BALTIMORE
GAS AND
ELECTRIC

CHARLES CENTER · P. O. BOX 1475 · BALTIMORE, MARYLAND 21203

November 30, 1984

ARTHUR E. LUNDVALL, JR.
VICE PRESIDENT
SUPPLY

Director of Nuclear Reactor Regulation
Attention: Mr. J. R. Miller, Chief
Operating Reactors Branch #3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Calvert Cliffs Nuclear Power Plant
Units Nos. 1 & 2; Dockets Nos. 50-317 and 50-318
Reactor Coolant Pump Seal Integrity Following Loss of Offsite Power

Reference: NRC letter from Mr. D. G. Eisenhut to Mr. A. E. Lundvall, Jr. (BG&E), dated August 29, 1984.

Gentlemen:

In the referenced letter, the NRC Staff stated that Baltimore Gas and Electric Company's response to NUREG-0737 Item II.K.3.25 was deemed unacceptable. Your staff requested additional information which would show why our facility operating licenses should not be modified to require automatic initiation of reactor coolant pump (RCP) seal cooling upon loss-of-offsite power. The staff cited apparent inadequacies in our procedures for manual restoration of cooling to the RCP seals under loss-of-offsite power conditions. In addition, the staff asserted that the existing seal cooling design is not in conformance with General Design Criterion 44.

In accordance with 10 CFR 50.54(f), our response is enclosed for your information and use. We reviewed each of the staff's contentions in light of the safety significance of the seal cooling function and have concluded that General Design Criterion 44 is presently not and never has been applicable to the RCP seal cooling system at Calvert Cliffs. The seal cooling water supply is not required to assure seal integrity following a loss-of-offsite power. In addition, contrary to statements in your safety evaluation, we place no reliance on operator action to manually restore flow to the RCP seals following a loss-of-offsite power. Restoration of flow to the seals is a discretionary action that is employed only to support restarting the reactor coolant pumps following restoration of normal AC power. The reactor coolant pumps are only restarted to facilitate a more orderly plant cooldown via forced circulation of primary coolant (in lieu of natural circulation cooldown), and is not required to assure plant safety.

We also reviewed those events identified by the staff as involving RCP seal failures at other operating facilities and have concluded on the basis of available information that those events do not indicate the potential for seal failure at Calvert

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Cliffs from a loss of seal cooling water flow. This conclusion supports our independent determination that, under loss-of-offsite power conditions, a loss of seal cooling water flow alone will not cause seal failure.

In summary, Baltimore Gas and Electric Company believes that the Calvert Cliffs design as evaluated in the enclosure to this letter satisfies the requirements of NUREG-0737 Item II.K.3.25 and that, accordingly, our licenses need not be modified in order to assure compliance with any of the Commission's regulations.

If you should have any additional questions concerning this matter, please do not hesitate to contact us.

For your information and record-keeping purposes, approximately 190 professional man-hours (BG&E and contractor) were expended in the preparation of this response.

BALTIMORE GAS & ELECTRIC COMPANY

By: A. E. Lundvall, Jr.
Vice President - Supply

STATE OF MARYLAND :
TO WIT:
CITY OF BALTIMORE :

Arthur E. Lundvall, Jr., being duly sworn, states that he is Vice President of the Baltimore Gas and Electric Company, a Corporation of the State of Maryland; that he executed the foregoing for the purposes therein set forth; that the statements made therein are true and correct to the best of his knowledge, information, and belief; and that he was authorized to execute the same on behalf of said Corporation.

WITNESS My Hand and Notarial Seal: Minnie L. Robinson
Notary Public
My Commission expires July 1, 1986.

Enclosure

AEL/BSM/vf

cc: D. A. Brune, Esq.
G. F. Trowbridge, Esq.
Mr. D. H. Jaffe, NRC
Mr. T. Foley, NRC

ENCLOSURE

November 30, 1984

BG&E RESPONSE TO 8/29/84 NRC 50.54(f) LETTER ON RCP SEAL INTEGRITY FOLLOWING LOSS OF OFFSITE POWER

SUMMARY OF NRC POSITION

NUREG-0737 Item II.K.3.25 requires licensees to determine, on a plant specific basis, by analysis or experiment, the consequences of a loss of cooling water to the reactor coolant pump seals. The pump seals should be designed to withstand a complete loss of AC power for at least two hours. Adequacy of the seal design should be demonstrated.

The intent of this position is to prevent excessive loss of reactor coolant system inventory following a loss of AC power. Loss of AC power for this case is construed by the NRC to be a loss of offsite power. As a solution, the NRC has determined that supplying emergency power to the component cooling water pumps is an acceptable alternative to actually assessing the impacts of a loss of component cooling water to the RCP seals.

BG&E has responded to II.K.3.25 by stating that the component cooling water supply to the RCP seals is not required after a loss of offsite power because, under this condition, the reactor coolant pumps will not be running. BG&E indicated that seal cooling would only be restored under certain conditions following restoration of normal AC power where it was desirable to restart the reactor coolant pumps. The procedure for manual restoration of component cooling water flow in support of RCP restart was briefly described in BG&E's prior submittals.

Regarding BG&E's response, the NRC's only concern appears to be that sufficient information has not been provided to justify the acceptability of manual operator action to reinstate seal cooling. Inherent in the staff's specific concerns is the presumption that a loss of seal cooling will result in seal failure. To date the staff has not provided information that supports this position. The Staff's specific concerns are summarized below:

1. BG&E has not provided information to show that the operator has enough time to reinstate seal cooling after a loss-of-offsite power prior to seal failure;

2. BG&E did not describe the information that would alert the operators that seal cooling was lost;

3. BG&E did not describe the controls available to the operator to allow him to restore and verify cooling flow;

4. BG&E did not address other demands on the control room operator's attention following a loss of offsite power;

5. BG&E failed to address the impacts of potential operator errors; and

6. The RCP seal cooling system design, by reason of the absence of an emergency power supply, is not in conformance with General Design Criterion 44.

BG&E EVALUATION

1. Description of the Calvert Cliffs RCP Seal Design

The reactor coolant pumps used at Calvert Cliffs are Byron Jackson Type DFSS centrifugal pumps. These pumps utilize a hydrodynamic face seal design for the shaft seal. When the pump is in operation, sealing is accomplished by the rotating face rings running against the stationary faces. In the hydrodynamic mechanical seal, a combination of pressure unbalance and springs are used to keep the faces of the seal closed. The seal faces are in an almost rubbing contact with a very thin hydrodynamic fluid film generated by the rotation of the shaft. The configuration is shown in Attachment 1.

Attachment 2 depicts the configuration of the seal assembly in relation to the pump housing and shaft. A close-clearance thermal barrier assembly (pump cover) is mounted above the water-lubricated bearing to retard heat flow from the pump to the seal cavity. The thermal barrier would also serve as an additional barrier to reduce leakage from the pump, in the event of seal failure.

The shaft seal assembly located above the thermal barrier consists of four mechanical seals: three full-pressure face-type seals mounted in tandem, and a fourth low-pressure backup vapor seal on top of the seal assembly which is designed to withstand full operating system pressure with the pumps stopped. Although each of the three lower seals are designed for full system pressure, flow through the seal cavity is staged so that pressure is reduced by one-third across each seal face. The fourth seal is normally exposed to the pressure of the Volume Control Tank (approx. 60 psi). This seal configuration provides for extended seal life and multiple redundancy in the event of seal stage failures.

Each seal consists of a titanium carbide rotating face and a carbon stationary face. It is the carbide-to-carbon interface that forms the primary seal. Non-metallic "O"-rings and "U"-cups are used to provide a sliding secondary seal or wiping action between the rotating and stationary seal faces. They also serve to help maintain the desired pressure drop between seal stages. These non-metallic components are not required to assure performance of the primary seal function.

Controlled reactor coolant leakage across the seals provides seal lubrication while the pumps are operating. This controlled leakage flows through orifices mounted parallel to the seals to provide uniform pressure breakdown across each seal. Seal cooling is accomplished by transferring heat from the controlled leakage to the component cooling water (CCW) system via an integral heat exchanger. The heat exchanger is mounted above the thermal barrier and encloses the full circumference of the seal cavity. Circulation of controlled leakage through the integral heat exchanger is provided by a recirculating impeller which is part of the pump rotating assembly. After circulation through the integral heat exchanger, the controlled leakage is delivered to the seals prior to discharge from the seal assembly as controlled bleed-off flow. When the

reactor coolant pumps are tripped (as in a loss-of-offsite power) circulation of controlled leakage through the integral heat exchanger ceases as the pump shaft and associated recirculating impeller spin to a stop. However, controlled leakage flow is maintained across the seals of an idle pump as a result of the pressure drop across each seal stage.

2. Function and Importance of the RCP Seal Cooling System

The RCP seal cooling function at Calvert Cliffs is classified as non-safety related and is served by a portion of the component cooling water (CCW) system that is considered non-essential following all design basis events.

The primary purpose of the RCP seal cooling system is to remove heat from the seal faces while the reactor coolant pumps are operating. Upon a complete loss-of-offsite power and subsequent RCP trip, the temperature of the seals will begin to rise as the result of the loss of recirculation flow through the integral heat exchanger. Eventually, the temperature may exceed 250°F at which point the "O"-rings and "U"-cups will become brittle. If the temperature exceeds 250°F the pump manufacturer recommends that the seal assembly be disassembled and inspected and that these non-metallic components be replaced as necessary. However, operation of the pumps with degraded "O"-rings or "U"-cups is acceptable (although not preferable) since complete failure of these components only results in the loss of the secondary sealing function. The primary sealing function, established by four seals each of which is designed to withstand full reactor coolant system pressure and temperature, will be maintained.

In summary, the Calvert Cliffs RCP seal cooling system is not necessary to assure the integrity of the reactor coolant pressure boundary while the pumps are idle. Its purpose is to accommodate removal of heat generated during normal reactor coolant pump operation and to assure the integrity of non-metallic components installed to provide a secondary seal. Maintaining CCW flow to the reactor coolant pump seal assembly in the absence of recirculation flow only succeeds in removing heat from the metal structures immediately adjacent to the integral heat exchanger; it is not an effective means of removing heat from the seal faces.

3. Manual Restoration of Seal Cooling

Upon restoration of normal AC power, the control room operators may elect to restart the reactor coolant pumps to either assist in normal plant cooldown or to return to power operations. To support restart of the pumps, the operators are instructed to manually restore CCW flow to the seal assemblies in accordance with Abnormal Operating Procedure (AOP) 7C, "Loss of Component Cooling." AOP-7C stresses the importance of controlled restoration of CCW flow to the reactor coolant pump under any situation involving the loss of the CCW system, including a loss-of-offsite power. This procedure is designed to minimize thermal stresses in the RCP seal assembly as cooling is slowly restored to the integral heat exchanger. Instrumentation is provided in the control room to alert the operators of a loss of component cooling water flow and to allow the monitoring of seal temperature.

Since the restoration of CCW flow to the RCP seals is not necessary to assure the integrity of the reactor coolant pressure boundary, the NRC's

concerns regarding the efficacy of procedures for restoration of CCW flow are moot. As stated in the above arguments, these procedures are only employed to support restart of the reactor coolant pumps following a restoration of normal AC power. The applicable procedures and supporting instrumentation and controls may be viewed at Calvert Cliffs.

4. Evaluation of Seal Failures at Other Facilities

The NRC Staff stated that BG&E's original response only focused on seal failure data which supported acceptance of present operating designs and did not address data which conflict with a favorable conclusion. The Staff provided a list of eleven examples of seal failure events and stated, without any discussion of the details of the events or their potential applicability to Calvert Cliffs, that they did not support our conclusions.

We reviewed available information characterizing the nature of these events and found that none of them indicated the potential for failure of the Calvert Cliffs RCP seals due to a loss of offsite power.

Examples 1 and 3 pertained to alleged failures of seals at Davis-Besse. The leakage associated with these events never exceeded 3 or 4 gpm, so it could be debated whether these events were true seal failures. In any case, the seal system in these examples did not include the full-pressure-capable vapor seal incorporated into the Calvert Cliffs RCP seal design.

Example 2 cited by the NRC involved the failure of a Westinghouse seal at H. B. Robinson Unit 2. The plant staff was aware that an idle pump had a failed seal stage but, since leakage was low, elected to restart the pump and continue plant operations. Gross leakage only occurred after the pump was operated to the point of complete loss of the primary seal function.

Example 4 also involved a total seal failure caused by degradation of a single seal stage during pump operation. The pump was operated for over an hour before it became evident that seal failure was in progress. Excessive leakage would not have occurred if the pump had been shut down earlier in the event.

Examples 5, 6, 7, and 8 also involved instances of seal failures in operating reactor coolant pumps. They provide no evidence that an idle pump is susceptible to gross seal failure.

Examples 9 and 10 involved failures of Bingham seals at Oconee in 1974. Unlike the Byron Jackson seal, the Bingham seal design used at Oconee at that time had a problem with differential thermal expansion of the seal components which caused the seals to fail when they were overheated. This problem was subsequently corrected by Bingham.

Example 11 pertained to a seal failure at LaSalle Unit 1 (a boiling water reactor) which was caused not by a loss of seal cooling flow, but by the thermal stresses caused by an increase in cooling flow.

None of the examples discussed above involved a seal failure at a Combustion Engineering pressurized water reactor. Furthermore, none of the

examples indicated that a loss of seal cooling alone could result in a loss of the primary seal function at a Combustion Engineering plant. Consequently, none of the examples cited by the NRC provides a sound technical basis for automation of the Calvert Cliffs seal cooling supply. In particular, there is no apparent operational evidence that a loss of RCP seal cooling alone to an idle pump can directly violate the reactor coolant pressure boundary integrity.

5. Conclusions

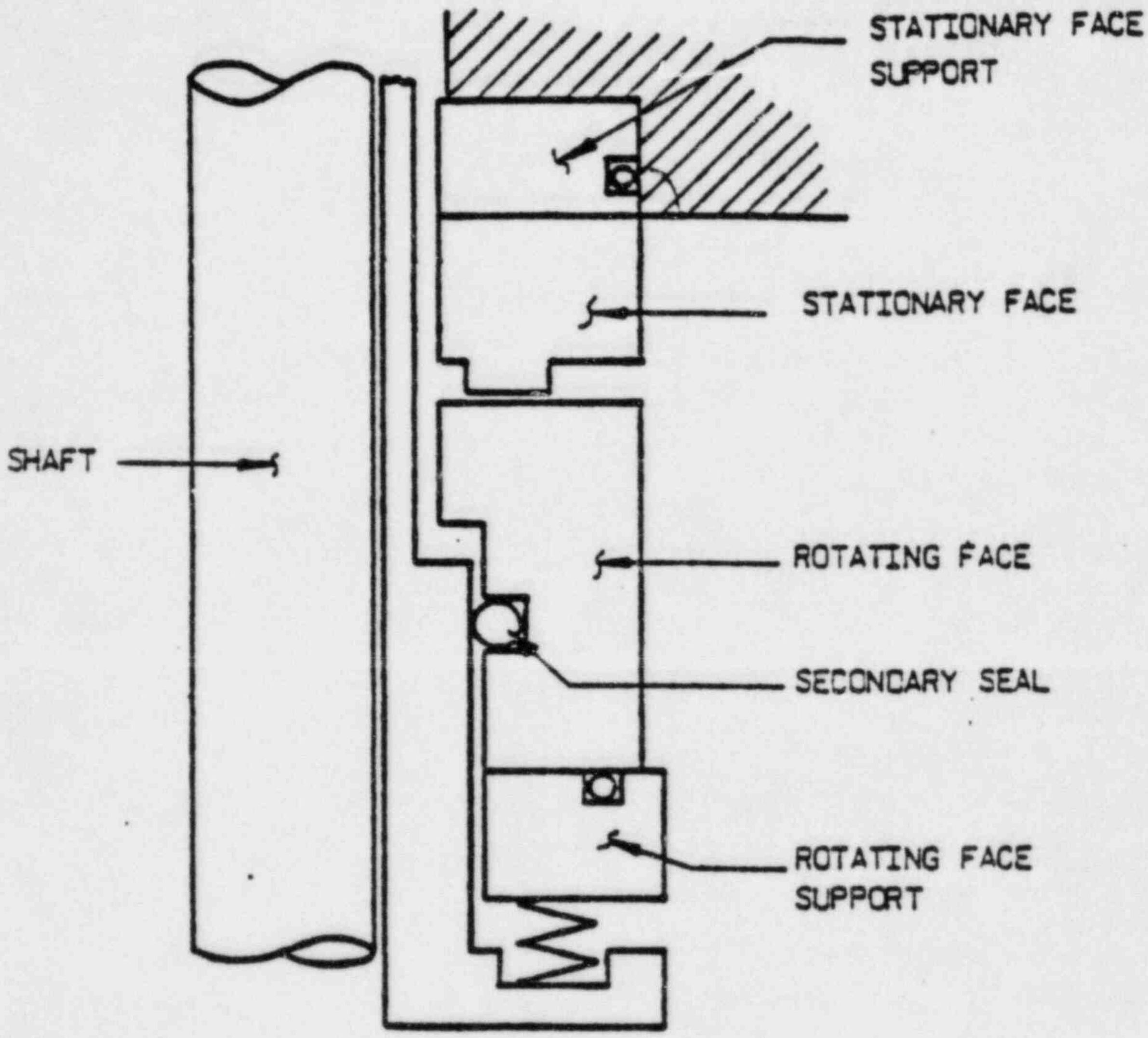
Based on the above evaluation, BG&E concludes that the post-TMI requirement (II.K.3.25) to assess the capability of the RCP seals to withstand a loss of cooling for two hours has been satisfied. Because the seal cooling system does not serve an effective or necessary heat removal function for an idle pump, seal failure will not occur as the result of a loss of offsite power, and GDC-44 is therefore not applicable to the seal cooling supply.

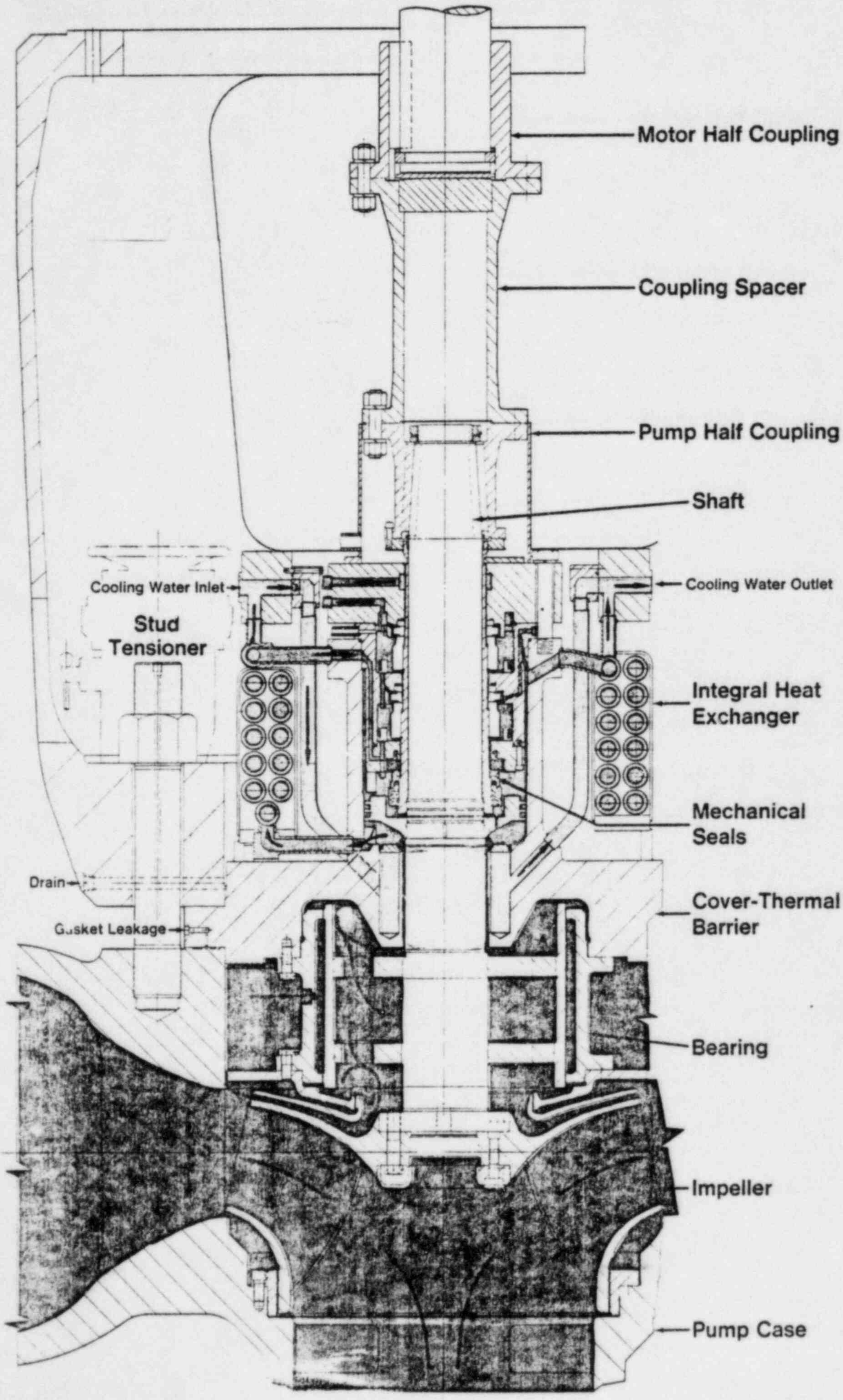
This overall conclusion is supported by statements contained in Section 4.2.2.5, "Component Cooling Water System Analysis," of NUREG/CR-3511[1].

(1) NUREG/CR-3511, "Interim Reliability Evaluation Program: Analysis of the Calvert Cliffs Unit 1 Nuclear Power Plant," Volume 1, March 1984.

ATTACHMENT 1

HYDRODYNAMIC SEAL





Motor Half Coupling
Coupling Spacer
Pump Half Coupling
Shaft
Cooling Water Inlet
Cooling Water Outlet
Stud Tensioner
Integral Heat Exchanger
Mechanical Seals
Drain
Gasket Leakage
Cover-Thermal Barrier
Bearing
Impeller
Pump Case