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

May 1, 1992

Docket No. 52-002

APPLICANT: Combustion Engineering, Inc. (CE)

PROJECT: CE System 80+

SUBJECT: SUMMARY OF MEETING WITH CE REGARDING CE SYSTEM 80+ DESIGN CERTIFICATION (REACTOR COOLANT PUMP SEALS AND INTERSYSTEM LOSS OF COOLANT ACCIDENTS)

On March 19, 1992, a meeting was held between members of the Nuclear Regulatory Commission (NRC) staff and representatives of CE at the NRC office in Rockville, Maryland, regarding the integrity of the reactor coolant pump (RCP) seals upon loss of coolant and intersystem loss of coolant accident (ISLOCA) considerations. The list of attendees is provided as Enclosure 1. The presentation given by CE is provided as Enclosure 2.

In response to NRC questions, CE stated that there is test data for KSB seals with only component cooling water cooling and only seal injection. Tests were run until the seal temperature stabilized. NRC asked that these test results be submitted for staff review. CE also stated that the alternate ac source starts automatically on loss of off-site power (LOOP) and seal injection would be supplied within 10 minutes. They stated that the seal can operate without any cooling for at least 30 minutes. CE also stated that the controlled bleed-off line would have to be manually isolated in a fairly short time in the event of LOOP and failure of both diesel generators and failure of the alternate ac source. The staff asked when a no cooling test would be performed and when the results would be available. In this regard, the staff stated that the Byron-Jackson tests were not accepted by the NRC and noted that a Regulatory Guide is under development that will address acceptable test criteria. CE expressed the opinion that the NRC request for additional information indicating that a safety-grade back-up for seal cooling was not consistent with draft Regulatory Guide 1008.

NRC staff asked whether CE considered a steam turbine powered seal injection. CE replied that this was an option considered in development of the EPRI requirements document and it was not selected. NRC again raised the question about any charging pump dependency on component cooling water availability. CE must address any such interdependence between the two sources of seal cooling.

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ENCLOSURE 1

ATTENDEE LIST

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SYSTEM 80+
REACTOR COOLANT PUMP
SEAL DESIGN
&
PERFORMANCE

GSI-023

RCP SEAL FAILURES

CESSAR-DC POSITION (AMENDMENT F)

EXCESSIVE SEAL LEAKAGE IS PREVENTED FOR NORMAL OR OFF-NORMAL OPERATING CONDITIONS BY:

- USE OF PROVEN MULTI-STAGE SHAFT SEAL ARRANGEMENT
- REDUNDANT AND INDEPENDENT SEAL COOLING SYSTEMS (CCW & SI)
- ALTERNATE AC POWER SUPPLY TO CVCS CHARGING PUMPS TO PROVIDE SEAL INJECTION (SI) WATER FOR STATION BLACKOUT

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SYSTEM 80+
RCP SEAL DESCRIPTION CE-KSB

- SEAL SYSTEM CONSISTS OF THREE HYDRODYNAMIC SEAL STAGES ARRANGED IN SERIES
- EACH STAGE IS CAPABLE OF OPERATING AT FULL SYSTEM PRESSURE
- FIRST TWO STAGES BREAK DOWN APPROXIMATELY 84% OF SYSTEM PRESSURE (42% EACH)
- THIRD STAGE BREAKS DOWN REMAINING 16% OF SYSTEM PRESSURE AND ACTS AS A VAPOR SEAL

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CONTROLLED LEAKAGE

- ALSO CALLED CONTROLLED BLEEDOFF (CBO) FLOW
- CONTROLLED LEAKAGE COOLS AND LUBRICATES SEAL FACES
- CONTROLLED LEAKAGE FLOWS THROUGH THROTTLE SEAL COOLERS (TSC) MOUNTED PARALLEL TO EACH SEAL TO PROVIDE PRESSURE BREAKDOWN ACROSS EACH SEAL STAGE. TSC's ALSO PROVIDE SECONDARY SEAL COOLING
- CONTROLLED LEAKAGE NORMALLY 4.0 GPM AND COLLECTED IN VOLUME CONTROL TANK

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SEAL MATERIALS

ALL THREE SEAL STAGES USE SAME MATERIALS

- STATIONARY FACE - TUNGSTEN CARBIDE
- ROTATING FACE - CARBON GRAPHITE

SECONDARY STATIC SEALS (O-RINGS) - ACCOMMODATE AXIAL MOVEMENT OF ROTATING ASSEMBLIES

- O-RINGS - ETHYLENE PROPYLENE (EP)

SEAL COOLING

- o SEAL COOLING PROVIDED BY INDEPENDENT AND REDUNDANT COOLING SYSTEMS
  - SEAL INJECTION (SI) WATER (6.6 GPM EACH PUMP AT 120°F) INTRODUCED INTO SEAL COOLING CIRCUIT.
  - COMPONENT COOLING WATER (CCW) WHICH COOLS SEAL WATER BY HIGH PRESSURE SEAL COOLER (HPSC) AND THROTTLE SEAL COOLERS (TSC).
- o SEALS CAN OPERATE INDEFINITELY WITH:
  - LOSS OF SEAL INJECTION (SI) WATER WITH COMPONENT COOLING WATER AVAILABLE.
  - LOSS OF CCW WITH SI AVAILABLE.

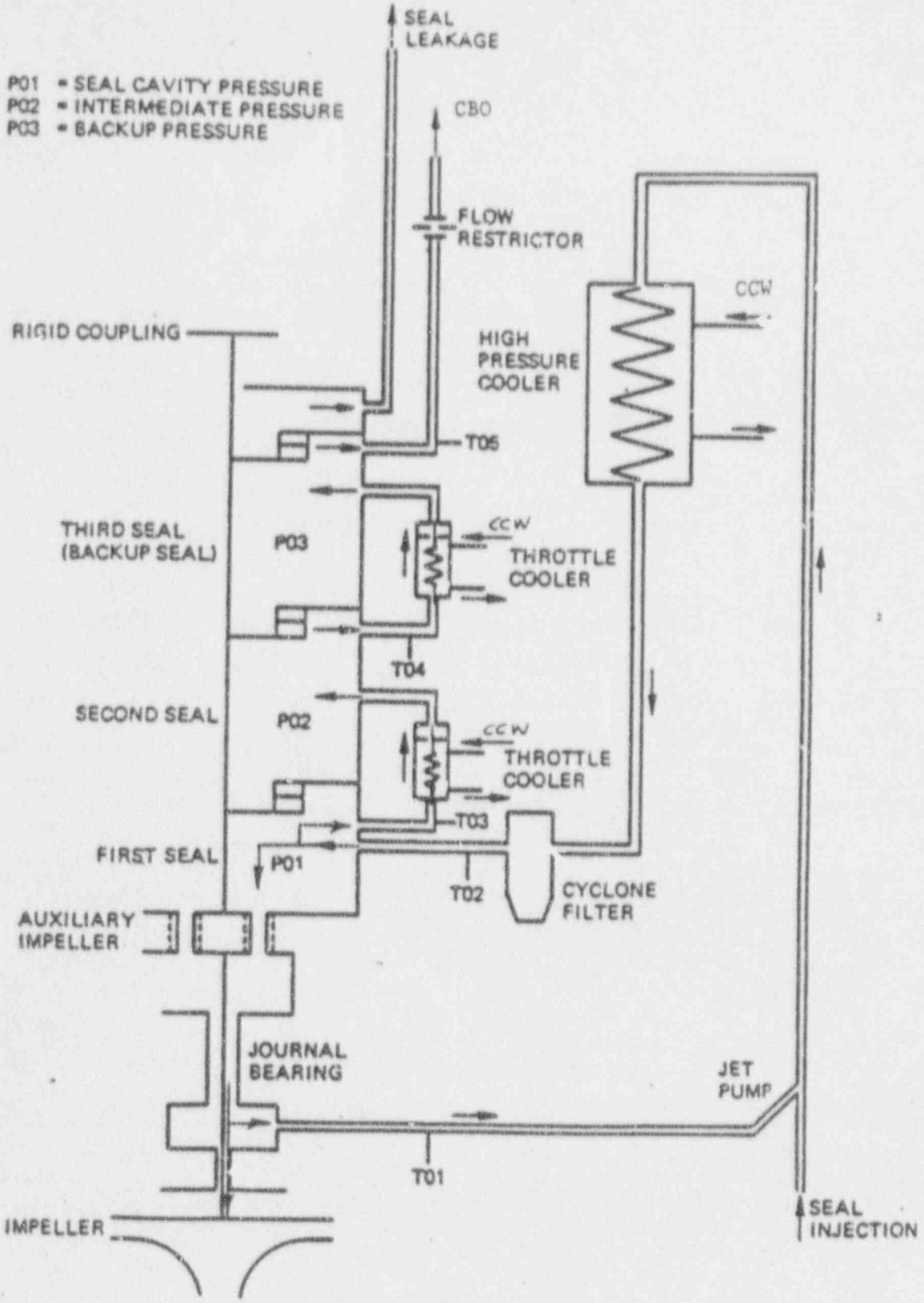

Figure 2 Flow Diagram for Hydrodynamic Shaft Seal System.
Normal Operation - with CCW & SI

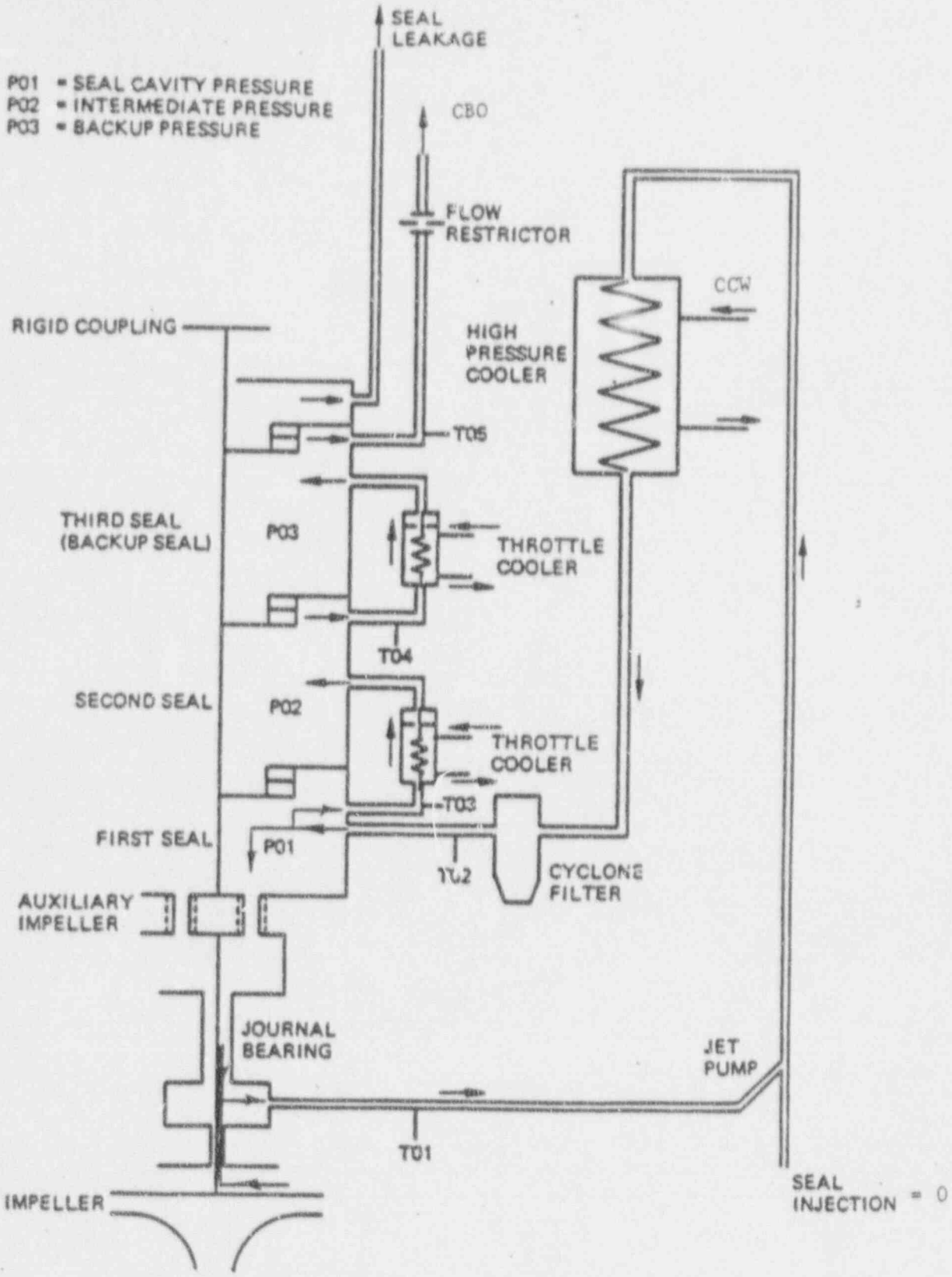

Figure 3 Flow Diagram for Hydrodynamic Shaft Seal System.
Operation without SI & with CCW

RCP SEAL INSTRUMENTATION

- CONTROLLED LEAKAGE (CBO) FLOW RATE MEASURED - ESTABLISHES SEAL MALFUNCTION IF CBO INCREASES BEYOND LIMITS

- SEAL CAVITY PRESSURES - SEAL NO. 2, SEAL NO. 3, CBO — ALLOWS OPERATOR TO ANTICIPATE SEAL PROBLEMS

- SEAL WATER TEMPERATURES - SEAL INJECTION IN, HPSC/IN, HPSC/OUT, SEAL NO. 2, SEAL NO. 3 — ALLOWS OPERATOR TO ANTICIPATE SEAL PROBLEMS

- DISPLAYED AND ALARMED IN CONTROL ROOM TO WARN OPERATOR OF POSSIBLE SEALS PROBLEMS.

- PUMP EQUIPPED WITH VIBRATION MONITORING SYSTEM TO WARN OPERATOR OF ANY EXCESSIVE VIBRATION WHICH COULD CAUSE SEAL PROBLEMS.

SEAL FAILURE DEFINITIONS

SEAL FUNCTION MAINTAINED

- ONE OR TWO OF FULL PRESSURE SEALS FAILS, VAPOR SEAL FUNCTIONS AND DIRECTS CONTROLLED LEAKAGE TO VCT
- IF ONE FULL PRESSURE SEAL FAILS CONTINUOUS OPERATION ALLOWED
- IF TWO FULL PRESSURE SEALS FAIL VAPOR SEAL HOLDS FULL SYSTEM PRESSURE WITH PUMP IDLE; ALLOWS OPERATOR TO PERFORM ORDERLY PLANT SHUTDOWN
- NO GROSS SEAL FAILURE-LEAKAGE DIRECTED TO VCT-VAPOR SEAL FUNCTIONS

SEAL FAILURE DEFINITIONS

COMPLETE LOSS OF SEAL FUNCTION (GROSS SEAL LEAKAGE)

PREREQUISITES:

- o FAILURE OF TWO FULL PRESSURE SEALS
- o FAILURE OF VAPOR SEAL (HAS NOT HAPPENED IN ABB/CE PLANT)
- o FAILURE - INABILITY OF SEAL TO HOLD PRESSURE

CONSEQUENCES:

- o LEAKAGE PAST VAPOR SEAL IN EXCESS OF 25 GPM CRITERIA OF RG 1.[illegible]5

RCP SEAL INJECTION/CVCS DESIGN (RAI 440.118)

SEAL INJECTION (SI) PROVIDED BY TWO INDEPENDENT & REDUNDANT CVCS DIVISIONS TO ASSURE RELIABILITY, REDUNANCY AND AVAILABLITY.

- CHARGING/SI PORTION OF CVCS ASME III - SAFETY CLASS 3 DESIGN
- TWO CENTRIFUGAL CHARGING PUMPS - SAFETY CLASS 3 DESIGN
- CHARGING PUMPS POWERED FROM NON-SAFETY RELATED BUSES
- EACH DIVISION CAN PROVIDE COMPLETE CHARGING FLOW RANGE (44-132 GPM)
- FOR STATION BLACKOUT (SBO) EVENT CHARGING PUMPS POWERED FROM ONSITE ALTERNATE AC (AAC) POWER SUPPLY.
- FOR SBO EVENT CONTINUED SEAL COOLING ASSURED BY SI AND AAC.
- CVCS/SI SYSTEM DESIGN MEETS DRAFT RG 1008 REQUIREMENTS FOR AN INDEPENDENT POWERED SYSTEM

RCP SEAL INTEGRITY ISSUES
(RAI 440.119)

GSI-23 SEAL FAILURES SCENARIO:

o MECHANICAL OR MAINTENANCE INDUCED FAILURES:

- OPERATING EXPERIENCE WITH RCP SEALS HAS IMPROVED SIGNIFICANTLY SINCE 1983.

- PER CEOG REPORT ONLY 23 FAILURES REPORTED FOR 59 RCP'S OVER 8 YEAR TIME SPAN IN CE PLANTS

- ONLY THREE OF THESE FAILURES INVOLVED LEAKAGE PAST LAST OR VAPOR SEAL. LEAKAGE WAS CONSIDERABLY BELOW 25 GPM CRITERIA OF RG 1.155

- SYSTEM 80+ SEALS ARE SAME AS PALO VERDE SEALS AND THERE HAVE BEEN NO UNPLANNED PLANT SHUTDOWNS DUE TO SEAL PERFORMANCE ALONE

- SEAL PERFORMANCE IS A RELIABILITY CONCERN AND NOT A SAFETY CONCERN

RCP SEAL INTEGRITY ISSUES (RAI 440.119)

GSI-23 SEAL FAILURE SCENARIO:

- o SEAL FAILURES RESULTING FROM LOSS OF SEAL COOLING
- o SYSTEM 80+ RCP SEALS HAVE INDEPENDENT & REDUNDANT SEAL COOLING TO WITHSTAND:
  - FOR LOSS OF ALL AC POWER (I.E., SBO), AAC POWER SUPPLIED TO CHARGING PUMPS WHICH FURNISH SI FOR SEAL COOLING. AAC POWER ALSO FURNISHED TO CCW SYSTEM PUMPS & SW SYSTEM PUMPS TO ENSURE CCW TO CHARGING PUMPS.
  - FOR LOSS OF NON-ESSENTIAL CCW TO RCP'S INDEPENDENT OF SBO, SI WATER IS USED TO COOL SEALS. ESSENTIAL CCW SUPPLIED TO CHARGING PUMPS. ESSENTIAL CCW SYSTEM IS SAFETY GRADE AND FULLY REDUNDANT.
  - LOSS OF SERVICE WATER (SW) IS NOT CREDIBLE SINCE TWO SW DIVISIONS ARE SAFETY GRADF & FULLY REDUNDANT.
  - FOR LOSS OF OFF-SITE POWER (LOOP), CHARGING PUMPS/SI ARE POWERED FOR AAC. CCW PUMPS ARE SIMULTANEOUSLY POWERED FROM EMERGENCY DIESEL GENERATORS.

RCP SEAL INTEGRITY ISSUES (CONT'D)

- CCW AND SI TO RCP'S IS NOT TERMINATED DUE TO A SIAS OR CIAS.

- FOR LOSS OF AIR, SEAL COOLING IS MAINTAINED BECAUSE:
  - THERE ARE NOT PNEUMATICALLY OPERATED VALVES IN THE CCW FLOW PATH
  - PNEUMATIC VALVE IN SI FLOW PATH FAIL OPEN

DRAFT REGULATORY GUIDE DG1008
(RAI 440.119)

SYSTEM 80+ POSITION ON DG1008 RESOLUTIONS:

- SYSTEM 80+ RCP SEALS ARE READY DESIGNED AND MANUFACTURED TO MEET 10CFR50 APPENDIX B QA PROGRAM REQUIREMENTS. IN ADDITION, SEALS ARE MANUFACTURED IN CLEAN ROOM ENVIRONMENT; ARE HYDROSTATICALLY PRESSURE TESTED AND OPERATIONALLY TESTED IN SEAL TEST RIG.

- SYSTEM 80+ DESIGN INCLUDES NECESSARY INSTRUMENTATION, INSTRUCTIONS AND OPERATING GUIDELINES TO DETECT INCIPIENT SEAL FAILURE AND PROTECT SEALS FOR NORMAL AND OFF-NORMAL PLANT CONDITIONS.

- SYSTEM 80+ DESIGN INCLUDES INDEPENDENT SEAL COOLING VIA AN ON-SITE AAC POWER SOURCE TO POWER THE CHARGING PUMPS WHICH PROVIDE SI TO COOL THE SEALS.

RCP SEAL OPERATING EXPERIENCE
(RAI 440.120)

SYSTEM 80+ SEAL INTEGRITY PROVEN BY OFF-NORMAL OPERATING EVENTS AT PALO VERDE:

- APRIL 1986 - UNIT NO. 2 RCP'S EXPERIENCED LOSS OF SI AND CCW FOR APPROXIMATELY 3 HOURS. COOLING RESTORED AND RCP'S OPERATED UNTIL JULY 1986 WHEN LEAKAGE FROM RCP 2B REACHED 2-3 GPM. UNIT SHUT DOWN FOR REFUELING AND SEALS REPLACED. TOTAL OPERATING TIME OF 14 MONTHS ON SEALS.

- JULY 1988 - UNIT NO. 1 RCP'S EXPERIENCED INTERMITTIN LOSS OF CCW AND SI FOR 8 HOURS. NO SEAL FAILURE OR LEAKAGE REPORTED.

- MARCH 1989 - UNIT NO. 3 RCP'S EXPERIENCED LOSS OF CCW AND SI FOR 90 MINUTES PRIOR TO REFUELING OUTAGE. AFTER RESTORATION OF SEAL COOLING PUMPS OPERATED AS PART OF PLANT COOLDOWN. RCP 1B LEAKAGE REACHED 1.25 GPM. NO LEAKAGE FROM OTHER PUMPS.

FOR ALL EVENTS LEAKAGE WAS LESS THAN 25 GPM CRITERIA.

RCP COOLER TUBE RUPTURE
(RAI 440.121 & 122)

- HIGH PRESSURE SEAL COOLER (HPSC) OR THROTTLE SEAL COOLER (TSC) TUBE RUPTURE ASSUMED
- OVERPRESSURIZATION OF CCW SYSTEM PREVENTED BY APPROPRIATELY SIZING CCWS HPSC RELIEF VALVE (THIS VALVE ALSO RELIEVES THE TSC CCW SYSTEM PIPING)
- HPSC RELIEF VALVE DISCHARGES INTO CONTAINMENT TO PREVENT RELEASE OF RADIOACTIVITY INTO ENVIRONMENT
- HPSC RELIEF VALVE DISCHARGES TO HOLD UP VOLUME WHICH SPILLS OVER TO IRWST. OPERATOR HAS SUFFICIENT VOLUME IN IRWST TO CONDUCT RCS COOLDOWN AND DEPRESSURIZATION
- LEAK INTO CCWS DUE TO A HPSC TUBE RUPTURE CAN BE DETECTED BY RADIATION DETECTORS IN CCWS OR BY A RISING CCWS SURGE TANK LEVEL
- LEAK CAN BE ISOLATED BY CLOSING THE HPSC TUBE SIDE ISOLATION VALVES OR THE CCWS ISOLATION VALVES

HPSC & TSC

DESIGN INTEGRITY
(RAI 440.123)

- HPSC AND TSC DESIGNED PER ASME SECTION III SUBSECTION NB (CLASS 1) FOR PRIMARY SIDE AND SUBSECTION ND (CLASS 3) FOR COOLING WATER SIDE

- INTEGRITY OF SEAL COOLERS ASSURED BY PERFORMING AN ASME SECTION III DESIGN STRESS ANALYSIS FOR DESIGN, NORMAL, UPSET, FAULTED, TEST AND TRANSIENT LOADING CONDITIONS

- TRANSIENTS INCLUDE LOSS AND RESTORATION OF CCW AND SI WITH PUMP OPERATING AND ON HOT STANDBY

- ANALYSIS PERFORMED TO DEMONSTRATE THAT SEAL COOLER TUBE BUNDLES ARE RIGID AND NOT SUBJECT TO CYCLIC FATIGUE DUE TO VIBRATION

SUMMARY

- SYSTEM 80+ RCP'S UTILIZE PROVEN MULTIPLE STAGE SEALS BASED ON PALO VERDE DESIGN AND EXPERIENCE
- SEALS ARE FURNISHED WITH REDUNDANT AND INDEPENDENT SEAL COOLING VIA SI AND CCW SYSTEMS
- FOR OFF-NORMAL CONDITIONS (I.E. SBO), AAC POWER IS SUPPLIED TO CHARGING PUMPS TO PROVIDE SI TO SEALS
- FOR HPSC OR TSC TUBE RUPTURE, CCW SYSTEM IS FURNISHED WITH RELIEF VALVES TO PREVENT OVER PRESSURIZATION OF CCWS
- RELIEF VALVES DISCHARGE INTO CONTAINMENT TO PREVENT RADIOACTIVE RELEASE INTO ENVIRONMENT

With regard to ISLOCA, CE stated that for the seal coolers a relief valve would be installed on the component cooling water lines inside containment that would discharge to the in-containment refueling water storage tank. NRC staff requested that the assumptions and results for sizing that relief valve be submitted. NRC staff asked that the equivalent leakage area pathway through the RCP seals and out a high pressure cooler tube break be compared to a steam generator tube break. For other ISLOCA locations, the NRC staff reviewed their guidance for CE's consideration in responding to the request for information that the staff had previously sent. The staff indicated that the existing response was not adequate.

(Original signed by J N. Wilson for)

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Enclosures:
1. List of attendees
2. CE presentation

DISTRIBUTION:

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