9406070127

May 23, 1994

MEMORANDUM FOR: Timothy E. Collins, Acting Chief
Reactor Systems Branch
Division of Systems Safety and Analysis

FROM: Mark P. Rubin, Acting Chief
BWR Reactor Systems Section
Division of Systems Safety and Analysis

SUBJECT: PRELIMINARY SAFETY ASSESSMENT - BWR CORE SHROUD CRACKING ISSUE

The BWR Systems Section has prepared the enclosed preliminary safety assessment of the BWR core shroud cracking issue (Enclosure 1). This input was provided to Jack Strosnider and Ashok Thadani on May 13, 1994. The input provided to the Reactor Systems Branch by the Probabilistic Safety Assessment Branch has also been provided (Enclosure 2).

/s/

Mark P. Rubin, Acting Chief
BWR Reactor Systems Section
Division of Systems Safety and Analysis

Enclosures: As stated

cc w/enclosure:
R. Jones
M. Virgilio

SRXB:DSSA
ACubbage
5/2/94

SRXB:DSSA
MRubin
5/2/94

Doc name: G:\memo.mpr

DISTRIBUTION
Central file
SRXB R/F
MRubin
MRazzaque
ACubbage
ACubbage R/F

RD-IC-1
X-FD-8-3-Pipe Cracks
X-MHIS-3-2-2

9406070127 940523
CF ADOCK 05000237
CF

003057 RETURN TO REGULATORY CENTRAL FILES

ENCLOSURE 1

BWR CORE SHROUD CRACKING
PRELIMINARY SAFETY ASSESSMENT FOR CECO PLANTS - SRXB

1. INTRODUCTION

Following detection of a 360° crack in the core shroud at Brunswick during the Fall of 1993, a safety assessment was performed by the staff which evaluated the plant specific and generic implications of the Brunswick shroud inspection findings. (INSERT CONCLUSIONS OF BRUNSWICK ASSESSMENT). This assessment focussed on welds in the upper portion of the core shroud because this was the region that was affected at Brunswick. Potential cracks at other locations of the core shroud were not evaluated in this assessment, because the lower region of the shroud was not believed to be as susceptible to cracking due to the fluence and chemistry conditions. Recent core shroud inspections at Dresden Unit 3 and Quad Cities Unit 1, however, have identified 360° cracks of significant depth in the lower portion of the shroud, below the core region. The identification of these cracks, in areas that were previously not thought to be susceptible, significantly changes the assumptions of the previous safety assessment, and also calls into question the integrity of other vessel internal components. This new information is also important because significant leakage through cracks in the lower shroud could defeat the ability to reflood the reactor vessel to two-thirds core height following a design basis recirculation line break, which would result in the inability to cool the core if the core spray system was also affected. The following assessment provides both an evaluation of the significance of the cracks that have been found at Dresden 3 and Quad Cities 1, and also of the acceptability of continued operation of Dresden 2 and Quad Cities 2 which have not yet been inspected for core shroud cracking. It should be noted that this assessment is based on preliminary information obtained from the licensee during telecons, and that at this time the staff has not received this information in writing.

2. UNITS CURRENTLY SHUTDOWN - DRESDEN UNIT 3 AND QUAD CITIES UNIT 1

Recent core shroud inspections at Dresden Unit 3 have identified a 360° crack at the H5 location, in addition to several less extensive cracks at other locations. The total thickness of the shroud at the H5 location is 2 inches plus a 1 inch weld thickness for a total of 3 inches. The thickness of the crack found at Dresden 3 is approximately 1 to 1.5 inches, as determined by rough techniques. The crack is located in the core plate support ring which is 18 inches below the bottom of the fuel. Quad Cities Unit 1 has also identified significant cracking at the H5 weld location. The crack depth at both units will be further evaluating in the near future using more refined UT technology.

The licensee has preliminarily evaluated the significance of the observed cracks during normal operation, accident condition and earthquake conditions. While the licensee considers the likelihood small that the shroud will crack through wall, the staff assumes that the shroud is cracked through wall for the purpose of this assessment, since the crack depth is not known with any certainty at this time. During normal operations, the licensee has concluded that the core shroud will not lift even if it has cracked through the wall, and that there is no safety concern associated with normal operation as leakage through the crack would be minimal. For accident conditions, two scenarios are of particular concern, design basis recirculation line break (DBLOCA) and main steam line break (MSLB). For the DBLOCA, the primary concern with a crack at this location in the shroud, as opposed to the location that was cracked at Brunswick, is the ability to reflood the reactor vessel to two-thirds core height following a design basis recirculation line break. As was the case in the Brunswick assessment, the MSLB event is significant in that the this event results in the largest upward load on the shroud, and upward shroud motion could impact the ability of the control rods to insert and the ability of the core spray system to perform its safety function.

For the MSLB scenario, the licensee has performed a preliminary evaluation which concludes that the loads during this event are not sufficient to lift the core shroud given a through wall failure at the H5 weld location. Without lifting the shroud, the licensee does not expect leakage through the cracked shroud to exceed

40 gpm which would cause no impact on ECCS performance, or the ability to shutdown the reactor. Upward displacement is expected, however, for the MSLB occurring simultaneously with the design basis earthquake. Even for this scenario which would lift the shroud, the licensee's preliminary evaluation has concluded that there would be no significant impact on the ability to scram the reactor or the function of the ECCS. This assessment concerning shroud displacement and its impact on the control rods and the core spray system to the staff's conclusions and needs to be confirmed by the staff.

For the DBLOCA scenario, the licensee has stated that the given a through wall crack at the H5 location, the shroud will not lift during the event. While the lateral loads which would occur during a DBLOCA could cause the shroud to shift creating a leakage path, the licensee has stated that lateral movement of the shroud is limited to 1 inch due to the location of the core plate, and that the leakage associated with a 1 inch lateral shift would be on the order of 30 to 40 gpm. Leakage of this magnitude would not be sufficient to impact two-thirds core coverage. While the staff finds this reasonable, the Division of Engineering must review the licensee's basis that the shroud will not move more than an inch. It is also possible that the shroud may buckle or damage internal components when subjected to large lateral loads. For this to occur, however, the shroud must be cracked through wall, and a large recirculation line break must occur. The probability of a design basis recirculation line break is on the order of 1E-4. While this event could be a significant contribution to core damage frequency, it would still meet the safety goals. For long-term operation, this would be unacceptable, but, with further evaluation by the licensee and review by the NRC, restart and operation of the units until the next outage may be acceptable.

3. OPERATING UNITS - DRESDEN UNIT 2 AND QUAD CITIES UNIT 2

For the two operating units, Dresden Unit 2 and Quad Cities Unit 2, there are other concerns in addition to those discussed above. The licensee has a written JCO for these units that is available at the site. On the basis of a preliminary review of this document, the staff concludes that the licensee's JCO is not adequate. The licensee's assessment did not address lateral loads during the

DBLOCA, nor did it address the consequences of failure of the shroud at locations other than H5.

The staff has performed an independent preliminary assessment for the operating units. Since the shrouds at these units have not been inspected, the integrity of the shroud is in question at all weld locations. This would include one weld in particular, H4, for which the consequences of a through crack could be more severe than at the H5 location. The lateral motion of the shroud is not limited to 1 inch at this location, thus the lateral loads of the DBLOCA could shift the shroud such that significant leakage from the shroud to the annulus could occur resulting in a potential impact on the ability to reflood the core and provide cooling with the core spray system. While the consequences of this scenario would be severe, there is no evidence at this time that the shroud is cracked at the H4 location at these units. In addition, DBLOCA is a low frequency event as discussed above. The MSLB consequences discussed above for the shutdown units would generally apply for the operating units, therefore the staff does not consider the MSLB scenario to be significant. Based on this independent assessment, the staff concludes preliminarily that continued operation of Dresden Unit 2 and Quad Cities
Unit 2 is acceptable.

Enclosure 2

RISK INSIGHTS FOR CORE SHROUD CRACKING

On the basis of previous evaluations of the Brunswick unit 1 IGSCC and its propagation, several assumptions are made for the high carbon 304 stainless steel material used for the shroud and shroud welds. Extend of the cracks and the rate of propagation are consistent with that of the Brunswick findings regardless of the crack location on the shroud, and may take more than several years to develop a crack depth of more than 50% for 2.2 inch welds under normal operating conditions. Under a special water chemistry to slow down the rate of crack propagation, it is reasonable to assume that the complete circumferential crack propagation through the remainder of the weld may take mare than ten years.

On risk perspective, three limiting events are considered concurrent with the shroud cracks, where such event may accelerate the sequence of the event and lead into the eventual core damage state, either due to vertical or radial displacement of the shroud or a combination of both. The limiting events considered are a seismic event, upper shroud cracks concurrent with a steam line break, and suction line break of a recirculation loop concurrent with a circumferential cracks at the bottom of the shroud weld.

The seismic event may further induce lateral acceleration as well as the vertical lifting of the shroud with the cracks located at the upper shroud, and exaggerate a lateral movement caused by an asymmetric pressure gradient induced by the lower shroud cracks. However, according to an EPRI study (Probabilistic Hazard Evaluation at Nuclear Plant Sites in the United States, EPRI NP-4726, 1988), the frequency of an seismic event at the Dresden and Quad Cities appears to be low with a mean frequency of 3E-5/year for a horizontal acceleration of 2 times of design value. With a subjective assessment in terms of seismic intensity with an epi-center away from the plant may further reduce the frequency figures. Now, 0.2g - 0.35g acceleration may not be sufficient enough to displace the upper shroud and the fuel bundles without a steam line break coincident with the upper shroud cracks. According a LaSalle and Brunswick IPEs (Individual Plant Evaluation), an event frequency of a steam line break is an order of 1.0E-4/year. On the basis of the above, it is concluded that the limiting event for the upper shroud cracks is a steam line break.

Now, considering the failure to shutdown the reactor timely manner as well as mitigating actions, an incremental change of conditional core damage frequency is expected to be greater than 1.0E-5/year in accordance with the analysis for the Brunswick event.

Same seismic event with lower shroud weld cracks may induce further lateral movement for the shroud with the bottom cracks due the greater asymmetric pressure gradient induced by the lower cracks. However, the piping associated with the risers and jet pumps may act as a circumferential constraint to prevent large lateral displacement of the shroud. The cracks at the bottom of the shroud concurrent with the suction line break of a recirculation loop could cause large pressure gradient across the radial direction of the core, but may not contribute to the lifting force of the core internals. Therefore, it is concluded that the limiting event for the lower shroud cracks is the suction line break of a recirculation loop.

According to a frequency data in the National Reliability Evaluation Program and the IPE submittal, the largest number reported for the frequency of large LOCA (greater than 0.3 square foot breaks) is reported as 3.0E-4/year, in which more than one stuck-open SRVs and other large breaks are included. Therefore, the event frequency with a line break at the suction line of a recirculation loop is less than 1.0E-4/year. Again, the recirculation line break will be dominating event for the cracks at the shroud bottom. On the basis of the assumption that the crack depth at the shroud bottom is about 50% of total welds and a complete crack propagation through the wall may take more than 10 years, it is concluded that the conditional core damage frequency without a recovery action is approximately 1.0E-5/year. Now, when the circumferential lower cracks are completed propagated through the welds, the weight of the shroud may still limit the leaks through the cracks, and the piping associated with the jet pumps may constrain the lateral movements.

The following table illustrates the magnitude of total CDF values submitted in IPEs by the licensee as well as other pertinent information;

PLANT	DESIGN	TOTAL CDF / YR.
Brunswick 1&2	BWR-4, Mark 1	2.70E-5
Dresden 2&3	BWR-3, Mark 1	1.85E-5
Quad Cities 1&2	BWR-3, Mark 1	1.20E-6

SUMMARY OF RISK INSIGHTS

It is concluded that the limiting events for the shroud cracks concurrent with dominant failure events are:

1. the upper shroud cracks with a steam line break is an limiting event with an incremental core damage frequency less than 1.0E-5/year.

2. The bottom shroud cracks with a recirculation suction line break is a limiting event with an incremental core damage frequency of less than 1.0E-5/year, even in a range of 1.0E-6/year.

3. It appears that the frequency and event contribution of other cracks at the intermediate level of the shroud lies somewhere between the above two.

A. Operability of Dresden 3 and Quad Cities 1

The incremental changes of the conditional CDF due to the events are within the screening criteria of vulnerability given in the IPE guidance document NUREG-1335. However, the inspection findings should be within the assumptions presented in the above, and the water chemistry be maintained as well as the leakage monitoring after restart.

B. Justification of Continuing Operation (JCO) for Dresden 2 and Quad Cities 2

The incremental changes of the conditional CDF due to the potential limiting events should be considered as approximately in an order of 1.0E04/year, since the cracks are assumed to be propagated completely through the welds. Additional mitigating measures, such as water chemistry, surveillance, and additional heat sinks beyond the requirements in Technical Specifications, could reduce the figure. However, the 1.0E-4/year is within the vulnerability screening criteria.