VIRGINIA ELECTRIC AND POWER COMPANY
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United States Nuclear Regulatory Commission
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Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
SURRY POWER STATION UNITS 1 AND 2
COMPONENT COOLING WATER SYSTEM DESIGN
THERMAL BARRIER LEAKAGE CONSIDERATIONS
EVALUATION SUMMARY

As discussed in our May 22, 1989, management meeting, the Component Cooling Water (CCW) system design has been recently evaluated regarding isolation capability of the system in the event of a leak in the Reactor Coolant Pump thermal barrier. We conclude that provision for system isolation is addressed within the existing licensing design basis, although system enhancements will be made to upgrade portions of the system to the more demanding criteria of current design practice. Specifically, upstream of the thermal barrier two safety-related check valves will replace the one existing check valve, a safety-related relief valve will replace the existing relief valve, and associated piping modifications will use 1500 lb class safety-related materials. These enhancements will be made prior to startup. Additional enhancements are being considered for the portion of this system downstream of the thermal barrier, including possible replacement of the existing downstream trip valve with redundant safety-related trip valves or an upgrade of the existing downstream system to safety-related. Due to the engineering and procurement lead times, this effort and any associated modifications will be completed during the next refueling outages. We will inform you after our engineering study is complete as to the specific details of these enhancements.

In the broader context of CCW design review, we note that this system is scheduled for assessment as part of our design base documentation/configuration management effort during the first half of 1990. Any other related issues affecting the existing licensing design base of the CCW system will be addressed as part of this effort.

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The CCW system design evaluation summary regarding RCP thermal barrier leakage considerations and a safety evaluation of the proposed modifications are attached for your information. Should you have any questions regarding this evaluation, please do not hesitate to contact us.

Very truly yours,

W. L. Stewart
Senior Vice President - Power

Enclosure

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ENCLOSURE TO SERIAL NUMBER 89-406

SURRY UNITS 1 AND 2 EVALUATION SUMMARY
ISOLATION OF THE COMPONENT COOLING WATER SYSTEM
REACTOR COOLANT PUMP THERMAL BARRIER LEAK

INTRODUCTION

A concern involving the design of the Component Cooling Water (CCW) system was identified involving the ability of the system as presently designed to be adequately isolated in the event of a leak in the Reactor Coolant Pump (RCP) thermal barrier. A failure of the CCW system design to isolate this thermal barrier leak would potentially introduce reactor coolant into the CCW system and could expose portions of this system to pressures and temperatures above their design ratings.

As a result of this concern, Westinghouse was contacted to provide additional information concerning the failure mode of the RCP thermal barrier and the design basis leakage flow which could be expected. Their preliminary responses indicated a leakage flow that was significantly greater than the system's relief valve capacity and based on this information, a station deviation was filed concerning the potential for overpressurization of the CCW system.

This design concern has been investigated and certain actions have been identified to provide additional assurance of the integrity of the CCW system in the event of an RCP thermal barrier failure.

SYSTEM DESIGN

The Component Cooling Water (CCW) system is a low pressure, low temperature system providing cooling water to a large number of heat exchangers inside containment, in the auxiliary building and in other areas of the plant. There are two main headers for each unit and these headers supply a number of smaller headers both inside and outside containment. The nominal pressure rating for the CCW system is 150 lb. class and the maximum operating temperature range is typically from 120°F to 150°F. Portions of this nonsafety-related system are designed to seismic criteria and some components are considered safety-related.

The configuration of the CCW system piping supplying the RCP thermal barrier is shown in Attachment 1. The piping from the inlet of the first manual isolation valve upstream of the RCP thermal barrier to the outlet of the first manual isolation valve downstream of the thermal barrier is schedule 160 carbon steel and the valves within this boundary are 1500 lb. class. This portion of the CCW system is capable of withstanding full RCS temperatures and pressures.

The system is designed to automatically isolate the 1500 lb. class portion of the CCW system in the event of high flow. A flow rate of 50 gpm (10 gpm over the normal 40 gpm flow) through the downstream flow element, (FT-107/207), would cause high flow trip valve (TV-120/220) to close. With the concurrent closure of the upstream 1500 lb. class check valve this would result in the isolation of the RCP thermal barrier. Additional overpressure protection is provided by a relief valve, (RV-150/250), downstream of TV-120/220 in the common CCW return line for the three RCP thermal barriers. This relief valve is inside containment and has a set pressure of 150 psi and a flow capability of 167 gpm. RV-150/250 protects the 150 lb. class containment isolation valve (TV-107/207) from overpressurization.

The concerns, which are beyond the original licensing design basis, are as follows:

- The 1500 lb. class portion of the CCW system is not analyzed to the more demanding current seismic design criteria although it has been evaluated and determined that it would retain its integrity during a seismic event.

- The 1500 lb. class portion of the CCW system is not safety-related.

- The failure mode of TV-120/220 is fail-open.

- The flow capacity of RV-150/250 could be less than the leak rate of the thermal barrier under postulated worst-case conditions.

These concerns are addressed by examining the nature of a RCP thermal barrier leak and then evaluating the ability of the current design to detect and isolate this leak.

RCP THERMAL BARRIER LEAK

The RCPs at Surry are equipped with internal heat exchangers (thermal barriers) used to cool reactor coolant entering the RCP seals in the event of a loss of normal seal injection. The thermal barrier prevents the overheating of the RCP seals and their subsequent failure with the consequential loss of reactor coolant through the seals.

The thermal barrier components are conservatively designed to withstand differential pressures of 2500 psi in accordance with ASME code allowable stresses. The thermal barrier was also designed, fabricated and tested in accordance with applicable requirements for safety related components for nuclear systems.

The operating history of Westinghouse thermal barriers indicates only one instance of a minor internal leak in a RCP model older than the Surry type 93A RCP. That minor leak did not increase in rate and the RCP was removed from service and repaired. No other instance of thermal barrier leakage has been identified in over 12 million hours of operation.

Westinghouse has concluded that a catastrophic failure of an RCP thermal barrier is not a credible event. While such failures could result in calculated leakage flows into the CCW system ranging from 275 gpm to 558 gpm (depending on the conservatism of the calculation), they are not addressed as a design basis requirement.

Westinghouse has calculated the credible leak rate due to a loss of integrity of the RCP thermal barrier to be 7.5 gpm. They concluded that this leak rate was a conservative assessment for the following reasons:

1. Low failure probability - As detailed earlier, there has been only one minor incident of thermal barrier leakage in over 12 million hours of operating history. In addition, the high water purity requirements for the reactor coolant and CCW systems create a favorable chemistry environment which reduces the potential for corrosion. Finally, Westinghouse has identified that there is conservatism in the tube design which supports that the tube will not be subject to collapse. Tube collapse is more likely than a crack, and would result in zero leakage.

2. No crack propagation - Because the high pressure reactor coolant is outside the tubes in the thermal barrier, any existing crack will tend to close rather than propagate due to the external forces.

Therefore, the design basis leak for the RCP thermal barrier is conservatively defined as a constant 7.5 gpm.

EVALUATION

The existing 1500 lb. class portion of the CCW system piping will provide adequate isolation of the credible RCP thermal barrier leak of 7.5 gpm. However, a review of the design of this system results in the following conclusions: 1) the existing system design would require an operator to make a containment entry to assure isolation of this leak; and 2) although the existing system design meets the original licensed design basis, today's design practices for this type of system are more demanding. Based on these conclusions, the existing 1500 lb. class portion of the CCW system is being evaluated and will be modified where appropriate to enhance system operability and to upgrade the design. These enhancements will be fully implemented by the end of the next refueling outages.

Modification to the portion of the CCW system upstream of the RCP thermal barrier will be completed prior to unit restart. The CCW system design upstream of the thermal barrier as shown on Attachment 1, will be modified as follows:

- The one existing upstream check valve will be replaced by two 2 inch check valves in series to assure isolation. Leakage monitoring connections will be provided to permit functional testing of the check valves. These valves are seismically qualified and supported and are safety-related.

- The existing 1500 lb. relief valve will be replaced by a safety-related relief valve.

- The modifications to the piping, including the valves, will use 1500 lb. class materials and seismic, safety-related design requirements will be specified.

Enhancements to the CCW system from the RCP thermal barrier outlet flange to the Containment Isolation Valves (TV-107/207) require a significantly greater engineering, design, and installation effort. Due to the engineering/design and procurement lead time, these modifications will be implemented during the next refueling outages. Preliminary design evaluations would indicate modifying the CCW system downstream of the RCP thermal barrier as follows:

- The one existing downstream trip valve would be replaced with two automatic trip valves in series to assure isolation.

- The modification to the system, including the valves, will use 1500 lb. class materials, and seismic and safety-related design requirements will be specified.

CURRENT OPERATION

The current design of the CCW system provides diverse instrumentation and alarm annunciation to identify that there is a 7.5 gpm leak in an RCP thermal barrier and to locate which of the three RCP thermal barriers is experiencing the leak.

Temperature Indication. The CCW lines from each RCP thermal barrier contain RTDs which provide temperature indication on the benchboards and on the plant computer, and high temperature annunciation in the control room. High temperature annunciation is also provided for CCW return header from containment as well as at the inlet to the CCW Pumps from the return header. A leak flow of 7.5 gpm from the reactor coolant system into the 40 gpm flow of CCW would increase the discharge temperature from 120°F to 180°F (RCS at 500°F). Since annunication occurs at 145°F, this would permit an operator to identify the source of even a smaller RCP thermal barrier leak.

Flow Indication. Flow indication is available on the benchboards and on the plant computer for each CCW line from its respective RCP thermal barriers (see Attachment 1). The setpoint for high flow annunciation and automatic closure of TV-120/220 is 50 gpm. This flow relates to a thermal barrier leak flow of 10 gpm which is slightly higher than the design basis leak of 7.5 gpm. This is conservative in that it permits normal fluid transients but would isolate if a significant leak should occur. Existing flow instrumentation would identify the RCP having a thermal barrier leak since a 7.5 gpm leak would represent a flow increase of over 15 percent.

Radiation Monitor. The addition of small amounts of Reactor Coolant on the order of 7.5 gpm or less will measurably increase the activity of this system. The two Component Cooling System radiation monitors, RM-105 and RM-106, are located in the Component Cooling Heat Exchanger discharge piping. These monitors would alarm on the high activity caused by a thermal barrier leak. The activity detected by RM-105 & 106 would also cause the CCW Surge Tank Vent to be isolated. These indications would alert the control room operators to identify the RCP thermal barrier which was leaking using temperature and flow inputs from the control room benchboards or the computer.

Surge Tank Level. The CCW Surge Tank level is monitored in the control room. High and low surge tank levels are annunciated. A steady increase in level would be another indication of CCW System inleakage.

Reactor Coolant System (RCS) Leakage. Technical Specifications require that RCS leakage be monitored and that an action statement be entered if unidentified RCS leakage exceeds one gpm. Any significant RCP thermal barrier leakage would be either identified and isolated through this process or the Unit would be shut down to comply with LCO requirements.

Numerous indications are available to alert the control room operators that a RCP thermal barrier leak is occurring and then determine which of the three RCP's is experiencing the leak. When that has occurred, the operators can isolate the leak by manually actuating TV-120/220 from the control room. A leak greater than 10 gpm while not considered credible by Westinghouse would be automatically isolated by TV-120/220.

To further assure identification and isolation of an RCP thermal barrier leak, the following actions will be accomplished prior to unit restart:

- The calibration of the temperature, flow, level, and radiation monitoring instrumentation involved in detecting a RCP thermal barrier leak will be verified to be current.

- The function of the temperature, flow, level, and radiation monitoring instrumentation involved in detecting a RCP thermal barrier leak will be verified to be satisfactory.

- Procedures will be implemented to require that the 1500 lb. manual isolation valve downstream of TV-120/220 be closed by an operator if a thermal barrier leak should occur. This action will occur within 4 hours of the identification of the leak consistent with the LCO period for RCS leakage.

EVALUATION SUMMARY

A design review of the provisions for isolating the CCW system in the event of a RCP thermal barrier leak raised questions regarding the design basis definition of the leak and the conservatism of the current CCW system design to provide isolation of the leak. Further investigations with Westinghouse revealed that a catastrophic failure of a RCP thermal barrier which would achieve a flow rate in the 275 gpm to 558 gpm range was not a credible event. The design basis failure of a RCP thermal barrier would have a leak flow rate of 7.5 gpm.

The original system design for isolating a RCP thermal barrier leak into the CCW system is acceptable for a 7.5 gpm leak, however, manual operator action may be necessary. Certain design enhancements will be implemented to eliminate the need for manual operator actions and provide additional assurance that a thermal barrier leak to the CCW system can be isolated. These design enhancements will be completed during the next refueling outage.

The original system design and instrumentation remains adequate in assuring detection and isolation of the leak in the RCP thermal barrier. The components required to identify and isolate this leak will be verified to be functioning in a satisfactory manner and to meet design basis requirements prior to power operation.

SAFETY EVALUATION OF PROPOSED MODIFICATIONS

The design modifications being performed to add redundant, safety-related check valves upstream of each RCP thermal barrier within the 1500 lb. class portion of the CCW system do not represent an unreviewed safety question. These modifications represent enhancements to the original system design which limit the requirements for operator action in high radiation areas as well as providing the greater design conservatism which is typically found in more recent CCW system designs.

A) The probability of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the UFSAR has not been increased. Information received from the manufacturer of the Reactor Coolant Pump (RCP), Westinghouse, has confirmed that the credible failure of the RCP thermal barrier is a leak with a flow rate of 7.5 gpm. The original system design is fully capable of isolating this small leak with no modifications. However, an operator entry into containment would have been required to close the manual isolation valve upstream of the thermal barrier if the swing check valve had failed to seat. The design modification which will be accomplished prior to unit restart involves the installation of redundant, safety-related check valves to replace the single nonsafety-related check valve in the original design. The new check valves will be 1500 lb. class and a new safety-related, 1500 lb. class relief valve will be installed in place of the existing nonsafety-related relief valve. The modification will be performed to seismic design criteria and safety-related materials will be used.

The new check valves being installed utilize a piston-type design while the previous valve was a swing check. The piston check valve is a more positive acting valve than a swing check and typically provides less leakage. The use of two of the piston check valves rather than one swing check reduces the probability of a malfunction of equipment important to safety. If either of the safety-related piston check valves functions during a thermal barrier leak, the 150 lb. class CCW system upstream of the check valves will be protected from overpressurization. The design of the piston check valve assures that both will function. Also, the use of a safety-related relief valve in this system provides additional assurance that equipment important to safety will function as designed.

This modification would have no effect on the probability of occurrence of a thermal barrier leak. The consequences of the thermal barrier leak would be reduced since redundant, safety-related piston check valves would assure that overpressurization could not occur upstream of the RCP thermal barrier thus eliminating the requirement for any operator action to mitigate the failure of the swing check valve to seat.

B) The possibility for an accident or malfunction of a different type than any evaluated previously in the UFSAR has not been created. Operability of components required to mitigate the consequences of a thermal barrier leak has been enhanced by replacing a single nonsafety-related check valve with redundant safety-related check valves. The operation of the RCP thermal barrier is not affected in any manner by this modification. The pressure drop through two 2 inch piston check valves is slightly greater than the existing pressure drop through one 1 and 1/2 inch swing check valve. This is insignificant since the flows must be balanced by throttling the CCW discharge valves.

The existing design of the CCW system downstream of the RCP thermal barrier includes both a trip valve, TV-120/220, and a manual isolation valve within the 1500 lb. class portion of the system. The trip valve can be either manually actuated by the operators from the control room or will automatically trip on high flow. Diverse temperature, flow and radiation monitor indication is available on the control room benchboards to permit the operators to easily identify a RCP thermal barrier leak and isolate the appropriate trip valve. The operators could provide additional assurance of isolation of the leak by making a containment entry and closing the manual isolation valve downstream of the trip valve. This action provides redundant isolation should any malfunction of the trip valve occur.

The operability of the RCPs is unaffected by this modification, and the operability of the features of the CCW system utilized in isolating a RCP thermal barrier leak has been enhanced.

C) The margin of safety as defined in the basis for any Technical Specification has not been reduced. The modification has provided redundancy upstream of the RCP thermal barrier. Either of the two piston check valves is capable of isolating the 150 lb. class CCW system from the RCP thermal barrier leak within the 1500 lb. class portion of the CCW system. The new safety-related relief valve set as 2485 psig is provided for thermal relief in the event of an inadvertent actuation of the trip valve TV-120/220. The CCW system downstream of the RCP thermal barrier can be effectively isolated either by operator action from the control room or automatically on flows greater than 50 gpm (a RCP thermal barrier leak greater than 10 gpm). The manual isolation valve downstream of the trip valve but still within the 1500 lb. class portion of the CCW system will be isolated within 4 hours of detection of a RCP thermal barrier leak, thus assuring leak isolation. The credible thermal barrier leak of 7.5 gpm would be safely contained and the margin of safety has been increased by the modification.