ENCLOSURE B

GE Nuclear Energy

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SAFETY EVALUATION

DRESDEN NUCLEAR POWER STATION

RECIRCULATION PUMP

COOLING SYSTEM LEAKAGE ALTERATION

(TWO LOOP OPERATION)

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I. INTRODUCTION

Design alterations will be performed on the Dresden 3, B-loop, Recirculation Pump Cooling System in order to capture primary system leakage that has been detected in the Reactor Building Closed Cooling Water (RBCCW) system. Leakage is apparently occurring through a flow pathway that has developed within the pump seal inner cooler which has allowed reactor coolant to enter the RBCCW passages within the pump cover. These alterations will capture the primary system leakage and carry it to an identified leakage sump where it will be monitored in accordance with the existing plant Technical Specifications.

II. RECIRC PUMP COOLING SYSTEM ALTERATIONS

The recirculation pumps have two RBCCW cooling water circuits. One, to the tube-in-shell heat exchanger, will remain unchanged. The second, in the internal drilled hole heat exchanger, which is presumed to have a leak between the reactor side and the RBCCW side will be isolated at the RBCCW inlet and the outlet vented to the identified leakage sump. Routing to the identified leakage sump will enable measurement of leakage, allowing operator action if leakage increases and approaches current Tech Spec limits.

The following basic alterations will be performed on the B-loop Recirculation Pump Cooling System:

1) Isolate the inlet cooling water line to the pump,
2) Pipe (vent) the cooling water exit line to a manifold where it will be piped to the identified leakage sump,
3) Install two pressure sensors in the vent line to monitor water jacket pressure, and,
4) Install two temperature sensors on the vent line to monitor effluent temperature.

The outcome of these alterations is that the pump drilled hole heat exchanger will no longer receive RBCCW (a situation already analyzed and approved by the pump manufacturer, Byron Jackson, see Reference 1 of Attachment 1) and that any leakage into the water jacket of the drilled hole heat exchanger cavity will now be directed to an identified leakage sump where the leakage rate will be monitored in accordance with the existing plant Technical Specifications and processed in accordance with the present plant practices and procedures. New pressure and temperature sensors will add diverse and redundant means of detecting degradation with respect to pump leakage flow rate information already afforded by the identified leakage sump instrumentation. Administrative controls will be established and put in place for reactor operation with this enhanced instrumentation feature.

III. SAFETY EVALUATION - TWO LOOP OPERATION

For this safety evaluation, the criteria of 10CFR50.59 are applied to the alterations being made to the Recirculation Pump Cooling System.

The predominant issues relevant to the safety evaluation of this plant alteration are presented in Attachment 1 to this report. These issues are:

-The Possibility of Leakage Increases,
-The Maximum possible leakage from the pump cover,
-The Consequences of Gross Seal Failure, and
-The Potential for Shaft Failure

Conclusions regarding these issues are summarized as appropriate to the following safety considerations in accordance with 10CFR50.59.

1) The alterations to the recirculation pump drilled hole heat exchanger will not increase the probability of occurrence of an accident previously evaluated in the SAR. This plant alteration will permit plant operation with a leak path between the primary coolant and the drilled hole heat exchanger RBCCW flow path. Leakage will be collected and controlled in accordance with the already established plant Technical Specifications. While there is a finite potential for increasing leak rate over time, such an increase would be expected to occur in a matter of days or longer based on the geometry of the cover and the material of which it is constructed. As long as the leakage is monitored with a frequency as cited in Attachment 1, there will be sufficient time to take corrective action. Enhanced instrumentation (addition of pressure and temperature sensors) provides information to advise plant operators should further leakage increases require operator action. Administrative controls will be developed and put in place for reactor operation for this enhanced instrumentation feature. With these precautions, it is concluded that the likelihood of an accident as previously evaluated in the SAR is not increased. The maximum postulated leakage is limited by the physical dimensions of the cooling water channels to a small break area ($0.01ft^2$). Such breaks have been analyzed in Safety Analysis Report (SAR) Section 5.2.3 (Challenges to Containment), Section 6.2.7 (Challenges to 10CFR50.46 and Appendix K), and Chapter 14 with respect to 10CFR100 radiological releases. These alterations have no known correlation to the severity of cracking in the shaft; however, should the shaft fail, that event is bounded by the Recirculation Pump Seizure event discussed in SAR section 4.3.3.4.3.

2) The alterations will not increase the consequences of an accident previously evaluated in the SAR. The recirculation pump drilled hole heat exchanger alteration will not degrade or prevent any of the operational characteristics which were assumed in the SAR analyses. The results discussed in SAR sections 5.2.3, 6.2.7, and Chapter 14 in all cases bound by large margins the worst case degradation scenario discussed in Attachment 1 that could be sustained by the altered system.

3) The alterations will not increase the probability of occurrence of a malfunction of equipment evaluated in the SAR. The pump manufacturer, Byron Jackson, has analyzed sustained operation with no drilled hole heat exchanger RBCCW flow and predicted no degradation in pump operation or performance. GE has reviewed the recirc pump drilled hole heat exchanger alteration and the relevant engineering and safety considerations and concluded that the alteration will not increase the probability of occurrence of a malfunction of equipment evaluated in the SAR.

4) The alterations will not increase the consequences of a malfunction of equipment previously evaluated in the SAR. The generic design, configuration, and modes of operation of the recirculation pump will not be altered. Therefore, as discussed in Attachment 1, no new malfunctions are postulated to occur.

5) The alterations to the recirculation pump cooling water system will not create the possibility of an accident or malfunction of a different type than previously evaluated in the SAR. Neither water jacket over pressure nor any other pump failure up to and including complete pump shaft failure will cause an event which is different than those analyzed in SAR sections 4.3.3.4.3, 5.2.3, 6.2.7, or Chapter 14.

6) The alterations will not reduce the margin of safety as defined in the basis for any Technical Specification. The margin of safety as defined in the bases for the Dresden Unit 3 Technical Specifications is unchanged by this alteration to the recirculation pump because no safety functions are being altered. No change to Dresden Technical Specification 3/4.6.D is required as a result of the alterations and no other Technical Specification changes appear to be necessary.

IV. CONCLUSION

The alterations to the recirculation pump drilled hole heat exchanger were evaluated against the Technical Specification requirements and the Safety Analysis Report. The plant will continue to be operated within the requirements of the existing Technical Specifications. The worst case degradation postulated to occur to the altered recirculation pump drilled hole heat exchanger is well within the already analyzed envelope for the plant as presented in the Safety Analysis Report, and does not involve an unreviewed safety question.

ATTACHMENT 1

OPERATION OF DRESDEN 3 RECIRCULATION PUMP WITH A LEAK IN THE COVER HEAT EXCHANGER

1. DESCRIPTION OF COOLANT FLOW PASSAGES WITHIN THE RECIRCULATION PUMPS

The Dresden 3 recirculation pumps are shown pictorially in Figure 1. There are three coolant flows used to maintain the seal cavity at temperatures within the seal design limits:

- o A Reactor Building Closed Cooling Water (RBCCW) flow of approximately 35 GPM flows through the shell side of the external tube-in-shell heat exchanger. Reactor coolant is pumped through the tube side by the auxilliary circulation impeller within the pump.

- o A RBCCW flow of approximately 12 GPM flows into the water jacket and through drilled hole passages within the pump cover. The inlet and outlet connections and the flow passages within the pump for this flow path are entirely separate from the external heat exchanger.

- o Seal purge is injected into the pump from the CRD hydraulic system to maintain seal cleanliness and also contribute to seal cooling.

The design pressure of the RBCCW coolant paths within the pump is 150 psig.

2. LEAKAGE FROM THE "B" RECIRCULATION PUMP

On February 12, 1990 a rise was noted in the level of the RBCCW surge tank. Because the recirculation pump heat exchangers are a source of reactor water in-leakage to RBCCW inside the drywell, a heat exchanger leak was suspect.

Prior work by GE had indicated the possibility of thermal cracking of the inside bore of the pump cover with resulting in-leakage to the RBCCW. This work is described in SIL 459.

With this information it was concluded that the most likely source of in-leakage of reactor water was from the drilled hole heat exchanger and not the tube and shell heat exchanger. Therefore, leak check measurements were made on the drilled hole heat exchangers on both pumps. This was accomplished by disconnecting both the inlet and outlet connections to RBCCW on both pumps such that the piping from the drilled hole heat exchanger(s) was open to the atmosphere. Then the Recirc pumps were internally pressurized by isolating the pumps via the maintenance valves on the suction and discharge of the pumps and pressurizing the bowl with seal purge from the CRD system.

Upon pressurization of the pumps over several hours it was noted that a leakage flow was coming out of the RBCCW outlet connection on the "B" recirc pump. The "A" pump showed no leakage.

Because the RBCCW system is designed to low pressure, on the order of 150 psi (as noted in SIL 459), the reactor coolant water in-leakage has a tendency to do two things; one is to contaminate RBCCW with reactor coolant and the second is to pressurize the low pressure system. Both of these conditions are unacceptable; therefore, an alteration was incorporated to enable continued pump operation with the small leak as described below.

Although cracking had been observed in other recirculation pump covers in ISI inspections at other plants, the above is the first known instance in any BWR of penetration through the pressure boundary between the reactor coolant and the RBCCW flow passages.

3. REQUIREMENTS OF PIPING SYSTEM TO VENT LEAKAGE FLOW

The following system alterations are to be used to prevent a continuous leakage of radioactive primary coolant into the RBCCW.

The RBCCW piping to the drilled hole heat exchanger would be isolated at the inlet to the pump and cut at the outlet connections which lead from the drilled hole heat exchanger passages. The RBCCW side would be isolated.

Vent piping begins at the pump RBCCW outlet connection which leads from the drilled hole heat exchanger passages and ends at the drywell equipment sump for identified leakage.

The Plant Technical Specifications limit total drywell leakage to 25 GPM of which 5 GPM can be unidentified. The identified leakage from the pump (including drilled hole heat exchanger leakage) will, when added to other leakage, be limited to 25 gpm per the Technical Specifications.

Pressure switches and temperature elements will be installed on the piping from the pump outlet connection with a pressure set point less than 150 psig (taking into account the pressure drop between the pressure switch and the water jacket) to identify increasing pressure in the water jacket and to monitor temperature continuously to give an early indication of an increase in leakage. Administrative controls will be developed and put in place for reactor operation for this enhanced instrumentation feature.

The total leakage rate into the sump for identified leakage will be monitored at intervals not to exceed four hours.

If the pressure set point at the pump connection is reached or if the pump leakage rate approaches the Technical Specification limit the pump would have to be depressurized or isolated.

4 CONTINUED PUMP OPERATION WITH THE LEAKAGE VENTED

Anticipating that in-leakage to the drilled holes could happen, reference 1 was prepared in September, 1989 by the pump manufacturer, Byron Jackson for the BWR Owners Group.

Reference 1 demonstrates by thermal, stress and fatigue analyses, the code capability and operability of the pump to operate without cooling flow through the drilled hole passages, but with normal flow to the external tube and shell heat exchanger. These analyses demonstrate acceptable pump operation with the leakage flow from the drilled hole passages vented, and that adequate seal cooling would be accomplished by the external heat exchanger and normal seal purge flow. The results of this work show that, purely from a pump point of view, it would be acceptable to run the pump with the drilled hole heat exchanger leaking with that leak vented to the atmosphere.

In that the structural integrity of the pump is not in question, running with a leak, the issue, becomes one of how does this finding fit in with the reactor system. It is a fact that, if a small leak of the magnitude discussed above, were to occur somewhere else in the system (inside the drywell) it would be accomodated under current Tech Specs as unidentified leakage. Consistent with Technical Specifications, plant operation could continue with unidentified leakage up to 5 gpm. On the other hand if this leakage were categorized as identified leakage and sent to the identified leakage sump, the reactor could continue to operate under current Tech Specs with total leakage up to 25 gpm. Such identified leakage could be considered to be leakage piped off from a valve bonnet, packing, gasket or pump shaft seal where the gross structural integrity of the pressure boundary is not at issue but only the leak tightness. So it is the objective of the drilled hole heat exchanger alteration to categorize the leakage from the drilled hole heat exchanger in the same manner. That is, that the structural integrity of the pump cover is not in question; it has been verified by structural analysis. But there is a leak, and even though that leak is through a portion of the pressure boundary material, it is not one that is important to the overall pressure integrity of the pump cover. Therefore the leakage will be treated as though it were leakage from a valve bonnet, packing, gasket, or pump shaft seal piped to the identified leakage sump along with other identified leakage, and such leakage will be monitored consistent with current Technical Specifications. That is, total leakage cannot exceed 25 gpm. Under these conditions, there is no difference between operating with this leak and any other identified leak.

If the size of the leak increases, then the unit will continue to be operated under Technical Specifications. If Technical Specification limits can not be met, the unit will be placed in cold shutdown within 24 hours.

5. OPERATIONAL CONSIDERATIONS -- FAILURE MODES AND EFFECTS ANALYSIS

5.1 Possibility of Leakage Increases

As described above a mode of operation can be established with an initial leakage flow to the sump.

Further deterioration of the pump based upon the same mechanism which caused the leak could cause an increase in leakage flow with time. For example it has been observed at other pumps inspected after service that multiple axial cracks exist on the inside surface of the cover bore. This type of cracking could become enlarged, or additional cracks could propagate to the depth needed to reach the RBCCW flow passages. Flow through the crack could cause an increase in leakage flow, for example by erosion, tunneling or "wire drawing".

The flow rate of the flashing steam might not be stable and might result in flow fluctuations of unknown severity. It would be necessary to monitor initial performance as well as trend later performance to determine whether any unexpected flow conditions developed.

Leak rates from cracks are dependent on stress and crack length. Once leakage starts, the leak rate is expected to increase with time mainly due to increase in crack opening due to steam cutting and/or crack extension. Analytical models show that the crack length for a 5 GPM leak in typical piping is approximately 8-9 inches. Field data support the analytical prediction. The leakage rate is typically, to a first order of approximation, proportional to the square of the crack length. For example, for a 0.5 GPM leak the corresponding crack length is approximately 2-3 inches. While there is a finite potential for increasing leak rate over time, such an increase would be expected to occur in a matter of days or longer. Therefore as long as leak rate is monitored with a frequency as cited above, there will be sufficient time to take corrective action.

5.2 Maximum possible leakage from the pump cover

In order to determine the worst case leakage from the cover assuming operation as described above with the drilled hole passages vented it is necessary to consider the details of the RBCCW flow passages within the pump.

There are fifteen vertical drilled holes of 1 1/2 inch diameter. The inlet and outlet to the drilled hole passages consist of two 1 1/8 inch diameter holes, one at the inlet and one at the outlet. These 1 1/8 inch holes lead to the water jacket which is formed of plate welded to the outside of the pump cover casting. The pressure rating of the water jacket is 150 psig. The drilled 1 1/2 inch diameter holes, the slanting 1 1/8 inch diameter inlet and exit holes and the water jacket can be seen in Figure 1.

The construction of the cover casting results in a ligament thickness of approximately 0.30 inches between the vertical drilled holes and the cover bore, however the minimum ligament thickness only occurs at the points of tangency. The geometry would allow axial cracking as has been observed in some pump inspections but does not favor fragmentation.

Nevertheless, if it were assumed as a worst case assumption that the inner portion of the pump bore near the drilled holes became severely deteriorated so that the only resistance to flow was the two 1 1/8 inch diameter inlet and outlet holes, which are approximately 4 inches long, the magnitude of the worst case flow, which would be critical flow flashing into steam has been calculated to be 1400 GPM. The portion of the cover inboard of the drilled holes is not relied upon in determining the overall structural capability of the cover and such a postulated deterioration is not a threat to overall pressure retaining capability.

The above flow exiting a 1 1/8 inch drilled hole would be discharged directly into the water jacket and as a consequence would overpressurize the water jacket which is designed to 150 psig. Failure of the water jacket would allow the above leakage flow to enter the drywell directly.

5.3 Consequences of Gross Seal Failure

If the amount of reactor coolant entering the pump seal cavity overheats the seals the elastomers may lose their resillience and start to leak. The maximum calculated leak rate through a severely degraded seal has been calculated to be 55 GPM and operation as described above will not affect this maximum value.

5.4 Potential for Shaft Failure

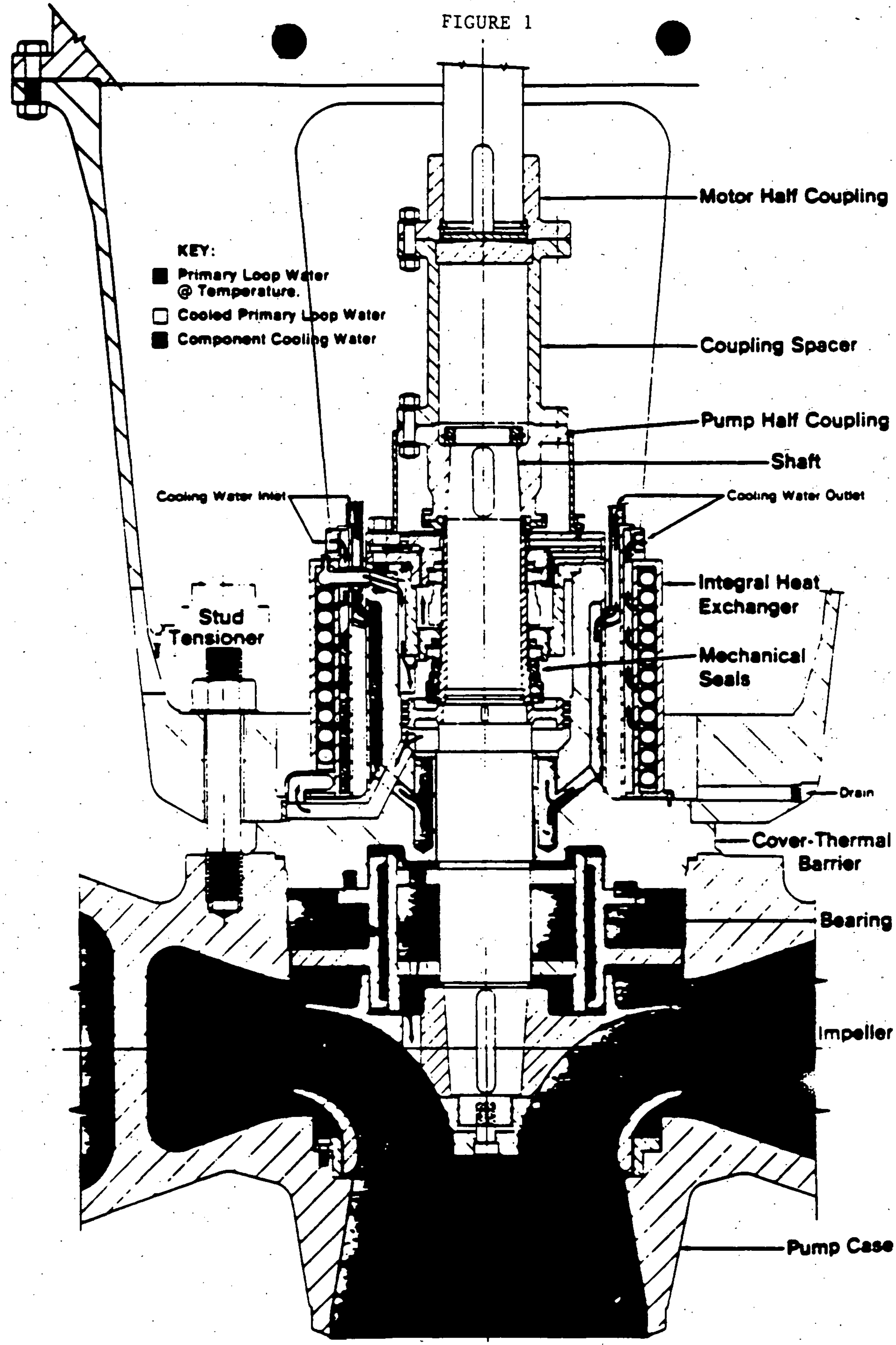
In pumps inspected at other plants, shaft cracking as well as cover bore cracking has been observed, both believed to be caused by the same thermal cycling mechanism. It is likely that thermal cracking of the Dresden 3 pump shaft has occurred. Observations of shaft cracking are reported in SIL 459 and RICSILs 028,029 and 043.

The crack initiation mechanism for the shaft as for the cover is believed to be high cycle thermal mixing of seal purge flow with reactor coolant. The high cycle thermal stresses could be a sufficient cause for the depth of cracking from the cover bore to the heat exchanger drilled holes. However, BWR Owners Group investigations lead to the conclusion that high cycle thermal stresses alone could not propagate cracks to the critical crack depth which would result in shaft failure, i.e., that severe cracking of shafts would require high occasional mechanical loads or a slow acting thermal stress. Therefore, the incidence of through wall cracking of the cover is not indicative that the shaft has had the type of loadings sufficient to propagate cracks to a depth that would lead to failure.

A completely failed or severed shaft is not considered to be a safety concern. This is because the shaft is not a safety component and the amount of consequential damage internal to the pump associated with shaft failures have not damaged pressure boundary components.

Reference 1. Shutdown of Cooling Water to Cover Holes in General Electric BWR 3/4/5 Recirculation Pumps, BW/IP International, Byron Jackson Products, SR-0651, Rev. B, 18 September 1989

FIGURE 1



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