Tier 2 Restrictions

When inoperability of the SWC results in the inoperability of one or more SDC trains, the appropriate end state should be Mode 4 with SG heat removal.

5.5.21 T.S. 3.7.10 EMERGENCY CHILLED WATER SYSTEM

The Emergency Chilled Water (ECW) system provides a heat sink for the removal of process and operating heat from selected safety-related air-handling systems during a transient or accident. The ECWS is actuated on SIAS and provides water to the HVAC units of the Emergency Safety Feature (ESF) equipment areas (e.g. main control room, electrical equipment room, safety injection pump area). The Applicability of this system is defined as Modes 1 through 4. The likelihood of a LOCA in Mode 4 and the heat loading on the system in Mode 4 are much reduced over the other applicable modes. Extended inoperability of this system in Mode 4 due to a single train out of service would not significantly impact Mode 4 risks. The remaining train is sufficient to maintain HVAC cooling. Repair of the ECW system in Mode 4 poses an overall lower plant risk of core damage due to the robustness of plant RCS heat removal resources in Mode 4 and the added risks associated with the transition to Mode 5.

<u>Plant Applicability</u>

PVNGS 1, 2 & 3, SONGS 1 & 2, Waterford 3

<u>Limiting Condition for Operation (LCO)</u>

Two ECW trains shall be OPERABLE in Modes 1, 2, 3 and 4.

<u>Licensing Basis for LCO</u>

In Modes 1, 2, 3 and 4, the ECW System is required to be OPERABLE when a LOCA or other accident would require ESF operation.

In Mode 5, potential heat loads are smaller and the probability of accidents requiring the ECW System is low.

ECW provides cooling to safety-related HVAC units to provide cooling to equipment required to operate during/following a design basis accident. For most plant equipment, ECW is a backup to normal HVAC. For a subset of equipment, only ECW is available, but cooling is provided by both ECW trains.

<u>Condition Requiring Entry into End State</u>

Mode 5 entry is required when one ECW train is inoperable and not returned to service in the TS AOT/CT.

<u>Proposed Modification for End State Required Actions</u>

Modify Condition B of TS to accommodate a Mode 4 end state with a 12 hour entry requirement.

<u>Basis for Proposed Change</u>

ECW and normal HVAC are modeled in the PRA for all modes. ECW provides cooling to safety related HVAC. Because normal HVAC would be available in all non-LOOP situations, cooling to most plant equipment would remain available. Should an event occur during Mode 4, the post-accident heat loads would be significantly reduced (allowing more time for manual recovery actions, including alternate ventilation measures).

These measures include opening doors/vents and or provision for temporary alternate cooling equipment. Extended operability of the ECW in Mode 4 due to a single train out of service would not significantly impact Mode 4 risks. The remaining train is sufficient to maintain HVAC cooling. Repair of the ECW in Mode 4 poses an overall lower plant risk of core damage due to the robustness of Plant RCS heat removal resources in Mode 4 and the added risks associated with the transition to Mode 5. Furthermore, the availability of automatic SIAS actuation in Mode 4 supports the operator actions in responding to events that threaten reactor and/or containment integrity.

Defense-in-Depth Consideration

The Applicability of this system is defined as Modes 1 through 4. The likelihood of a LOCA in Mode 4 and the heat loading on the system in Mode 4 are much reduced over the other applicable modes. Extended inoperability of this system in Mode 4 due to a single train out of service would not significantly impact Mode 4 risks. The remaining train is sufficient to maintain HVAC cooling. Repair of the ECW system in Mode 4 poses an overall lower plant risk of core damage due to the robustness of plant RCS heat removal resources in Mode 4 and the added risks associated with the transition to Mode 5. Furthermore, the availability of SIAS in Mode 4 supports the operator actions in responding to events that threaten the reactor and/or containment integrity. Hence, sufficient Defense-in-Depth is retained when the end state is modified from Mode 5 to Mode 4.

Tier 2 Restrictions

None. Reduced pressure operation in Mode 4 should be considered to reduce the potential of a LOCA without Emergency Chilled Water.

5.5.22 T.S. 3.7.11 CONTROL ROOM EMERGENCY AIR CLEANUP SYSTEM

The Control Room Emergency Air Cleanup System (CREACUS)[9] provides a protected environment from which operators can control the plant following an uncontrolled release of radioactivity, chemicals or toxic gas. The current TSs requires operability of CREACUS from Mode 1 through 4 to support operator response to a DBA. Operability in Mode 5 and 6 may also be required at some plants for chemical and toxic gas concerns. The CREACUS is needed to protect the Control Room (CR) in a wide variety of circumstances. Long term plant operation in the presence of degraded CREACUS should be based on placing the plant in a state which poses the lowest plant risk. In general, plant operation in Mode 4 poses a lower operation risk of core damage than in Mode 5.

<u>Plant Applicability</u>

All

<u>Limiting Condition for Operation (LCO)</u>

Two CREACUS trains shall be OPERABLE in Modes 1, 2, 3 [or] 4 [5 and 6] and [during movement of irradiated fuel assemblies].

<u>Licensing Basis for LCO</u>

In Modes 1, 2, 3 and 4, the CREACUS must be OPERABLE to limit operator exposure during and following a DBA. In all Modes, the CREACUS is required to cope with the release from a rupture of an outside waste gas tank or external toxic gas challenges. During movement of irradiated fuel assemblies [and Core Alterations], the CREACUS must be OPERABLE to cope with the release from a fuel handling accident.

The CREACUS provides a protected environment from which operators can control the unit following an uncontrolled release of radioactivity [chemicals, or toxic gas].

The CREACUS consists of two independent, redundant trains that recirculate and filter the control room air. Each train consists of a prefilter and demisters*, a High Efficiency Particulate Air (HEPA) filter, an activated charcoal adsorber section for removal of gaseous activity (principally iodine), and a fan. Ductwork, valves or dampers and instrumentation also form part of the system, as do demisters that remove water droplets from the air stream. A second bank of HEPA filters follows the adsorber section to collect carbon fines, and to back up the main HEPA filter bank if it fails.

The CREACUS is an emergency system, part of which may also operate during normal unit operations in the standby mode of operation. Upon receipt of the actuating signal(s), normal air supply to the control room is isolated, and the stream of ventilation air is recirculated through the filter trains of the system. The prefilters and demisters remove any large particles in the air, and any entrained water droplets present to prevent excessive loading of the HEPA filters and charcoal adsorbers.

Actuation of the CREACUS places the system into either of two separate states of the emergency mode of operation, depending on the initiation signal. Actuation of the system to the emergency radiation state of the emergency mode of operation closes the unfiltered outside air intake and unfiltered exhaust dampers, and aligns the system for recirculation of control room air through the redundant trains of HEPA and charcoal filters. The emergency radiation state initiates pressurization and filtered ventilation of the air supply to the control room.

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[9] Alternate designations include CREACS, CREVAS, CREVS, and CREAFS.
* SONGS 2 & 3 do not include a demister as part of CREACUS.

Condition Requiring Entry into End State

Mode 5 operation is required when one CREACUS train is INOPERABLE in Modes 1, 2, 3 or 4 and not returned to service prior to the TS AOT/CT.

Proposed Modification for End State Required Actions

Modify Condition B of TS to accommodate a Mode 4 end state with initial entry in 12 hours.

Basis for Proposed Change

Operation of CREACUS has no direct impact on CDF and LERF as analyzed in the PRA. Regardless of the CREACUS status, the risk of Mode 4 are lower (or equivalent) to the similar Mode 5 operating state (See Section 5.4.3.4), since more mitigating systems are available in Mode 4 to respond to plant upset and there exist additional risks associated with the transition to Mode 5 from Mode 4.

Operability of CREACUS is important for protection from toxic gas hazards, as well as radiation hazards from other non-affected nuclear units on site. Protection from these hazards is independent of the plant operational Mode.

Defense-in-Depth Consideration

The CREACUS provides a protected environment from which operators can control the plant following an uncontrolled release of radioactivity, chemicals or toxic gas. The current TS requires operability of two trains of CREACUS from Mode 1 through 4 to support operator response to a DBA. The redundant train will be available to respond to plant accidents during the time period the companion train is being repaired.

The CREACUS is needed to protect the CR in a wide variety of circumstances. Long term plant operation in the presence of degraded CREACUS should be based on placing the plant in a state which poses the lowest plant risk. Operation of CREACUS has no direct impact on CDF and LERF as analyzed in the plant PRA. In general, plant operation in Mode 4 poses a lower operation risk of core damage than in Mode 5. Hence, sufficient Defense-in-Depth is retained when the end state is modified from Mode 5 to Mode 4.

Tier 2 Restrictions

Using CRMP ensures plant staff is aware of the system inoperability and that respiratory units and CR pressurization systems are available and operational and that leakage pathways are properly controlled. Also ensure availability of alternate shutdown panels and local shutdown stations.

5.5.23 T.S. 3.7.12 CONTROL ROOM EMERGENCY AIR TEMPERATURE CONTROL SYSTEM (CREATCS)

The CREATCS provides temperature control for the control room following isolation of the control room. The CREATCS consists of two independent, redundant trains that provide cooling and heating of recirculated control room air. Each train consists of heating coils, cooling coils, instrumentation, and controls to provide for control room temperature control.

The CREATCS is an emergency system. Portions of the CREATCS may also operate during normal unit operations. A single train of CREATCS will provide the required temperature control to maintain habitable control room temperatures following design basis accident.

Plant Applicability

Calvert Cliffs 1 & 2, Palisades, PVNGS 1, 2 & 3, Waterford 3, ANO 2

(Note: Cooling for St. Lucie units are included in the air cleanup system discussed in TS 3.7.11 (See Section 5.5.22), but the cooling system arguments contained in this section apply to St. Lucie Units 1 & 2.)

Limiting Condition for Operation (LCO)

Two CREATCS trains shall be OPERABLE in Modes 1, 2, 3 and 4, and during movement of irradiated fuel assemblies.

Licensing Basis for LCO

CREATCS is required to ensure continued control room habitability and ensure that the control room temperature will not exceed equipment operability requirements following isolation of the CR for a period of at least 30 days. In Mode 5 CREATCS may not be required for those facilities which do not require automatic control room isolation.

Condition Requiring Entry into End State

One CREATCS train inoperable and the required action and associated completion time of TS not met in Mode 1, 2, 3 or 4.

Proposed Modification of End State Required Actions

Modify Mode 5 end state required action to allow component repair in Mode 4 in 12 hours.

Basis for Proposed Change

Operation of CREATCS has no direct impact on CDF and LERF as analyzed in the PRA. Regardless of the system status, the risk of Mode 4 is lower (or equivalent) to the similar Mode 5 operating state (See Section 5.4.3.4), since more mitigating systems are available in Mode 4 to respond to an event and there are additional risks associated with the transition to Mode 5 from Mode 4.

Defense-in-Depth Consideration

The CREATCS provides a controlled temperature environment from which operators can control the plant. Operation of CREATCS has no direct impact on CDF and LERF as analyzed in the plant PRA. Redundancy of equipment results in very low likelihood of not having this standby feature when needed. Inability to control the plant within the control room would require plant shutdown via the ASP or local systems.

As a result of this redundancy and diversity, and considering the fact that plant operation in Mode 4 poses a lower operation risk of core damage than in Mode 5, it is concluded that sufficient Defense-in-Depth is retained when the end state is modified from Mode 5 to Mode 4.

Tier 2 Restrictions

None. For longer outages, ensure availability of alternate shutdown panel or local plant shutdown and control capability.

5.5.24 T.S. 3.7.13 ECCS PUMP ROOM EXHAUST AIR CLEANUP SYSTEM (ECCS PREACS) also ENGINEERED SAFETY FEATURE (ESF) PUMP ROOM EXHAUST AIR CLEANUP SYSTEM (PREACS)

The ECCS PREACS* filters air from the area of the active ESF components during the recirculation phase of a LOCA. The ECCS PREACS consists of two independent, redundant trains of equipment that provide filtering of air in the ECCS pump rooms during post LOCA recirculation cooling.

The ECCS PREACS is an emergency system. A single train will provide the required temperature control to maintain the ECCS pump room within acceptable limits.

Plant Applicability

Calvert Cliffs 1 & 2, St Lucie 1 & 2, Waterford 3

Limiting Condition for Operation (LCO)

Two ECCS PREACS trains shall be OPERABLE in Modes 1, 2, 3 and 4.

Licensing Basis for LCO

In Modes 1, 2, 3 and 4, the ECCS PREACS must be OPERABLE to ensure that the cleanup system is capable of meeting 10CFR100 radiation dose limits.

Condition Requiring Entry into End State

One ECCS PREACS train inoperable and required Action and associated Completion Time of TS not met in Modes 1, 2, 3 or 4.

Proposed Modification of End State Required Actions

Modify Mode 5 end state required action to allow component repair in Mode 4. The time for initial entry into Mode 4 is 12 hours.

Basis for Proposed Change

Operation of ECCS PREACS has no direct impact on CDF and LERF as analyzed in the PRA. Regardless of the system status, the risk of Mode 4 is lower (or equivalent) to the similar Mode 5 operating state (See Section 5.4.3.4), since more mitigating systems are available in Mode 4 to respond to an event and there are additional risks associated with the transition to Mode 5 from Mode 4.

Since the risk of a transition to SDC and subsequent Mode 5 operation are greater than that incurred by continued operation in Mode 4, and the likelihood of a requiring recirculation heat removal as a result of a LOCA initiated from Mode 4 is low, repairing the system while in Mode 4 is preferred.

Defense-in-Depth Consideration

The ECCS PREACS provides post-LOCA filtration for the ECCS pump rooms. This protects the public from radiological exposure resulting from auxiliary building leaks in the ECCS system. The current TS requires operability of CREACUS from Modes 1 through 4 to support cleanup during the LOCA recirculation phase.

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* At WSES the functions of the ECCS PREACS and PREACS is combined within the Controlled Ventilation Area (CVAS) Technical Specification.

The need for the PREACS is of low probability. Furthermore, the redundant train provides ample capability to perform the function. As discussed in Section 5.4 Large LOCAs in Mode 4 are incredible. Smaller LOCAs will unfold more slowly and result in lower releases and allow for alternate recovery actions including extended use of injection.

The short term need for the system is assessed by assuming: (1) the frequency of Mode 4 LOCAs requiring recirculation is bounded by of 0.0001 per year, (2) the probability of a significant leak into the ECCS pump room is about 0.1 and (3) the probability that the backup system is unavailable is 0.1 (very conservative). Then, the probability that the system will be needed over a given repair interval (assumed at 7 days or 0.0192 years) becomes $0.0001 \times 0.10 \times 0.10 \times 0.0192 = 1.92 \times 10^{-8}$. Hence, sufficient Defense-in-Depth is retained when the end state is modified from Mode 5 to Mode 4.

<u>Tier 2 Restrictions</u>

None.

5.5.25 T.S. 3.7.15 PENETRATION ROOM EXHAUST AIR CLEANUP SYSTEM (PREACS)

The PREACS* filters air from the penetration area between the containment and the auxiliary building The PREACS consists of two independent, redundant trains. Each train consists of a heater, demister or prefilter, HEPA filter, activated charcoal absorber and a fan.

Plant Applicability

Calvert Cliffs 1 & 2, Waterford 3

Limiting Condition for Operation (LCO)

Two PREACS train shall be OPERABLE in Modes 1, 2, 3, 4. Inability to return one PREACS to service in the allotted AOT requires plant shutdown to Mode 5 in 36 hours.

Licensing Basis for LCO

In Modes 1, 2, 3, 4, the PREACS must be OPERABLE to ensure that the penetration room filtering capability is within the 10CFR100 design basis assumptions. MHA assumptions and analyses are based on Mode 1 initiated events.

Condition Requiring Entry into End State

One PREACS train inoperable and required Action and associated Completion Time of Condition A not met in Modes 1, 2, 3 or 4.

Proposed Modification of End State Required Actions

Modify Mode 5 end state required action to allow component repair in Mode 4. Mode 4 entry is proposed to be in 4 hours.

Basis for Proposed Change

Operation of penetration room PREACS has no direct impact on CDF and LERF as analyzed in the PRA. Regardless of the system status, the risk of Mode 4 is lower (or equivalent) to the similar Mode 5 operating state (See Section 5.4.3.4), since more mitigating systems are available in Mode 4 to respond to an event and there are additional risks associated with the transition to Mode 5 from Mode 4.

Since the risk of a transition to SDC and subsequent Mode 5 operation are greater than that incurred by continued operation in Mode 4, repairing the system while in Mode 4 is preferred.

Defense-in-Depth Consideration

The PREACS provides filtration for the penetration room area. This protects the public from radiological exposure resulting from containment leakage through penetrations. The current TS requires operability of PREACS from Modes 1 through 4. The need for the PREACS is of particular importance following a severe accident with high levels of airborne radionuclides. These events are of low probability (for example, for Mode 1, the plant core damage frequency is on the order of 2×10^{-5} to 1×10^{-4} per year). Furthermore, the redundant train provides ample capability to perform the function.

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* At WSES the functions of the ECCS PREACS and PREACS is combined within the Controlled Ventilation Area (CVAS) Technical Specification.

The short term need for the system is assessed by assuming: (1) the frequency of Mode 4 core damage events is on the order of 0.00005 per year, and (2) the probability that the backup system is unavailable is 0.01. Then, the probability that the system will be needed over a given repair interval (assumed at 7 days or 0.0192 years) becomes $5 \times 10^{-5} \times 0.01 \times 0.0192 \sim 1 \times 10^{-8}$. Hence, sufficient Defense-in-Depth is retained when the end state is modified from Mode 5 to Mode 4. This assessment assumes a common cause assessment is performed early in the process to ensure availability and functionality of redundant system.

Tier 2 Restrictions

None.

5.5.26 T.S. 3.8.1 AC SOURCES – OPERATING

Plant operators must bring the plant to Mode 5 within 36 hours following the sustained inoperability of either or both required offsite circuits, either or both required Emergency Diesel Generators (EDGs), or one required offsite circuit and one required EDG.

In Modes 1, 2, 3 and 4, two qualified circuits between the transmission network (i.e. switchyard) and the onsite Class 1E electrical power distribution system are required to be available. Two separate and independent EDGs are also required to be available. These AC power sources ensure the availability of electrical power to shutdown the unit and maintain it in a safe shutdown condition following an Anticipated Operational Occurrence (AOO) or a postulated design basis accident. The risk associated with a proposed Mode 4 end state is expected to be less than the risk associated with the current Mode 5 end state. In Mode 5, the plant is more susceptible to Loss of Offsite Power (LOOP) events due to ongoing switchyard activities, which are not performed during Mode 4.

The Class 1E electrical power sources include the offsite AC power sources and the onsite standby AC power sources (i.e. EDGs). The offsite AC power sources consist of two electrically and physically separated circuits that provide power from the switchyard to the [4.16 kV] Engineered Safety Feature (ESF) buses. These circuits include all breakers, transformers, switches, interrupting devices, cabling and control equipment required to transmit power from the switchyard to the ESF buses. The onsite AC power sources consist of two separate and redundant standby EDGs. Each EDG is associated with its respective train of AC power. For multiple unit sites, backup AC power to a 4.16 kV ESF bus may be available from the unaffected unit. Sites with alternate AC capability include SONGS Units 2 & 3 and St. Lucie Units 1 & 2. Palo Verde provides AAC via use of an onsite combustion turbine.

The electrical AC power sources are designed to provide sufficient capacity, redundancy and reliability to ensure the availability of power to ESF systems so that the fuel, RCS and containment design limits are not exceeded during Modes 1, 2, 3 and 4. Consequently, the current end state for not meeting the required actions associated with the Limiting Condition for Operation (LCO) is Mode 5. As specified by TS 3.8.1, the plant operators must bring the plant to Mode 5 when the required action is not completed by the specified time for the associated condition. Entry into any of the conditions for the AC power sources implies that the AC power sources have been degraded and the single failure protection for ESF equipment may be ineffective.

<u>Plant Applicability</u>

All

<u>Limiting Condition for Operation (LCO)</u>

The following AC electrical sources shall be OPERABLE in Modes 1, 2, 3 and 4:

a. Two qualified circuits between the offsite transmission network and the onsite Class 1E AC Electrical Power Distribution System; [and]

b. Two Diesel Generators (DGs) each capable of supplying one train of the onsite Class 1E AC Electrical Power Distribution System.

Licensing Basis for LCO

The initial conditions of DBA and transient analyses assume ESF systems are OPERABLE. The AC electrical power sources are designed to provide sufficient capacity, capability, redundancy and reliability to ensure the availability of necessary power to ESF systems so that the fuel, RCS and containment design limits are not exceeded.

The unit Class 1E Electrical Power Distribution System AC sources consist of the offsite power sources (preferred power sources, normal and alternate(s)), and the onsite standby power sources (Train A and Train B (EDGs)). In addition, many sites include AAC capability (For SONGS 2 & 3, the opposite unit supplies backup for each train of 4.16 kV Class 1E power). As required by 10 CFR 50, Appendix A, GDC 17, the design of the AC electrical power system provides independence and redundancy to ensure an available source of power to the (ESF) systems.

The onsite Class 1E AC Distribution System is divided into redundant load groups (trains) so that the loss of any one group does not prevent the minimum safety functions from being performed. Each train has connections to two preferred offsite power sources and a single DG.

Offsite power is supplied to the unit switchyard(s) from the transmission network by [two] transmission lines. From the switchyard(s), two electrically and physically separated circuits provide AC power, through [step down station auxiliary transformers], to the [4.16 kV] ESF buses.

An offsite circuit consists of all breakers, transformers, switches, interrupting devices, cabling and controls required to transmit power from the offsite transmission network to the onsite Class 1E ESF bus or buses.

Certain loads required for accident mitigation are started in a predetermined sequence in order to prevent overloading the transformer supplying offsite power to the onsite Class 1E Distribution System. Within [1 minute] after the initiating signal is received, all automatic and permanently connected loads needed to recover the unit or maintain it in a safe condition are started via the load sequencer.

In the event of a loss of power, the ESF electrical loads are automatically connected to the DGs in sufficient time to provide for safe reactor shutdown and to mitigate the consequences of a Design Basis Accident (DBA) such as a LOCA.

Condition Requiring Entry into End State

Plant operators must bring the plant to Mode 5 within 36 hours following the sustained inoperability of either or both required offsite circuits, either or both required Emergency Diesel Generators (EDGs), or one required offsite circuit and one required EDG.

Proposed Modification for End State Required Actions

Modify Condition G [Condition F for SONGS] of ISTS to specify a Mode 4 end state on SG heat removal with a 12 hour entry time.

Basis for Proposed Change

In Modes 1, 2, 3 and 4, two qualified circuits between the transmission network (i.e. switchyard) and the onsite Class 1E electrical power distribution system are required to be available. Two separate and independent EDGs are also required to be available. These AC power sources ensure the availability of electrical power to shutdown the unit and maintain it in a safe shutdown condition following an Anticipated Operational Occurrence (AOO) or a postulated design basis accident. The risk associated with a proposed Mode 4 end state is less than the risk associated with the current Mode 5 end state. In Mode 5, it is likely that increased plant maintenance activities (particularly those involving the switchyard) will make the plant is more susceptible to LOOP events.

The qualitative comparison of plant risk, as a measure of CDF and LERF, indicates that it is more risk significant to transition the plant to, and operate in, the current Mode 5 end state rather than remain in Mode 4 if the completion time for the required LCO actions cannot be met. Hence, Mode 4 is the preferred end state for this TS.

Defense-in-Depth Consideration

Entry into Mode 4 or remaining in Mode 4 as the end state when an LCO completion time cannot be met provides several advantages for the plant operating staff. Mode 4 operation ensures that the plant is shutdown and is at reduced temperature. Maintaining the plant in Mode 4 with degradation in the AC power sources is less risk significant than during Mode 5. Depending on the RCS conditions, the steam generators may or may not be available for RCS heat removal following an AOO or a design basis accident.

During Mode 4 with the steam generators available, plant risk is dominated by a Loss of Offsite Power (LOOP) initiating event. There are several redundant and diverse means available for removing heat from the RCS during this mode of operation. LCO entry resulting from the inoperability of both onsite AC sources (i.e. EDGs) followed by LOOP causes a station blackout event. For this event, the turbine driven auxiliary feedwater pump, which does not rely on the AC power sources to operate, is available for RCS heat removal via the steam generators during Mode 4. For all other LCO entries which do not lead to station blackout following LOOP during Mode 4, Feed and Bleed (for non 3410 MWt CE PWRs) capability is also available for RCS heat removal if the Auxiliary Feedwater System should fail. If the RCS conditions are such that the steam generators are not available for RCS heat removal during Mode 4, then only the SDC System is available for RCS heat removal for non-station blackout events.

During Mode 5 operation, the steam generators are not available for RCS heat removal. The SDC system is the only means available for removing heat from the RCS. Since the SDC system depends on the AC power sources to perform its function, RCS heat removal cannot be accomplished following a station blackout event during Mode 5 operation. This is similar to the case in Mode 4 with the unavailability of the steam generators during a station blackout event. Without RCS heat removal, boil-off of reactor coolant will occur much sooner, thus, reducing the time for recovery and consequently increasing plant risk. The plant configuration during Mode 5 involves the switching and realignment of AC buses (ESF and non-ESF) to offsite sources. The changing of transformer taps and other significant switchyard activities are performed during Mode 5. These activities degrade or eliminate the redundancy of electrical equipment that is available during Mode 4. Thus, the plant configuration in Mode 5 increases the likelihood of losing offsite power. This in turn increases the plant risk due to LOOP during Mode 5 operation. The risk of transitioning the plant to the current Mode 5 end state if the completion time for the LCO required action cannot be met also increases the overall plant risk associated with Mode 5.

Therefore, the proposed modification of the TS end state from Mode 5 to Mode 4 with SG heat removal provides several advantages for the plant operating staff such as more time to perform repair/recovery actions, provides diverse methods of RCS heat removal, results in a lower plant risk configurations and retains sufficient Defense-in-Depth.

Tier 2 Restrictions

Switchyard activities other than those necessary to restore offsite power should be prohibited when AC power sources are degraded. Note that to properly utilize turbine driven AFW pumps the SG pressure should be maintained above the minimum recommended pressure required to operate the TDAFW.

5.5.27 T.S. 3.8.4 DC SOURCES – OPERATING

The plant operators must bring the plant to Mode 5 within 36 hours following the sustained inoperability of one DC electrical power subsystem for a period of 2 hours. The DC system varies among CE PWRs. The risk assessment applies to all DC power configurations. For purposes of discussion, the description of the SONGS DC system is presented.

In Modes 1, 2, 3 and 4 the DC electrical power subsystems provide motive and control power to selected ESF equipment, which are required for shutting down the reactor and maintaining it in a safe condition following an AOO or postulated design basis accident. If an inoperable DC electrical power subsystem cannot be restored to operability within the required completion time, the plant operators must transition the plant to the Mode 5 end state. The risk associated with a proposed Mode 4 end state is less than the risk associated with the current Mode 5 end state.

For CE PWRs (with the exception of the San Onofre, Palo Verde, Calvert Cliffs and Waterford Units), the Class 1E 125 VDC electrical power system consists of two independent and redundant safety related subsystems. The Class 1E 125 VDC electrical power system at San Onofre, Palo Verde and Calvert Cliffs consists of four independent and redundant safety subsystems. At Waterford, these are three 125 VDC safety related subsystems. Each subsystem consists of one battery, the associated battery change(s) for each battery, and all the associated control equipment and interconnecting cables.

The 125 VDC electrical power system at SONGS consists of four independent and redundant safety related Class 1E DC electrical power subsystems (Train A, Train B, Train C and Train D). Each subsystem consists of one 125 VDC battery, a battery charger for the battery, and all the associated control equipment and interconnecting cabling.

During normal operation, the 125 VDC load is powered from the battery chargers with the batteries floating on the system. In case of loss of normal power to the battery charger (which is powered from the safety related 480v source) the DC load is automatically powered from the station batteries.

The 125 VDC loads vary among the CE PWRs. At SONGS for example, Train A and Train B 125 VDC electrical power subsystems provide control power for the 4.16 KV switchgear and 480 V load center AC load groups A and B, Diesel generator A and B control systems, and Train A and B control systems, respectively. Train A and Train B DC subsystems also provide DC power to the Train A and Train B inverters, as well as to Train A and Train B DC valve actuators, respectively. The inverters in turn supply power to the 120 VAC vital buses.

Train C and Train D 125 VDC electrical power subsystems provide power for NSSS control power and DC power to Train C and Train D inverters, respectively. Train C DC subsystem also provides DC power to the Auxiliary Feedwater Pump inlet valve HV-4716 and the AFWP electric governor.

The DC power sources have sufficient capacity for the steady state operation of the connected loads during Modes 1, 2, 3 and 4, while at the same time maintaining the battery banks fully charged. Each battery charger also has sufficient capacity to restore the battery to its fully charged state within the specified time period while supplying power to the connected loads. The DC sources are required to be operable during Modes 1, 2, 3 and 4 and connected to the associated DC buses. Consequently, Mode 5 is the current state for not restoring an inoperable DC electrical subsystem to operable status within 2 hours. Entry into the LCO for DC power sources implies that the DC power sources have been degraded.

<u>Plant Applicability</u>

All

Limiting Condition for Operation (LCO)

All of the DC electrical power subsystems are required to be operable during Modes 1, 2, 3 and 4. At SONGS for example, the Train A, Train B, Train C and Train D DC electrical power subsystems shall be OPERABLE in Modes 1, 2, 3 and 4.

Licensing Basis for LCO

The initial conditions of Design Basis Accident (DBA) and transient analyses assume that Engineered Safety Feature (ESF) systems are operable. The DC electrical power system provides normal and emergency DC electrical power for the DG control systems, emergency auxiliaries, and control and switching during all modes of operation.

The operability of the DC sources is consistent with the initial assumptions of the accident analyses and is based upon meeting the design basis of the unit. This includes maintaining the DC sources operable during accident conditions in the event of: 1) an assumed loss of all offsite AC power or all onsite AC power; and 2) a worst case single failure. The DC sources satisfy Criterion 3 of the NRC Policy Statement.

The station DC electrical power system provides the AC emergency power system with control power. It also provides both motive and control power to selected safety related equipment and preferred AC vital bus power (via inverters). As required by 10CFR50, Appendix A, GDC 17, the DC electrical power system is designed to have sufficient independence, redundancy, and testability to perform is safety functions, assuming a single failure. The DC electrical power system also conforms to the recommendations of Regulatory Guide 1.6 and IEEE-308.

Condition Requiring Entry into End State

The plant operators must bring the plant to Mode 5 within 36 hours following the sustained inoperability of one DC electrical power subsystem for a period of 2 hours.

Proposed Modification for End State Required Actions

Modify Condition B of ISTS to a Mode 4 on SG heat removal end state with a 12 hour entry requirement.

Basis for Proposed Change

In Mode 1, 2, 3 and 4 all of the redundant and independent DC electrical power subsystems are required to be available at the CE PWRs. The DC electrical power subsystems provide motive and control power to selected ESF equipment, which are required for shutting down the reactor and maintaining it in a safe condition following an AOO or postulated design basis accident. If an inoperable DC electrical power subsystem cannot be restored to operability within the required completion time, the plant operators must transition the plant to the Mode 5 end state. Plant operation in Mode 4 maximizes redundancy and diversity for RCS heat removal. The risk associated with a proposed Mode 4 end state is less than the risk associated with the current Mode 5 end state. Mode 4 operation with SGHR also averts risks associated with SDC entry.

Hence, Mode 4 is the acceptable end state for this TS.

Defense-in-Depth Consideration

The DC power sources have sufficient capacity for the steady state operation of the connected loads during Modes 1, 2, 3 and 4, while at the same time maintaining the battery banks fully charged. Each battery charger also has sufficient capacity to restore the battery to its fully charged state within the specified time period while supplying power to the connected loads. The DC sources are required to be operable during Modes 1, 2, 3 and 4 and connected to the associated DC buses. Consequently, Mode 5 is the current state for not restoring an inoperable DC electrical subsystem to operable status within 2 hours. Entry into the LCO for DC power sources implies that the DC power sources have been degraded.

With a DC electrical power subsystem inoperable during Mode 4, the plant risk is dominated by LOOP events. Such an event with concurrent failure of the unaffected EDG can progress to a station blackout. These events challenge the capability of the ESF systems to remove heat from the RCS. Entry into Mode 4 as the end state when an inoperable DC electrical power subsystem cannot be restored to operability within 2 hours provides the plant staff with several advantages. For station blackout cases, the turbine-driven auxiliary feedwater pump is available for RCS heat removal when steam pressure is adequate. If this pump becomes unavailable, the lack of RCS heat removal initiates boiling of the steam generator inventory. Boil-off of steam generator inventory and a certain amount of RCS inventory must both occur in order to uncover the core. Under this condition, the plant operators have a significant amount of time to perform the necessary repair and/or recovery of offsite power. For non-station blackout cases, the remaining train(s) (motor and/or turbine-driven) of auxiliary feedwater are available for RCS heat removal if steam pressure is adequate. Should the remaining train(s) fail, Feed and Bleed capability is available for certain CE PWRs to provide RCS heat removal. Units with Feed and Bleed capability when one DC power source is inoperable include those non 3410 MWt plants with sufficient bleed capability via one of the two PORV paths. All remaining units, including the 3410 MWt, will be incapable of RCS heat removal via Feed and Bleed because of design features or insufficient capacity via the remaining PORV path. Loss of the remaining train(s) of auxiliary feedwater and Feed and Bleed capability will initiate boiling in the steam generators, similar to the station blackout cases. Mode 4 operation with an inoperable DC power source provides the plant operators with the advantages of diverse means of RCS heat removal and significant amount of time to perform repairs and recovery before core uncovery occurs.

With a DC electrical power subsystem inoperable during Mode 5, the plant risk is also dominated by LOOP events. The plant configuration during this mode makes it much more likely than Mode 4 for a LOOP event to occur. The plant configuration during Mode 5 involves the switching and realignment of AC buses (ESF and non-ESF) to offsite sources. The changing of transformer taps and other significant ongoing switchyard activities are performed during Mode 5. These activities degrade or eliminate the redundancy of electrical equipment that is available during Mode 4. The increased LOOP challenges also increase the plant risk during Mode 5 operation. Should the RCS be vented in Mode 5 to establish CS pump backup for the SDC system, only the remaining train of SDC will be available for RCS heat removal. If the SDC system train becomes unavailable due to equipment failure or as a consequence of a station blackout, there are no redundant (independent) means of removing heat from the RCS. The lack of RCS heat removal via steam generators under such conditions leads to core uncovery in a much shorter time period because there is less total inventory to boil-off. The shorter time makes it less likely for the operators to perform the necessary repairs and recovery, thus increasing the plant risk during this mode of operation. The risk of transitioning the plant to the current Mode 5 end state when one inoperable DC power source cannot be restored to operability within 2 hours also increases the overall plant risk associated with this mode of operation.

Therefore, the proposed modification of the TS end state from Mode 5 to Mode 4 on SG heat removal provides several advantages for the plant operating staff such as more time to perform repair/recovery actions, provides diverse methods of RCS heat removal, results in a lower plant risk configuration, and retains sufficient Defense-in-Depth.

<u>Tier 2 Restrictions</u>

None.

5.5.28 *T.S. 3.8.7 INVERTERS – OPERATING*

The plant operators must bring the plant to Mode 5 within 36 hours following the sustained inoperability of one required inverter for a period of 24 hours. The DC system varies among CE PWRs. The risk assessment applies to all DC power configurations. For purposes of discussion the description of the SONGs DC system is presented.

In Modes 1, 2, 3 and 4, the inverters provide the preferred source of power for the 120 V AC vital buses which power the Reactor Protective System (RPS) and the Engineered Safety Feature Actuation System (ESFAS). The inverters ensure the availability of AC power for the systems instrumentation required to shutdown the reactor and maintain it in a safe condition after an Anticipated Operational Occurrence (AOO) or a postulated DBA. The Class 1E (125 VDC) station batteries via the respective Class 1E 125 VDC buses provide an uninterruptible source of power for the inverters. If an inoperable inverter cannot be restored to operability within the required 24 hour completion time, the plant operators must bring the plant to the Mode 5 end state. The risk associated with a proposed Mode 4 end state is comparable to or less than the risk associated with the current Mode 5 end state. The inoperability of an inverter during Mode 4 or 5 does not preclude the actuation of operable ESF equipment.

The inverter provides a dedicated source of uninterruptible power to its associated vital bus. An operable inverter requires the associated vital bus to be powered by the inverter and have output voltage and frequency within the acceptable range. In order to be operable, the inverter must also be powered from the associated station battery. Maintaining the inverters operable ensures that the redundancy incorporated in the design of the RPS and ESFAS is maintained. The inverters ensure an uninterruptible source of power, provided the station batteries are operable, to the vital buses even if the [4.16] kV ESF buses are not energized. Entry into the LCO required action implies that the redundancy of the inverters has been degraded.

The inoperability of a single inverter during Mode 4 operation will have little of no impact on plant risk. The inoperable inverter causes a loss of power to the associated bistable channel of RPS. Tripping of the reactor has already been accomplished prior to Mode 4 entry and the inoperability of an inverter will have no impact on the RPS. The inoperable inverter also causes a loss of power to one of the four ESFAS trip paths. This has no impact on the ability of the ESFAS to perform its function. Thus, there is no impact on the plant risk during this mode of operation.

The plant risk due to an inoperable inverter during Mode 5 is similar to the plant risk during Mode 4. However, the plant configuration during Mode 5 makes the unit more susceptible to a LOOP event due to the potential for ongoing switchyard activities. When the transition risk and the increased likelihood of a LOOP are considered, the overall plant risk associated with Mode 5 is larger than the plant risk associated with Mode 4. Hence, Mode 4 is the preferred end state for this TS.

<u>Plant Applicability</u>

Calvert Cliffs 1 & 2, Palisades, PVNGS 1, 2 & 3, SONGS 2 & 3, St. Lucie 2*

<u>Limiting Condition for Operation (LCO)</u>

All of the safety related inverters are required to be operable during Modes 1, 2, 3 and 4. At SONGS for example, the required Train A, Train B, Train C and Train D inverters shall be operable in Modes 1, 2, 3 and 4.

* St. Lucie Unit 2 TS is 3.8.3.1

Licensing Basis for LCO

The initial conditions of DBA and transient analyses assume ESF systems are operable. The DC to AC inverters are designed to provide the required capacity, capability, redundancy and reliability to ensure the availability of necessary power to the RPS and ESFAS instrumentation and controls so that the fuel, RCS, and containment design limits are not exceeded.

The operability of the inverters is consistent with the initial assumptions of the accident analyses and is based on meeting the design basis of the unit. This includes maintaining required AC vital buses operable during accident conditions in the event of: 1) an assumed loss of all offsite AC electrical power or all onsite AC electrical power; and 2) a worst case single failure. Inverters are part of the distribution system and, as such, satisfy Criterion 3 of the NRC Policy Statement.

Condition Requiring Entry into End State

The plant operators must bring the plant to Mode 5 within 36 hours following the sustained inoperability of one required inverter for a period of 24 hours.

Proposed Modification for End State Required Actions

Modify Condition B of ISTS to a Mode 4 on SG heat removal end state with a 12 hour entry requirement.

Basis for Proposed Change

In Modes 1, 2, 3 and 4 all trains of the inverters are required to be operable. The inverters provide the preferred source of power for the 120 V AC vital buses, which power the Reactor Protective System (RPS) and the Engineered Safety Feature Actuation System (ESFAS). The Class 1E (125 VDC) station batteries via the respective Class 1E 125 VDC buses provide and uninterruptible source of power for the inverters. If an inoperable inverter cannot be restored to operability within the required 24 hour completion time, the plant operators must bring the plant to the Mode 5 end state. The risk associated with a proposed Mode 4 end state is comparable to or less than the risk associated with the current Mode 5 end state. The inoperability of an inverter during Mode 4 or 5 does not preclude the actuation of operable ESF equipment.

The inoperability of a single inverter during Mode 4 operation will have little or no impact on plant risk. The inoperable inverter causes a loss of power to the associated bistable channel of RPS. Tripping of the reactor has already been accomplished prior to Mode 4 entry and the inoperability of an inverter will have no impact on RPS. The inoperable inverter also causes a loss of power to one of the four ESFAS trip paths. This has no impact on the ability of the ESFAS to perform its function. Thus, there is no impact on the plant risk during this mode of operation.

The plant risk due to an inoperable inverter during Mode 5 is similar to the plant risk during Mode 4. However, the plant configuration during Mode 5 makes the unit more susceptible to a LOOP event due to the potential for ongoing switchyard activities. When the transition risk and the increased likelihood of a LOOP are considered, the overall plant risk associated with Mode 5 is larger than the plant risk associated with Mode 4. Hence, Mode 4 is the preferred end state for this TS.

Defense-in-Depth Consideration

The inverters are included as four independent and redundant trains. Each inverter provides a dedicated source of uninterruptible powered to its associated vital bus. An operable inverter requires the associated vital bus to be powered by the inverter and have output voltage and frequency within the acceptable range. In order to be operable, the inverter must also be powered from the associated station battery. Maintaining the inverters operable ensures that the redundancy incorporated in the design of the RPS and ESFAS is maintained. The inverters ensure an uninterruptible source of power, provided the station batteries are operable, to the vital buses even if the [4.16] kV ESF buses are not energized. Entry into the LCO required action implies that the redundancy of the inverters has been degraded.

The inoperability of a single inverter during Mode 4 operation will have little or no impact on plant risk. The inoperable inverter causes a loss of power to the associated bistable channel of RPS. Tripping of the reactor has already been accomplished prior to Mode 4 entry and the inoperability of an inverter will have no impact on RPS. The inoperable inverter also causes a loss of power to one of the four ESFAS trip paths. This has no impact on the ability of the ESFAS to perform its function. Thus, there is no impact on the plant risk during this mode of operation.

When the transition risk and the increased likelihood of a LOOP are considered, the overall plant risk associated with Mode 5 is larger than that associated with Mode 4. Hence, the proposed Mode 4 end state retains sufficient Defense-in-Depth and is an acceptable end state for ISTS 3.8.7.

Tier 2 Restrictions

None.

Table 5.5–1
Technical Specification End State Assessment

Technical Specification Action	Title	Current End State	Proposed End State	Plant Applicability	Proposed Basis: Relative Risk Assessment	Proposed Basis: Deterministic Assessment
3.1 Reactivity Control Systems						
SONGS 3.1.9 C.1 3.1.2.2 for other plants	Boration Systems – Operating (Tank Boron contents)	Mode 5 – 30 hrs	Mode 3 – 6 hrs	ANO 2 Millstone 2 SONGS 2 & 3 St Lucie 1 & 2 Waterford 3	Short term inoperability of boration systems has negligible impact on risk. Mode 3 operation poses least challenge to boration system inoperability. Maintaining plant in Mode 3 also averts risk of plant realignments during Mode 5 SDC entry.	ISTS does not include an equivalent TS. Once all rods are inserted, borated water has low importance for Modes 3 & 4. Availability of redundant train provides adequate level of Defense-in-Depth. Increased boration is required at lower temperatures. Thus, modes 4 and 5 would be more reliant on boration systems to control shutdown margin. Therefore, Mode 3 should be preferred to Mode 4. Either mode would be preferred to Mode 5.
3.3 Instrumentation						
SONGS 3.3.5 H.2 ISTS(analog) 3.3.4 F.2 ISTS(digital) 3.3.5 E.2	ESFAS Instruments-RAS (RWST low)	Mode 5 – 36 hrs	Mode 4 – 12 hrs	ANO 2 SONGS 2 & 3 Waterford 3	Mode 4 on SG heat removal is a lower risk end state than Mode 5. Low risk results from increased diversity and redundancy in core and RCS heat removal equipment. Also RCS heat removal via SG averts SDC entry risks. Mode 4 on SDC is also acceptable for heat removal, however risks will vary from being generally equivalent to those in Mode 5 (unvented operation) to being much less than those in Mode 5 (vented operation).	NUREG-1432 lists applicable Modes for RAS instrumentation as only Modes 1, 2 & 3. RAS is less likely in Mode 4 due to lower LOCA probability in mode 4 and time for operators to manually actuate RAS is adequate (existing ISTS basis). Defense in depth is assured by availability of redundant RAS channels and low likelihood of system challenge during repair interval. Current Mode 5 end state designation for the SONGS units is inconsistent with ISTS philosophy.
SONGS 3.3.6 F.2 ISTS(analog) 3.3.4 F.2 ISTS(digital) 3.3.5 E.2	ESFAS Logic and Manual trip SIAS, RAS, CIAS, CCAS	Mode 5 – 36 hrs	Mode 4 - 12 hrs	All	Mode 4 SG operation poses overall lower risk of core damage and radiation release than does Mode 5. Mode 4 operation on SG also averts transition risks associated with SDC entry. Increased risks of equipment inoperability are offset by the transition risk to enter SDC and reduced potential	Sufficient time and indications are available to support manual generation of SIAS, CIAS and CCAS. To minimize human error one train of manual SIAS and CIAS trip and actuation logic should be retained for consistency with the ECCS shutdown TS.

Table 5.5–1
Technical Specification End State Assessment

Technical Specification Action	Title	Current End State	Proposed End State	Plant Applicability	Proposed Basis	
					Relative Risk Assessment	Deterministic Assessment
					for loss of core heat removal	
SONGS 3.3.8 B.2 ISTS(analog) 3.3.7 B.2 ISTS(digital) 3.3.8 B.2	CPIS	Mode 5 – 36 hrs	Mode 4 – 12 hrs	SONGS 2 & 3	Mode 4 SG operation poses overall lower risk of core damage and radiation release than does Mode 5. Mode 4 operation on SG also averts transition risks associated with SDC entry. Increased risks of equipment inoperability are offset by the transition risk to enter SDC and reduced potential for loss of core heat removal	CPIS is not required for Mode 1 DBA response. CPIS is redundant to CIAS. Operator is trained to close purge valve on indication of In-Containment radiation. Releases to containment are much less likely and lower in magnitude than that possible for full power DBA. In Mode 4, the function is provided via a redundant channel. Adequate time is available for manual action.
SONGS 3.3.9 A.1 ISTS(analog) 3.3.8 B.2 ISTS(digital) 3.3.9 B.2	CRIS	Mode 5 – 36 hrs (except SONGS 2 & 3)	Manually Align 1 Train of CREACS into Emergency Mode	Calvert Cliffs 1 & 2 PVNGS 1,2 &3 Waterford 3	CRIS initiates CREACUS. CRIS consists of two redundant actuation trains. Operators are trained to align CREACUS on indication of CRIS inoperability. Even in the event this is not done, adequate time is available for manual action.	Defense in depth assured by low likelihood of system challenge. CRIS initiates CREACUS. CREACUS provides airborne radiological protection for the control room operators, as demonstrated by the control room accident dose analyses for the most limiting design basis LOCA fission product release. CREACUS also provides protection from releases of toxic gases and chemicals. Plant Radiation challenges to CREACUS are lower in Mode 4 than Mode 5 due to the lesser Mode 4 CDF. Other challenges (toxic gas, etc.) remain the same in all shutdown modes. Releases to containment are much less likely and lower in magnitude than that possible for full power DBA.
SONGS NA ISTS(analog) 3.3.9 B.2	CVCS Isolation Signal	Mode 5 – 36 hrs	Mode 4 – 12 hrs	Calvert Cliffs 1 & 2	The CVCS Isolation Signal is redundant to SIAS. Mode 4 SG operation poses overall lower risk of core damage and radiation release than does Mode 5. Mode 4 operation on SG also averts transition	Each of the two CVCSIS actuation subsystems will isolate a separate letdown isolation valve in response to a high pressure. Inoperability of the CVCSIS has no impact on plant CDF in any operational mode. Plant core damage potential will be generally lower in Mode 4 than in Mode 5

Table 5.5–1
Technical Specification End State Assessment

Technical Specification Action	Title	Current End State	Proposed End State	Plant Applicability	Proposed Basis: Relative Risk Assessment	Proposed Basis: Deterministic Assessment
					risks associated with SDC entry. Increased risks of equipment inoperability are offset by the transition risk to enter SDC and reduced potential for loss of core heat removal	due the increased redundancy and diversity of core heat removal mechanisms. Furthermore, when SDC entry may be avoided, transition risks associated with SDC alignment errors may be averted. LERF probability is relatively small due to: (1) the lower radionuclide inventory in the RCS at shutdown, (2) the slower nature of the Mode 4/5 severe accident event progression and (3) increased time for operator actions and mitigation strategies.
SONGS NA ISTS(analog) 3.3.10 B.2	Shield Building Filtration Actuation Signal	Mode 5 – 36 hrs	Mode 4 – 12 hrs	Millstone 2 St Lucie 1& 2 Waterford 3	Inoperability of the SBFAS has no impact on plant CDF in any operational mode. Plant core damage potential will be generally lower in Mode 4 than in Mode 5 due the increased redundancy and diversity of core heat removal mechanisms. Furthermore, when SDC entry may be avoided, transition risks associated with SDC alignment errors may be averted. Provided leakage is controlled via TS 3.6.1 no LERF impact is incurred.	SBFAS initiates Shield Building Ventilation. Operators are trained to realign ventilation on indication of high radiation (e.g. via Containment High Area Radiation Monitors, CHARMs) or SBFAS inoperability. Furthermore, in Mode 4, the transient will unfold more slowly than at power and sufficient time exists for the operator to take manual action. With one SBFAS channel inoperable, the system may still provide its function via its redundant channel. These systems provide post-accident radiation protection to on-site staff and / or public.

Table 5.5–1 Technical Specification End State Assessment						
Technical Specification Action	**Title**	**Current End State**	**Proposed End State**	**Plant Applicability**	**Proposed Basis**	
					Relative Risk Assessment	**Deterministic Assessment**
3.4 Reactor Coolant System (RCS)						
3.4.6 B.1	RCS Loops-Mode 4	Mode 5 – 24 hrs	Mode 4 – 12 hrs	All	RCP operation not modeled in PRA since RCP operation not required to ensure heat removal during shutdown. Unavailability of SDC train increases risk of SDC operation, further supporting Mode 4 SGHR end state. Mode 4 on SG heat removal significantly lowers risk compared to plant operation on SDC.	Natural circulation possible during mode 4 with SG heat removal. Defined operator actions limit probability of inadvertent positive reactivity addition during extended period by requiring natural circulation prior to RCP restart. If unavailability of RCS loops is due to single SDC train unavailability, staying in a state with minimal reliance on SDC is preferred (Mode 4), due to increased diversity in RCS heat removal modes.
3.5 ECCS						
SONGS 3.5.4 C.2 ISTS 3.5.4 C.2	RWST (Boron concentration limits)	Mode 5 – 36 hrs	Mode 3 – 6 hrs	All	Boron concentration is controlled to support recovery from ATWS and to aid in plant cooldown following transients and is of low risk significance when plant is shutdown (particularly at higher temperatures). High boron limit based on boron precipitation concerns following larger LOCAs. These are very low probability events and adequate time exists to avert boron precipitation via entry to hotside/coldside injection.	Boron shutdown margin is high. The RWST water is treated to ensure large shutdown margins will exist (up to 9% SD margin), with all rods stuck out. Borated water concentration in RWST has low importance in shutdown modes.
3.6 Containment Systems						
3.6.1 B.2	Containment	Mode 5 - 36 hrs	Mode 4 – 12 hrs with excessive leakage	All	Mode 4 is a more resource rich state for core/RCS HR. Core cooling may be provided via SDC or SG heat removal. SDC operation and the act of	Radiological impact of in-containment releases from Mode 4 and Mode 5 are similar. SDC entry is subject to potential ISLOCA or inventory diversion scenarios which may result in the bypass of

Table 5.5–1 Technical Specification End State Assessment						
Technical Specification Action	Title	Current End State	Proposed End State	Plant Applicability	Proposed Basis	
					Relative Risk Assessment	Deterministic Assessment
					transitioning to SDC expose the plant to additional interfacing system LOCA (ISLOCA) events. The low LERF end state would be that associated with Mode 4 on SG heat removal. Continued operation in Mode 4 where containment closure is expected is more desirable end state than Mode 5 w/o containment closure requirements.	radiological material. No LERF impact, provided containment closure is assured and leakage is judged to be to small. Leakage in the fission product barrier is less important in Mode 4 than at full power. This is because the fission product active inventory is lower in mode 4 and the containment pressure threat will be lower due to less stored energy in the RCS. Containment leakages should be low due to restrictions on allowable leakage sources for entry in this action.
3.6.2 D.2	Containment Air Locks	Mode 5 - 36 hrs	Mode 4 – 12 hrs	All	Same as above	Defense in depth is assured via operability of redundant air lock seals. Entry into LCO has no impact on public risk.
SONGS 3.6.3 G.2 ISTS(analog) 3.6.3 F.2 ISTS(digital) 3.6.3 E.2	Containment Isolation Valves	Mode 5 - 36 hrs	Mode 4 – 12 hrs	All	Same as above.	Defense in depth is assured via operability of redundant CIVs in affected lines. Entry into LCO has no impact on public risk.
3.6.4 B.2	CTMT Pressure	Mode 5 - 36 hrs	Mode 4 – 12 hrs	All	Containment pressure initial condition does not vary significantly in CE large dry containments. This small variation has no direct impact on CDF or LERF. Mode 4 is a lower risk state than Mode 5 due to increased redundancy in RCS cooling systems. Mode 4 SGHR operation also averts risks associated with plant realignments during SDC	<u>UPPER LIMIT PRESSURE</u> Max. pressure is conservatively set by DB Analysis with a system with Mode 1 level energy release. In Mode 4 challenges to containment integrity are reduced due to (1) lower RCS internal energy level and (2) lower decay heat than present in Mode 1. Thus, in Mode 4, small increases in initial pressure, as

Table 5.5–1 Technical Specification End State Assessment						
Technical Specification Action	**Title**	**Current End State**	**Proposed End State**	**Plant Applicability**	**Proposed Basis** **Relative Risk Assessment**	**Deterministic Assessment**
					entry.	would be expected for large dry containments (on the order of several psia) will not violate containment design pressure limits during a subsequent DBA. <u>LOWER LIMIT</u> Since there is only a small impact on Mode 4 vs Mode 5 operation in plant initial conditions, the impact of inadvertent operation of CS will not be significantly different in Mode 4 or Mode 5. TS limits provide conservative operational guidance and may be violated without incurring a public risk Furthermore, subatmospheric design margins are sufficient to ensure adequate containment response for containment designs of interest.
3.6.5 B.2	Containment Air Temperature	Mode 5 - 36 hrs	Mode 4 – 12 hrs	All	Mode 4 is a lower risk state than Mode 5 due to increased redundancy in RCS cooling. Containment initial temperature has no direct impact on plant risk.	Possible variations in containment temperature above the current maximum temperature are expected to be very small and their occurrence should be rare. Currently, max. containment temperature set based on max expected containment temperature during full power operation. Lesser containment temperatures are expected at plant shutdown. Post MSLB peak containment temperature is used to help set EQ envelop. In Mode 4 this Containment temperature increase will be offset by the decreased RCS internal energy level and lesser core decay heat.
SONGS 3.6.6.1 B.2 & F.2	Containment Cooling Systems (Credit taken	Mode 5 - 36 hrs	Mode 4 – 84 hrs for CTMT Spray	ANO-2 Calvert Cliffs 1 & 2 St Lucie 1 & 2	Mode 4 on SG heat removal is a lower risk state (lower CDF) than Mode 5 due to increased redundancy in RCS cooling systems. Mode 4 and 5 risks while on	Defense-in-Depth maintained by availability of redundant train of containment cooling equipment. System required to reduce containment pressure to 1/2 of peak

Table 5.5–1 Technical Specification End State Assessment						
Technical Specification Action	Title	Current End State	Proposed End State	Plant Applicability	Proposed Basis	
					Relative Risk Assessment	Deterministic Assessment
ISTS 3.6.6A B.2 & F.2	for Iodine Removal)		Mode 4 – 36 hrs for CTMT Cooling	Waterford 3 (spray only)	SDC are approximately the same.	pressure following a DBA in 24 hours. Plants with diverse CHR, both systems not impaired. For plants with a non-diverse CHR: loss of CS will impact CDF due to its resultant failure of ECCS recirculation capability.
SONGS 3.6.6.2 C.1 ISTS 3.6.6B F.2	Containment Cooling Systems [Mode 4] (Credit not taken for Iodine Removal)	Mode 5 - 36 hrs	Mode 4 – 36 hrs for CTMT Cooling	Calvert Cliffs 1 & 2 Palisades SONGS 2 & 3 Waterford 3 (cooling only)	Mode 4 on SG heat removal is a lower risk state (lower CDF) than Mode 5 due to increased redundancy in RCS cooling systems. Mode 4 and 5 risks while on SDC are approximately the same.	Defense-in-Depth maintained by availability of redundant train of containment cooling equipment. System required to reduce containment pressure to 1/2 of peak pressure following a DBA in 24 hours. Plants with diverse CHR both systems not impaired. For plants with a non-diverse CHR: loss of CS will impact CDF due to resultant failure of ECCS recirc. May be able to demonstrate Mode 4 with a reduced RCS pressure restriction.
3.6.6.11 B.2	Shield Building	Mode 5 - 36 hrs	Mode 4 – 12 hrs with restrictions	Millstone 2 St Lucie 1 & 2 Waterford 3	Mode 4 is a more resource rich state. Core cooling may be provided via SDC or SG heat removal. SDC operation and the act of transitioning to SDC expose the plant to additional interfacing system LOCA (ISLOCA) events. The low LERF end state would be the one associated with Mode 4 on SG heat removal. In mode 4 containment closure is expected and CDF is either about the same or lower than for mode 5.	Provided containment closure is assured and leakage is not large. Leakage in the fission product barrier is less important in Mode 4 than at full power. This is because the fission product active inventory is lower in mode 4 and the containment pressure threat will be lower due to less stored energy in the RCS. Shield Building "leakage" at or near containment design basis levels is not explicitly modeled in the PRA. Provided containment leakage is controlled to small multiples of L_a, no LERF impact is incurred.

Table 5.5–1
Technical Specification End State Assessment

Technical Specification Action	Title	Current End State	Proposed End State	Plant Applicability	Proposed Basis: Relative Risk Assessment	Proposed Basis: Deterministic Assessment
3.7 Plant Systems						
SONGS 3.7.5 E.2 ISTS 3.7.5 C.2	Auxiliary Feedwater System	Mode 4 - 12 hrs	Mode 4 - 18 hrs without reliance upon SG for heat removal	All	Existing NUREG-1432 allows staying in Mode 4 if the RCS heat removal requirements are fully met by the use of SDC trains. It appears that flexibility already exists.	Unavailability of AFW limits usefulness of SG HR. In this situation, SDC operation in Mode 4 provides sufficient defense depth for RCS heat removal.
3.7.7 B.2	Component Cooling Water System (See App. C)	Mode 5 - 36 hrs	Mode 4 – 12 hrs	All except ANO 2	Component cooling needed for RCS heat removal in SDC (RCS heat removal). Vulnerable to SBO. Higher Mode 5 risk Mode 4 is lower risk than mode 5 since Mode 4 operation allows for non-CCW based RCS heat removal paths.	In addition to providing cooling to SDC heat exchangers, CCW supports the cooling of ECCS equipment, and cooling of RCPs. It also supports normal and emergency cooling of containment and post-accident heat removal during the recirculation mode. Unavailability of CCW reduces ability in one or more of the following areas: (1) Energy removal during SDC (2) RCP cooling during SG Heat Removal (3) Post-accident containment cooling, and (4) ECCS equipment cooling Availability of redundant train of CCW maintains design basis capability during repair.
3.7.8 B.2	Salt Water Cooling System / Service Water System / Essential Spray Pond System / Auxiliary CCW (See App. C)	Mode 5 -36 hrs	Mode 4 – 12 hrs on SGHR	All	Mode 4 is lower risk than mode 5 since Mode 4 operation allows for non-SDC based RCS heat removal paths Needed to support SDC heat removal function	The service water system supports the CCW system. It also supports required AC power sources (Emergency Diesel Generators) Availability of redundant train of equipment maintains design basis capability during repair.

Table 5.5–1
Technical Specification End State Assessment

Technical Specification Action	Title	Current End State	Proposed End State	Plant Applicability	Proposed Basis: Relative Risk Assessment	Proposed Basis: Deterministic Assessment
3.7.9 B.2	Ultimate Heat Sink (see App. C)	Mode 5 -36 hrs	Mode 4 – 12 hrs on SGHR	All except SONGS 2 & 3	Mode 4 is lower risk than mode 5 since Mode 4 operation allows for non-SDC based RCS heat removal paths Needed to support SDC heat removal function	The UHS supports the SWS system. Availability of redundant train maintains design basis capability during repair.
3.7.10 B.2	Emergency Chilled Water (see App. C)	Mode 5 -36 hrs	Mode 4 – 12 hrs	PVNGS 1,2 &3 SONGS 2 & 3 Waterford 3	Mode 4 is lower risk state than Mode 5 due to increased redundancy and diversity of equipment. Low RCS pressure restriction (PVNGS) further reduces potential for LOCAs and minimizes need for ECW system cooling.	In Modes 1, 2, 3 & 4, the ECW System is required to be OPERABLE when a LOCA or other accident would require ESF operation. The design basis of the ECW System is to remove the post-accident heat load from ESF spaces following a DBA coincident with a loss of offsite power. Availability of redundant train maintains design basis capability during repair.
3.7.11 B.2	CREACUS	Mode 5 - 36 hours	Mode 4 – 12 hrs	All	Mode 4 operation has greater system redundancy & diversity than mode 5 and hence results in lower operational risks. Also, the frequency of radiation challenges to CREACUS are lower in Mode 4 than Mode 5 due to the lesser Mode 4 CDF.	The CREACUS provides airborne radiological protection for the control room operators and protection from releases of toxic gases and chemicals. The redundant train of CREACUS remains operable. Mode 4 extended operation is allowable due to the low likelihood of an event requiring operator action that simultaneously challenges the CREACUS along with the unavailability of the redundant train.
3.7.12 B.2	CREATCS	Mode 5 -36 hrs	Mode 4 – 12 hrs	Calvert Cliffs 1 & 2 Palisades PVNGS 1,2 &3 Waterford 3	Mode 4 operation has greater system redundancy & diversity than mode 5 and hence results in lower operational risks.	The CREATCS is an emergency system which provides CR temperature control . The redundant train of CREATCS remains operable.

Table 5.5–1 Technical Specification End State Assessment						
Technical Specification Action	Title	Current End State	Proposed End State	Plant Applicability	Proposed Basis	
					Relative Risk Assessment	Deterministic Assessment
						Mode 4 extended operation is allowable due to the low likelihood of an event requiring operator action that simultaneously challenges the CREATCS along with the unavailability of the redundant train.
3.7.13 B.2	ECCS Pump Room EACS	Mode 5 -36 hrs	Mode 4 – 12 hrs	Calvert Cliffs 1 & 2 St Lucie 1 & 2 Waterford 3	See 3.7.12 B.2 above	The ECCS PREACS is an emergency system to control the post LOCA pump room radiation leakage The redundant train remains operable. Mode 4 extended operation is allowable due to the low likelihood of an event requiring operator action that simultaneously challenges the CREATCS, along with the unavailability of the redundant train.
3.7.15 B.2	Penetration Room EACS	Mode 5 -36 hrs	Mode 4 – 12 hrs	Calvert Cliffs 1 & 2 Waterford 3	See 3.7.12 B.2 above	The Penetration Room EACS is an emergency system to control the post accident penetration room radiation leakage The redundant train remains operable. Mode 4 extended operation is allowable due to the low likelihood of an event requiring operator action that simultaneously challenges the Penetration Room EACS, along with the unavailability of the redundant train.
3.8 Electrical Power Sources						
3.8.1 F.2	AC Sources-Operating	Mode 5 -36 hrs	Mode 4 – 12 hrs on SGHR	All	The risk associated with a proposed Mode 4 end state is less than the risk associated with the current Mode 5 end state. Risk reduction due to availability on HR pathways that are less	During Mode 4 with the steam generators available, plant risk is dominated by a Loss of Offsite Power (LOOP) initiating event. There are several redundant and diverse means available for removing heat from the RCS

Table 5.5–1
Technical Specification End State Assessment

Technical Specification Action	Title	Current End State	Proposed End State	Plant Applicability	Proposed Basis: Relative Risk Assessment	Proposed Basis: Deterministic Assessment
					dependent on power availability (e.g. TD or diesel driven AFW). The qualitative comparison of plant risk, as measured by CDF and LERF, indicates that it is more risk significant to transition the plant to and operate in the current Mode 5 end state rather than remain in Mode 4 if the completion time for the required LCO actions cannot be met. Hence, Mode 4 is an acceptable end state.	during this mode of operation.
3.8.4 B.2	DC Sources-Operating	Mode 5 - 36 hrs	Mode 4 - 12 hrs on SGHR	All	The qualitative comparison indicates that the risk of operating the plant in the current Mode 5 end state when an inoperable DC source cannot be restored to operability within 2 hours is greater than the risk of operating the plant in the proposed Mode 4 end state. Hence, Mode 4 is an acceptable end state for Condition B of TS 3.8.4.	With a DC electrical power subsystem inoperable during Mode 5, the plant risk is dominated by LOOP events. The plant configuration during this mode makes it much more likely than Mode 4 for a LOOP event to occur. Plant activities that occur during Mode 5, may degrade or eliminate the redundancy of electrical equipment that is available during Mode 4. The increased LOOP challenges also increase the plant risk during Mode 5 operation. The risk of transitioning the plant to the current Mode 5 end state when one inoperable DC power source cannot be restored to operability within 2 hours also increases the overall plant risk associated with this mode of operation.
3.8.7 D.2 SONGS	Inverters-Operating	Mode 5 -36 hrs	Mode 4 – 12 hrs on SGHR	Calvert Cliffs 1 & 2 Palisades PVNGS 1,2 &3 SONGS 2 & 3	The risk associated with a proposed Mode 4 end state is less than the risk associated with the current Mode 5 end state. In Mode 5, the plant is more susceptible to LOOP events due to ongoing activities, which are not	The inoperability of a single inverter during Mode 4 operation will have little or no impact on plant risk (See Section 5.5.28). The plant configuration during Mode 5 makes the unit more susceptible to a LOOP event due to the potential for ongoing activities.

Table 5.5–1
Technical Specification End State Assessment

Technical Specification Action	Title	Current End State	Proposed End State	Plant Applicability	Proposed Basis: Relative Risk Assessment	Proposed Basis: Deterministic Assessment
3.8.7 B.2					performed during Mode 4.	When the transition risk and the increased likelihood of a LOOP are considered, the overall plant risk associated with Mode 5 is larger than the plant risk associated with Mode 4. Hence, Mode 4 is the preferred end state. The proposed modification of the TS end state from Mode 5 to Mode 4 provides diverse methods of RCS heat removal, and results in a lower plant risk configuration.

5.6 IMPLEMENTATION AND MONITORING PROGRAM

A three-tiered approach has been identified for licensees to evaluate the risk associated with TS changes. Per Regulatory Guide 1.177:

"Tier 1 is an evaluation of the impact on plant risk of the proposed TS change as expressed by the change in Core Damage Frequency (ΔCDF), the Incremental Conditional Core Damage Probability (ICCDP), and when appropriate, the change in Large Early Release Frequency (ΔLERF) and the Incremental Conditional Large Early Release Probability (ICLERP). Tier 2 is an identification of potentially high-risk configurations that could exist if equipment in addition to that associated with the change were to be taken out of service simultaneously, or other risk-significant operational factors such as concurrent system or equipment testing were also involved. The objective of this part of the evaluation is to ensure that appropriate restrictions on dominant risk-significant configurations associated with the change are in place. Tier 3 is the establishment of an overall configuration risk management program to ensure that other potentially lower probability, but nonetheless risk-significant, configurations resulting from maintenance and other operational activities are identified and compensated for."

5.6.1 TIER 1: PRA CAPABILITY AND INSIGHTS

The risk changes associated with the TS changes proposed in this report will be risk-neutral or risk beneficial. In order to ensure that the proposed TS changes, once implemented will not result in a significant increase in plant risk (i.e. CDF and LERF) plant risk will be assessed and monitored regularly.

5.6.2 TIER 2: AVOIDANCE OF RISK-SIGNIFICANT PLANT CONFIGURATIONS

For some risk-informed TSs, specific Tier 2 restrictions may be required. These restrictions are intended to provide a "defense in depth" approach to the risk-informed process. The Tier 2 restrictions are intended to preclude scheduled preventive maintenance on risk significant equipment combinations and operational activities. Tier 2 items apply only to planned maintenance situations or planned operational activities, but will be evaluated as part of the Tier 3 assessment for unplanned situations. Tier 2 items for the various proposed TS changes are discussed in Section 5.5.

The occurrence of Tier 2 equipment combinations during unplanned maintenance situations is not restricted. The presence of Tier 2 issues will be identified shortly upon entry in the Tier 2 condition(s), and actions to exit that condition should be expeditiously identified and implemented. In constructing the proposed end states, several required actions were established with specific heat removal requirements (e.g. SGHR or on SDC). These restrictions were developed to ensure the end state risk is controlled. In modifying TS 3.6.1, limitations were provided to ensure containment remains essentially functional. No other specific Tier 2 items were identified to support the proposed Mode 4 changes. However, in several instances enhanced guidance is provided. This additional guidance is intended to be administratively controlled within the scope of the plant Maintenance Rule or Analogous Program.

5.6.3 TIER 3: RISK-INFORMED CONFIGURATION RISK MANAGEMENT

At present, a formal commitment to the Configuration Risk Management Program (CRMP) is required on the part of the utility, prior to implementation of risk-informed TS. This CRMP commitment statement is currently included in Administrative Section of the respective plant's Technical Specification. In the future this commitment may be subsumed within the programs used to comply with 10CFR50.65 A(4).

The purpose of the CRMP is to ensure that a proceduralized PRA-informed process is in place to assess the overall impact of plant maintenance and operations on plant risk. The CRMP commitment applies whenever a risk-informed TS is entered and risk-informed TS components are out of service. The primary focus of the CRMP is to ensure that PRA based risk insights are considered in the planning of operations and maintenance on plant equipment, structures and components. The overall objective of these actions is to control the instantaneous plant risk at acceptable levels.

To comply with the requirements of the CRMP, an additional Action Requirement will be added to each TS as described in Section 5.4.4 to invoke the CRMP within 24 hours of entering the action to shutdown below Mode 3. Among other features, the CRMP program will ensure the availability of the redundant TS component via a common cause assessment.

5.6.4 MONITORING PROGRAM

A plant specific program for monitoring the utilization of these end state changes will be developed by the respective utilities. A description of this program will be provided at the time of the submittal.

5.7 SUMMARY OF RESULTS

Qualitative and quantitative risk assessments of the plant operational differences while in Mode 4 and Mode 5, confirm that the recommended end state changes to allow Mode 4 as an acceptable end state will pose equal or lower risks than those in Mode 5. Availability of a Mode 4 end state also provides flexibility to the plant staff to avoid risks associated with SDC entry. In many instances where Mode 4 operation is requested as the final end state, availability of SG heat removal capability is proposed as a TS requirement.

The risk of shutdown operations was evaluated from the perspective of change in Core Damage Frequency (CDF). For the most part, as long as AFW equipment is not removed from service, the relative behavior of the lower mode CDFs were generally invariant to the TS LCO entry conditions and were not impacted significantly by the specific TS changes. The CDF was established for Mode 1 (normal operation), and various shutdown Modes: Mode 3 and Mode 4 with SG heat removal, Mode 4 on SDC and Mode 5 (vented operation). The risks of these modes are compared in Figure 5-1. Mode 1 serves as a reference point for typical expected risk. The figure shows that for San Onofre Units 2 & 3 the lowest plant shutdown risk occurs in Mode 4 with RCS heat removal through the steam generators. The greatest risk state of all modes occurs in Mode 5 when the RCS is vented to ensure CS backup for SDC. Sensitivity studies confirm the "lower risk" nature of Mode 4 operation for CEOG PWRs.

Table 5-1 documents the comprehensive list of TSs which were reviewed, the existing end state, the proposed end state, and the rationale for the proposed end state. A summary of the proposed changes to the TS required end state actions is also provided in Table 2-1.

6.0 REFERENCES

1. NUREG-1432, "Standard Technical Specifications, Combustion Engineering Plants," Rev. 1, April 1995, USNRC.
2. RG 1.174, USNRC, "An Approach for using Probabilistic Risk Assessment in Risk Informed Decision on Plant Specific Changes to the Licensing Basis," USNRC, July 1998.
3. RG 1.177, "An Approach for Plant Specific Risk Informed Decision Making: Technical Specifications," USNRC, August 1998.
4. USNRC, 10CFR50.36, "Technical Specifications," Federal Register, 60FR36953, July 19, 1995.
5. NUREG-1449, "Shutdown and Low-Power Operation at Commercial Nuclear Power Plants in the United States," USNRC, September 1993.
6. AEOD/S95-01, "Reactor Coolant System Blowdown at Wolf Creek on September 17, 1994," USNRC-AEOD, March 1995.
7. GL 88-17, "USNRC Generic Letter 88-17: Loss of Decay Heat Removal," USNRC, October 17, 1988.
8. IN 95-03, "USNRC Information Notice 95-03: Loss of Reactor Coolant Inventory and Potential Loss of Emergency Mitigation Functions While in a Shutdown Condition," USNRC, January 18, 1995.
9. IN 95-03 (Supplent 1), "USNRC Information Notice 95-03: Loss of Reactor Coolant Inventory and Potential Loss of Emergency Mitigation Functions While in a Shutdown Condition," USNRC, March 25, 1996.
10. GL 98-02, "USNRC Generic Letter 98-02: Loss of Reactor Coolant Inventory and Potential Loss of Emergency Mitigation Functions While in a Shutdown Condition," USNRC, May 28, 1998.
11. IN 99-14, "USNRC Information Notice 99-14: Unanticipated Reactor Water Draindown at Quad Cities Unit 2, Arkansas Nuclear One Unit 2, and Fitzpatrick," USNRC, May 5, 1999.
12. L-2289, Technical Report, "Analyses of Action Requirements for Failures in the Auxiliary Feedwater System of a PWR," T. Mankamo, I.S. Kim and P.K. Samanta, August 26, 1994.
13. CE NPSD-1045, "Joint Application Report: Modifications to Containment Spray System, and the Low Pressure Safety Injection System Technical Specifications," CE Owner's Group, March 1998.
14. Daily Event Report 35127, Salem: "Excessive Reactor Coolant Leakage...," USNRC, 12/09/98.
15. NUMARC 91-06, "Guidance for Industry Actions to Assess Shutdown Management," Nuclear Energy Institute, December 1991.
16. OPPD Letter FC-431-75A / LIC-75-0087 to NRC, "Loss of Component Cooling Water to Reactor Coolant Pump Seals," from T.E. Short, OPPD Division Manager-Production Operations, dated June 26, 1975.
17. GS-1520, "Report on Loss of Component Cooling Water Test on Nuclear Reactor Coolant Pump," Byron Jackson, April 9, 1979.
18. CEN-259, "An Evaluation of the Natural Circulation Cooldown Test Performed at The San Onofre Nuclear Generating Station: Compliance with the Testing Requirements of Branch Technical Position RSB 5-1," Combustion Engineering, January, 1984.
19. SONGS Units 2 & 3, "Individual Plant Examination," SCE, May 1993.
20. SONGS Units 2 Technical Specifications Bases, Amendment No. 127, 9/9/1999 (page B.3.6-28).

ATTACHMENT A

UNIT 2
EXISTING TECHNICAL SPECIFICATIONS END STATES AND TS CROSS REFERENCE

Table A-1 Results of Technical Specification Review: Summary of Current End States														
ISTS		SONGs TS #	Title	End State										
Analog	Digital			ISTS	SONGS	ANO	Calvert Cliffs	Palo Verde	SL-1	SL-2	WSES	FCS[3]	PAL	MP2
3.1 Reactivity Control System														
None	None	3.1.9 C.1	Boration Systems - Operating	NA	Mode 5 - 30 hrs	Mode 5 - 30 hrs	NA	NA	Mode 5 - 30 hrs	Mode 5 - 30 hrs	Mode 5 - 30 hrs	Mode 4 – 114 hrs	NA	Mode 5 - 36 hrs
3.3 Instrumentation														
3.3.4 F.2	3.3.5 E.2	3.3.5 H.2	ESFAS Instrumentation (RAS - RWST low)	Mode 4 - 12 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 - 12 hrs	NA	NA	NA	Mode 5 - 36 hrs	Mode 3 – 60 hrs[4]	Mode 4 - 30 hrs	NA
3.3.4 F.2	3.3.5 E.2	3.3.6 F.2	ESFAS Logic and Manual Trip SIAS, CIAS, CCAS, RAS	Mode 4 - 12 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 3 – 60 hrs[4]	Mode 4 - 30 hrs	Mode 5 - 36 hrs
3.3.7 B.2	3.3.8 B.2	3.3.8 B.2	CPIS	Mode 5 - 36 hrs	Mode 5 - 36 hrs	NA	NA	NA	NA	NA	NA	7 days + Mode 3 – 12 hrs[4]	NA	NA
3.3.8 B.2	3.3.9 B.2	3.3.9 B.1	CRIS	Mode 5 - 36 hrs	Manually Align 1 Train of CREACUS into Emerg. or LCO 3.0.3	NA	Mode 5 - 36 hrs (CRRS)	Mode 5 - 36 hrs (CREFAS)	NA	NA	Mode 5 - 36 hrs (CRIP)	7 days + Mode 3 – 12 hrs[4] (Ventilation Isolation)	NA	NA
3.3.9 B.2	NA	NA	CVCS Isolation Signal	Mode 5 - 36 hrs	NA	NA	Mode 5 - 36 hrs	NA	NA	NA	NA	NA	NA	NA
3.3.10 B.2	NA	NA	Shield Building Filtration Actuation Signal	Mode 5 - 36 hrs	NA	NA	NA	NA	Mode 5 - 36 hrs	Mode 5 – 36 hrs	Mode 5 – 36 hrs	NA	NA	Mode 5 - 36 hrs (EBFAS)
3.4 Reactor Coolant System														
3.4.6 B.1	3.4.6 B.1	3.4.6 B.1	RCS Loops - Mode 4	Mode 5 - 24 hrs (w/SDC)	Mode 5 - 24 hrs	Mode 5 - 20 hrs	Mode 5 - 24 hrs	Mode 5 - 24 hrs	Mode 5 - 30 hrs (w/SDC)	Mode 5 - 30 hrs (w/SDC)	Mode 5 - 24 hrs (w/SDC)	Mode 4 – 84 hrs[4]	Mode 5 - 24 hrs (w/SDC)	Mode 5 - 20 hrs
3.5 Emergency Core Cooling System														
3.5.4 C.2	3.5.4 C.2	3.5.4 C.2	RWST	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 – 42 hrs[4]	Mode 5 - 36 hrs	Mode 5 - 30 hrs
3.6 Containment Systems														
3.6.1 B.2	3.6.1 B.2	3.6.1 B.2	Containment	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 – 43 hrs[4]	Mode 5 - 36 hrs	Mode 5 - 36 hrs
3.6.2 D.2	3.6.2 D.2	3.6.2 D.2	CTMT Air Locks	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	92 days + 43 hrs[4]	Mode 5 - 36 hrs	Mode 5 - 36 hrs

Table A-1
Results of Technical Specification Review: Summary of Current End States

ISTS		SONGs TS #	Title	End State										
Analog	Digital			ISTS	SONGS	ANO	Calvert Cliffs	Palo Verde	SL-1	SL-2	WSES	FCS(3)	PAL	MP2
3.6.3 F.2	3.6.3 F.2	3.6.3 G.2	CIVs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 – 43 hrs(4)	Mode 5 - 36 hrs	Mode 5 - 36 hrs
3.6.4 B.2	3.6.4 B.2	3.6.4 B.2	CTMT Pressure	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 – 42 hrs(4)	Mode 5 - 36 hrs	Mode 5 - 40 hrs
3.6.5 B.2	3.6.5 B.2	3.6.5 B.2	CTMT Air Temp	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	NA	Mode 5 - 36 hrs	Mode 5 - 36 hrs
3.6.6A B.2 & F.2	3.6.6A B.2 & F.2	3.6.6.1 B.2 & F.2	CTMT Spray and Cooling Systems (Credit Taken for Iodine Removal)	Mode 5 - 84 hrs (CTMT Spray) Mode 5 - 36 hrs (CTMT Cooling)	Mode 4 - 84 hrs (CTMT Spray) Mode 4 - 36 hrs (CTMT Cooling)	Mode 5 - 36 hrs	Mode 5 - 36 hrs (Iodine Removal System)	NA	Mode 4 - 60 hrs (CTMT Spray) Mode 4 - 12 hrs (CTMT Cooling) (1) Mode 5 - 78 hrs (Spray Additive System)(2)	Mode 4 - 60 hrs (CTMT Spray) Mode 4 - 12 hrs (CTMT Cooling) (1) Mode 5 - 78 hrs (Iodine Removal System)(2)	Mode 5 - 30 hrs (CTMT Spray)	7 days + Mode 4 – 84 hrs(4)	NA	Mode 4 - 12 hrs ?
3.6.6B F.2	3.6.6B F.2	3.6.6.2 C.1	CTMT [Spray and] Cooling Systems [Mode 4] (Credit not taken for Iodine Removal)	Mode 5 - 36 hrs	Mode 5 - 36 hrs (CTMT Cooling)	NA	Mode 4 - 12 hrs	Mode 4 - 84 hrs & <385 psia	Mode 4 - 12 hrs	Mode 4 - 12 hrs	Mode 5 - 30 hrs (CTMT Cooling)	NA	Mode 4 - 30 hrs (CTMT Cooling)	NA
3.6.6.11 B.2	3.6.6.11 B.2	NA	Shield Building	Mode 5 - 36 hrs	NA	NA	NA	NA	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	NA	NA	Mode 5 - 36 hrs
3.7 Plant Systems														
3.7.5 C.2	3.7.5 C.2	3.7.5 E.2	AFW	Mode 4 - 18 hrs (w/o SG HR)	Mode 4- 12 Hrs	Mode 4- 12 Hrs (EFW)	Mode 4- 12 Hrs	Mode 4- 12 Hrs	Mode 4 - 12 Hrs	Mode 4 - 12 Hrs	Mode 4 - 12 Hrs (EFW)	NA	Mode 4 - 30 hrs	Mode 4 - 12 hrs
3.7.7 B.2	3.7.7 B.2	3.7.7 B.2	CCW (flow path)	Mode 5 - 36 hrs	Mode 5 - 36 hrs	NA	Mode 5 - 36 hrs (CC)	Mode 5 - 36 hrs (EW)	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	7 days + Mode 4 – 84 hrs(4)	Mode 5 - 36 hrs	Mode 5 - 36 hrs (RBCCW)

Table A-1
Results of Technical Specification Review: Summary of Current End States

ISTS		SONGs TS #	Title	End State										
Analog	Digital			ISTS	SONGS	ANO	Calvert Cliffs	Palo Verde	SL-1	SL-2	WSES	FCS(3)	PAL	MP2
3.7.8 B.2	3.7.8 B.2	3.7.8 B.2	SWC	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs (SRW)	Mode 5 - 36 hrs (ESPS)	Mode 5 - 36 hrs (Intake CW)	Mode 5 - 36 hrs (Intake CW)	Mode 5 - 36 hrs (ACCW)	7 days + Mode 4 – 84 hrs(4)	Mode 5 - 36 hrs (SWS)	Mode 5 - 36 hrs (SWS)
3.7.9 B.2	3.7.9 B.2	NA	UHS	Mode 5 - 36 hrs	NA	Mode 5 - 36 hrs (EC Pond)	Mode 5 - 36 hrs (Salt Water)	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 – 84 hrs(4)	Mode 5 - 36 hrs	Mode 5 - 36 hrs (UHS)
3.7.10 B.2	3.7.10 B.2	3.7.10 B.2	ECW	Mode 5 - 36 hrs	Mode 5 - 36 hrs	NA	NA	Mode 5 - 36 hrs	NA	NA	Mode 5 - 36 hrs	NA	NA	NA
3.7.11 B.2	3.7.11 B.2	3.7.11 B.2	CREACUS	Mode 5 - 36 hours	Mode 5 - 36 hours	Mode 5 - 36 hrs (CREVAS)	Mode 5 - 36 hrs (CREVS)	Mode 5 - 36 hrs (CREACS)	Mode 5 - 36 hrs (CREVS)	Mode 5 - 36 hrs (CREACS)	Mode 5 - 36 hrs (CREAFS)	7 days + Mode 4 – 42 hrs(4)	Mode 5 - 36 hrs (CRV)	Mode 5 - 36 hrs (CREVS)
3.7.12 B.2	3.7.12 B.2	NA	CREATCS	Mode 5 - 36 hours	NA	NA	Mode 5 - 36 hrs (CRETS)	Mode 5 - 36 hrs (CREATC)	NA	NA	Mode 5 - 36 hrs (CRATS)	30 days + Mode 4 – 42 hrs(4)	Mode 5 - 36 hrs (CRC)	NA
3.7.13 B.2	3.7.13 B.2	NA	ECCS Pump Room EACS	Mode 5 - 36 hours	NA	NA	Mode 5 - 36 hrs	NA	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs (CVAS)	NA	NA	NA
3.7.15 B.2	3.7.15 B.2	NA	Penetration Room EACS	Mode 5 - 36 hours	NA	NA	Mode 5 - 36 hrs	NA	NA	NA	Mode 5 - 36 hrs (CVAS)	NA	NA	NA
3.8 Power Sources														
3.8.1 G.2	3.8.1 G.2	3.8.1 F.2	AC Sources-Operating	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 – 48 hrs(4)	Mode 5 - 36 hrs	Mode 5 - 36 hrs
3.8.4 B.2	3.8.4 B.2	3.8.4 B.2	DC Sources-Operating	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 5 - 36 hrs	Mode 4 – 56 hrs(4)	Mode 5 - 36 hrs	Mode 5 - 36 hrs (DC Distr) Mode 4 - 12 hrs (DC Distr - Turbine Battery)
3.8.7 D.2	3.8.7 D.2	3.8.7 B.2	Inverters-Operating	Mode 5 - 36 hrs	Mode 5 - 36 hrs	NA	Mode 5 - 36 hrs	Mode 5 - 36 hrs	NA	NA	NA	Mode 4 – 72 hrs(4)	Mode 5 - 36 hrs	NA

Footnotes to Table A-1

(1) If plant were already in Mode 4 with an affected SDC loop, Condition B of 3.4.6 is also applicable. It requires entry into Mode 5 within 24 hours.
(2) Not applicable to all PWR designs.
(3) Fort Calhoun end states are different:

Mode 1 = Operating (Reactor Power ≥ 2%)
Mode 2 = Hot Standby (Reactor Power < 2% & T_{AV} > 515 °F)
Mode 3 = Hot Shutdown (T_{AV} > 515 °F & reactor subcritical)
Mode 4 = Cold Shutdown (T_{cold} < 210 °F & RCS at shutdown boron concentration)
Mode 5 = Refueling Shutdown (T_{cold} < 210 °F & RCS at refueling boron concentration)

(4) End state apples to < 2 of 3 flow paths available.

Table A-2 Technical Specification Numbering Cross-Reference												
ISTS		SONGs TS #	Title	Current End State								
Analog	Digital			ANO	CC	Palo Verde	SL-1	SL-2	WSES	FCS	PAL	MP2
3.1 Reactivity Control System												
None	None	3.1.9 C.1	Boration Systems - Operating	3.1.2.2 - flow path 3.1.2.6 - BAM pumps 3.1.2.8 - BAT	NA	NA	3.1.2.2	3.1.2.2	3.1.2.2	2.2.2	NA	3.1.2.2
3.3 Instrumentation												
3.3.4 F.2	3.3.5 E.2	3.3.5 H.2	ESFAS Instrumentation (RAS - RWST low)	3.3.2.1 Table 3.3-3 (#6.b)	3.3.4 E.2 Table 3.3.4-1 (#5a)		3.3.2.1 Table 3.3-3 (#5.b)	3.3.2 Table 3.3-3 (#5.b)	3.3.2 Table 3.3-3 (#5.b)	2.15 Table 2-3 #3b	3.3.3.B.2 Table 3.3.3-1 (#3.a)	3.3.2 Table 3.3-3 (#6.b)
3.3.4 F.2	3.3.5 E.2	3.3.6 F.2	ESFAS Logic and Manual trip SIAS, RAS, CIAS, CCAS	Table 3.3-3	3.3.5.B	3.3.6.E	3.3.2.1	3.3.2	3.3.2	2-15 Tables 2-3/2-4	3.3.4.B.2 Table 3.3.4-1 (#3)	3.3.2
3.3.7 B.2	3.3.8 B.2	3.3.8 B.2	CPIS	NA	NA	NA	NA	NA	NA	2.15 Tbl 2-4	NA	NA
3.3.8 B.2	3.3.9 B.2	3.3.9 B.1	CRIS	NA	3.3.8.B (CRRS)	3.3.9.B (CREFAS)	NA	NA	3.7.6.5 (CRIP)	2.12 2.15 2.22 Tbl 2-4	NA	NA
3.3.9 B.2	NA	NA	CVCS isolation signal	NA	3.3.9.D	NA	NA	NA	NA	NA	NA	NA
3.3.10 B.2	NA	NA	Shield Building Filtration Actuation Signal	NA	NA	NA	3.2.2.1 (CIAS)	3/2/2 (CIAS)	3.3.2 (CIAS)	NA	NA	3.3.2 Table 3.3-3 (#5) ? 3.6.5 (EBFS)
3.4 Reactor Coolant System												
3.4.6 B.1	3.4.6 B.1	3.4.6 B.1	RCS Loops-Mode 4	3.4.1.3	3.4.6.B	3.4.6.B	3.4.1.3	3.4.1.3	3.4.6.B	2.1.1(2)	3.4.6.B	3.4.1.3.A
3.5 Emergency Core Cooling System												
3.5.4 C.2	3.5.4 C.2	3.5.4 C.2	RWST	3.1.2.8	3.5.4.C	3.5.5.C	3.5.4	3.5.4	3.5.4	2.2.8 2.3 (1)a	3.5.4.C	3.5.4
3.6 Containment Systems												
3.6.1 B.2	3.6.1 B.2	3.6.1 B.2	Containment	3.6.1.1 3.6.1.5	3.6.1.B	3.6.1.B	3.6.1.1	3.6.1.1	3.6.1	2.6 (1)	3.6.1.B	3.6.1.1
3.6.2 D.2	3.6.2 D.2	3.6.2 D.2	CTMT Air Locks	3.6.1.3.A.3	3.6.2.D	3.6.2.D	3.6.1.3.A	3.6.1.3.A	3.6.1.3.A	2.6 (1)b	3.6.2.D	3.6.1.3.B

Table A-2
Technical Specification Numbering Cross-Reference

ISTS		SONGs TS #	Title	Current End State								
Analog	Digital			ANO	CC	Palo Verde	SL-1	SL-2	WSES	FCS	PAL	MP2
3.6.3 F.2	3.6.3 F.2	3.6.3 G.2	CIVs	N./A	3.6.3.D	3.6.3.E	3.6.3.1	3.6.3	3.6.3.D	2.6 (1)a 2.15 (2)	3.6.3.E	3.6.3.1
3.6.4 B.2	3.6.4 B.2	3.6.4 B.2	CTMT Pressure	3.6.1.4	3.6.4.B	3.6.4.B	3.6.1.4	3.6.1.4	3.6.1.4	2.6 (2)	3.6.4.B	3.6.1.4
3.6.5 B.2	3.6.5 B.2	3.6.5 B.2	CTMT Air Temp	3.6.1.4	3.6.5.B	3.6.5.B	3.6.1.5	3.6.1.5	3.6.1.5	NA	3.6.5.B	3.6.1.5
3.6.6A B2 & F.2	3.6.6A B2 & F.2	3.6.6.1 B2 & F.2	CTMT Spray and Cooling Systems (Credit for Iodine Removal)	3.6.2.1	3.6.8.C (Iodine Removal System)	NA	3.6.2.2 (Spray Additive System)	3.6.2.2 (Iodine Removal System)	3.6.2.1 (CTMT Spray)	2.4	NA	3.6.2.1.C
3.6.6B F.2	3.6.6B F.2	3.6.6.2 C.1	CTMT [Spray and] Cooling Systems [Mode 4] (Credit not taken for Iodine Removal)	NA	3.6.6.E	3.6.6.B	3.6.2.1	3.6.2.1	3.6.2.2 (CTMT Cooling)	NA	3.6.6.B (CTMT Cooling)	NA
3.6.6.11 B.2	3.6.6.11 B.2	NA	Shield Building	NA	NA	NA	3.6.6.2	3.6.6.2	3.6.6.2	NA	NA	3.6.5.2
3.7 Plant Systems												
3.7.5 C.2	3.7.5 C.2	3.7.5 E.2	AFW	3.7.1.2	3.7.3.E	3.7.5.C	3.7.1.2	3.7.1.2	3.7.1.2 (EFW)	2.5	3.7.5.C	3.7.1.2.B
3.7.7 B.2	3.7.7 B.2	3.7.7 B.2	CCW (flow path)	NA	3.7.5.B (CC)	3.7.7.B (EW)	3.7.3.1	3.7.3	3.7.3	2.4	3.7.7.B	3.7.3.1 (RBCCW)
3.7.8 B.2	3.7.8 B.2	3.7.8 B.2	SWC	3.7.3.1	3.7.6.B (SRW)	3.7.8.B (ESPS)	3.7.4.1 (Intake CW)	3.7.4 (Intake CW)	3.7.3 (ACCW)	2.4	3.7.8.B (SWS)	3.7.4.1 (SWS)
3.7.9 B.2	3.7.9 B.2	NA	UHS	3.7.4.1	3.7.7.B (Salt Water System)	3.7.9.A	3.7.5.1.C	3.7.5.1.C	3.7.4	2.4	3.7.9.A	3.7.11
3.7.10 B.2	3.7.10 B.2	3.7.10 B.2	ECW	NA	NA	3.7.10.B (ECW)	NA	NA	3.7.12 (ESCWS)	NA	NA	NA
3.7.11 B.2	3.7.11 B.2	3.7.11 B.2	CREACUS	3.7.6.1.B (CREVAS)	3.7.8.E (CREVS)	3.7.11.B (CREFS)	3.7.7.1 (CREVS)	3.7.7 (CREACS)	3.7.6.1 (CREAFS)	2.12	3.7.10.B (CRV)	3.7.6.1 (CREVS)
3.7.12 B.2	3.7.12 B.2	NA	CREATCS	NA	3.7.9.B (CRETS)	3.7.12.B	NA	NA	3.7.6.3 (CRATS)	2.12	3.7.11.B (CRC)	NA
3.7.13 B.2	3.7.13 B.2	NA	ECCS Pump Room EACS	NA	3.7.10 C	NA	3.7.8.1	3.7.8	3.7.7 (CVAS)	NA	NA	NA
3.7.15 B.2	3.7.15 B.2	NA	Penetration Room EACS	NA	3.7.12 B	NA	NA	NA	3.7.7 (CVAS)	NA	NA	NA
3.8 Power Sources												
3.8.1 G.2	3.8.1 G.2	3.8.1 F.2	AC Sources-Operating	3.8.1.1	3.8.1.H	3.8.1.H	3.8.1.1	3.8.1.1	3.8.1.1	2.7	3.8.1.F	3.8.1.1.A.2

Table A-2
Technical Specification Numbering Cross-Reference

ISTS		SONGs TS #	Title	Current End State								
Analog	Digital			ANO	CC	Palo Verde	SL-1	SL-2	WSES	FCS	PAL	MP2
3.8.4 B.2	3.8.4 B.2	3.8.4 B.2	DC Sources-Operating	3.8.2.3	3.8.7.C	3.8.4.B	3.8.2.3	3.8.2.1	3.8.2.1	2.7	3.8.4.C	3.8.2.3 (DC Distr) 3.8.2.5 (DC Distr - Turbine Battery)
3.8.7 D.2	3.8.7 D.2	3.8.7 B.2	Inverters-Operating	NA	3.8.7.B	3.8.7	NA	NA	NA	2.7	3.8.7.B	NA

ATTACHMENT B
SUMMARY OF SONGS PRA QUALITY ASSESSMENT

The PRA study for SONGS fully satisfies the requirements of a full-scope PRA. One of the main objectives of the PRA development was to be able to utilize its results and insights toward the enhancement of plant safety through risk-informed applications. With this objective in mind the PRA elements were developed in detail and integrated in a manner sufficient to satisfy both the NRC Generic Letter 88-20 requirements and support future plant applications, such as the risk-informed application evaluated in this report.

The original SONGS 2 & 3 PRA models (Levels 1 and 2) developed for the Individual Plant Examination (IPE) in response to Generic Letter 88-20 were determined to be consistent with the scope, level of detail and quality outlined in NUREG/CR-2300. Since the submittal of the SONGS 2 & 3 IPE (Reference B1) and IPEEE (Reference B2), SONGS has continued to refine and improve the PRA to include external events (fire and seismic), recent design, maintenance, and operational changes, shutdown risk, and enhanced Common Cause Failure (CCF) and initiating event modeling. The CCF model enhancements utilize the recently updated industry CCF parameter estimations (Reference B3) reported in NUREG/CR-6268. The refined SONGS 2 & 3 PRA model used to support this submittal reflects the current as-built and operated plant and is consistent with the definition of a full-scope model described in RG 1.174. Further, the Safety Monitor, which is used to analyze and quantify the SONGS 2 & 3 models, includes average annual maintenance unavailabilities (average risk analysis) and historical plant unavailabilities (dynamic risk analysis) such that plant configuration-based risk modeling can be readily performed.

References

B1 Letter, Docket Nos. 50-361 & 50-362, Response to Generic Letter 88-20, Supplement 4, "Individual Plant Examination for Severe Accident Vulnerabilities, San Onofre Nuclear Generating Units 2 & 3," From W.C. March (SCE) to U.S. Nuclear Regulatory Commission, dated 4/29/93.

B2 Letter, Docket Nos. 50-361 & 50-362, Response to Generic Letter 88-20, Supplement 4, "Individual Plant Examination of External Events (IPEEE), San Onofre Nuclear Generating Units 2 & 3," From W.C. March (SCE) to U.S. Nuclear Regulatory Commission, dated 12/15/95.

B3 NUREG/CR-6268, "Common Cause Failure Database and Analysis System," developed by INEEL for NRC's Office of Analysis and Evaluation of Operational Data, June 1998.

ATTACHMENT C
SUMMARY COMPARISON OF CEOG COOLING WATER SYSTEMS DESIGNATIONS AND ASSOCIATED HEAT LOADS

Table C-1:
Comparison of Cooling Water Systems Designations

	CEOG PLANTS								
Cooling Water System	**ANO-2**	**CC**	**FCS**	**MP2**	**SL 1&2**	**PAL**	**PVNGS**	**SONGS**	**WSES**
Essential Chilled Water System							√	√ (ECW)	√ (ESCHWS)
Normal Chilled Water System							√		
Component Cooling Water System	√	√	√		√	√		√	√
Essential Cooling Water System							√		
Nuclear Cooling Water System							√		
Reactor Building Closed Cooling Water System				√					
Turbine Plant Cooling Water System			√	√ (TBCCWS)	√ (TCWS)		√ (TCWS)	√	√ (TCCWS)
Service Water System (SWS)	√	√		√		√			
Auxiliary Component Cooling Water System									√
Essential Spray Pond System							√		
Intake Cooling Water System					√				
Plant Cooling Water System							√		
Raw Water System			√						
Salt Water System (SAS)		√						√ (SWCS)	
Emergency Cooling Pond	√								
Essential Spray Pond							√		

Table C-2: Cooling Load Dependencies for CEOG Plants

CEOG Plant	Cooling Loads							
	EDGs	Safety-Related HVAC [Note 2]	RCPs/ PCPs	CTMT Fan Coolers	ECCS/CS Pumps	SDC Hx	CCW Hx	SWS Hx
ANO-2	SWS	SWS	CCW	SWS	SWS	SWS	SWS	
CC	SWS	SAS	CCW	SWS	CCW	CCW	SAS	SAS
FCS	[Note 1]	-	CCW	CCW	CCW	CCW	RWS	
MP2	SWS	SWS	RBCCW	RBCCW	RBCCW	RBCCW	SWS	
Palisades	SWS	SCS	CCW	SWS	CCW	CCW	SWS	
PVNGS	ESPS	ECWS	ECWS/ NCWS	NCHWS	ECHWS	ECWS	ESPS/ PCWS	
SONGS	[Note 1]	CCW	CCW	CCW	CCW	CCW	SWCS	
SL1	[Note 1]	[Note 1]	CCW	CCW	CCW	CCW	ICW	
SL2	[Note 1]	[Note 3]	CCW	CCW	CCW	CCW	ICW	
WSES	CCW	CCW	CCW	CCW	CCW	CCW	ACCW	

Notes:

1. System does not rely on the plant cooling water system (i.e. air cooled).
2. Heat from HVAC loads is rejected to the safety-related chilled water system. The safety-related chillers are cooled by the identified cooling water system. For ANO-2, heat from the HVAC loads is rejected directly to the Service Water System.
3. For St. Lucie Unit 2, only the Control Room Air Conditioning System uses CCW for cooling. There is no chilled water system at either St. Lucie plant.

<u>Acronyms:</u>

ACCWS	Auxiliary Component Cooling Water System
CCW	Component Cooling Water System
CS	Containment Spray
CTMT	Containment
ECCS	Emergency Core Cooling System
ECW	Emergency Chilled Water
ECWS	Essential Cooling Water System
ECHWS	Essential Chilled Water System
EDGs	Emergency Diesel Generators
ESPS	Essential Spray Pond System
ESCHWS	Essential Services Chilled Water System
Hx	Heat Exchanger
HVAC	Heating, Ventilation and Air Conditioning
ICWS	Intake Cooling Water System
NCWS	Nuclear Cooling Water System
NCHWS	Normal Chilled Water System
NSWS	Nuclear Service Water System
PCPs	Primary Coolant Pumps
PCWS	Plant Cooling Water System
RBCCWS	Reactor Building Closed Cooling Water System
RCPs	Reactor Coolant Pumps
RWS	Raw Water System
SDC	Shutdown Cooing
SAS	Saltwater System
SWCS	Saltwater Cooling System
TBCCWS	Turbine Building Closed Cooling Water System
TCWS	Turbine Cooling Water System
TCCWS	Turbine Closed Cooling Water System
SWS	Service Water System