NRC FORM 680 (11-2002) NRCMD 10.159

U.S. NUCLEAR REGULATORY COMMISSION

DIFFERING PROFESSIONAL OPINION

FOR PROCESSING USE ONLY

1. DPO CASE NUMBER: DPO-2005-003

2. DATE RECEIVED: 2/16/2005

INSTRUCTIONS: Prepare this form legibly and submit three copies to the address provided in Block 14 below.

3. NAME OF SUBMITTER	4. POSITION TITLE			5. GRADE
Melvin C Shannon	Senior Resident Inspector, Oconee			GG-14
6. OFFICE/DIVISION/BRANCH/SECTION	**7. BUILDING**	**8. MAIL STOP**	**9. SUPERVISOR**	
USNRC/Region II/DRP/Branch 1/ Oconee			Michael Ernstes	

10. DESCRIBE THE PRESENT SITUATION, CONDITION, METHOD, ETC., WHICH YOU BELIEVE SHOULD BE CHANGED OR IMPROVED. *(Continue on Page 2 or 3 as necessary.)*

1. The inspectors found that the feedwater line terminal end pipe whip restraints had been left in an over tightened condition. This condition did not meet the design criteria specified in the FSAR, did not meet the stress limits specified in the ASME code of record B31.1, did not meet the NRC's stress criteria specified in MEB 3.1, did not meet the NRC's fatigue criteria specified in MEB 3.1 and did not meet the fatigue stress criteria specified in the more recent ASME/ANSI codes. Region II DRS and NRR evaluated the Oconee Pipe Whip Restraint Issue and the licensee's supporting calculation, and concluded that the "feedwater pipe would not break" based on the number of fatigue cycles. This allowed closure of the issue.

11. DESCRIBE YOUR DIFFERING OPINION IN ACCORDANCE WITH THE GUIDANCE PRESENTED IN NRC MANAGEMENT DIRECTIVE 10.159. *(Continue on Page 2 or 3 as necessary.)*

Attached wpd file sent

12. Check (a) or (b) as appropriate:

☑ a. Thorough discussions of the issue(s) raised in item 11 have taken place within my management chain; or

☐ b. The reasons why I cannot approach my immediate chain of command are:

SIGNATURE OF SUBMITTER	DATE	SIGNATURE OF CO-SUBMITTER *(if any)*	DATE
[signature]	02/16/2005		

13. PROPOSED PANEL MEMBERS ARE *(in priority order)*:

1. Jim Tatum
2. Gary Hammer
3. Joe Lenahan

14. Submit this form to:

Differing Professional Opinions Program Manager

Office of: ______

Mail Stop: ______

15. ACKNOWLEDGMENT

THANK YOU FOR YOUR DIFFERING PROFESSIONAL OPINION. It will be carefully considered by a panel of experts in accordance with the provisions of NRCMD 10.159, and you will be advised of any action taken. Your interest in improving NRC operations is appreciated.

SIGNATURE OF DIFFERING PROFESSIONAL OPINIONS PROGRAM MANAGER (DPOPM): [signature]

PRE-CONDITIONS MET: ☑ YES ☐ NO

DATE OF ACKNOWLEDGMENT: 2/18/2005

1. It is my opinion that when assessing the as found condition of the over tightened whip restraints, two different conditions need to be assessed. The first being the affects of fatigue on the piping, because fatigue can degrade the piping to where it can fail under reduced loading. The second being the affect (increased risk of failure) due to the added stress/strain on the piping. I think that this opinion is supported by a statement in the ASME Section VIII code, Section 5-110.2, Significance of Compliance with Requirements for Cyclic Loading, states that "Compliance with these requirements means only that the vessel is suitable from the standpoint of possible fatigue failure; complete suitability for the specified operation is also dependent on meeting the general stress limits and any applicable special stress limits."

a) Fatigue was evaluated and it was concluded that sufficient fatigue cycles did not occur so the piping would not be susceptible to fatigue failure. However, in my opinion, the analysis to determine the differential expansion of the whip restraint and feedwater piping was in error (16% increase), the coefficient of thermal expansion for the whip restraint was improper based on the chemical analysis of the whip restraint rods (4% increase), the modulus of elasticity was improper based on the chemical analysis of the feedwater piping (10% increase), and the analysis did not consider the fact that the whip restraints were pretensioned (11% increase). For an overall increase in stress of 47% above what was shown in the licensee's calculation (44,181 psi vs. 64,970 psi). In addition, the ASME code also notes that " If the stress of this type exceeds twice the yield strength of the material, the elastic analysis may be invalid and successive thermal cycles may produce incremental distortion."

b) The increase in risk of failure due to the high stress/stain applied around the circumference of the piping, was not evaluated. It is my opinion that this part of the issue is the most significant. NRR previously concluded the following:

"The high thermal stresses caused by the bound rods resulted in an increased probability of a pipe break at the whip restraint location. EMEB does not have a procedure to quantify the increase in pipe break probability for this condition." This memo was dated October 27, 2003. On the same date, a memo from Mr. Embro (NRR) stated that "I agree with John that the probability of a pipe break is increased. It's not really possible to quantify with any precision what that increase would be."

This was and is a reasonable conclusion, as stress/strain is increased, the probability of failure of the piping is increased. DRS concluded that the piping would not fail due to fatigue and this was used to close the issue based on if it cannot fail it cannot be a problem. However, DRS and NRR disregarded the previous statements by NRR.

2. It is also my opinion that this issue is not a thermal fatigue issue. For example, if we assume that the whip restraint has the same coefficient of thermal expansion as the feedwater piping, is heated up to 465 degrees F like the feedwater pipe and the restraint is then tightened to obtain the same stress/strain on the feedwater piping, then there would be "no" fatigue cycles. The stress/strain on the feedwater piping is the same regardless of how it got there. Using the difference in thermal expansion is just a method to try to evaluate the issue. Should we assume that an over stressed pipe is OK because there are no fatigue cycles, or do we need to evaluate the over stressed condition in addition to the fatigue condition? In reality we cannot prove that the condition existed for more than one or two cycles.

In addition the ASME Code addresses this issue in Appendix 4 of ASME Section VIII, 1971,

"Primary Local Membrane Stress" by stating that "Cases arise in which a membrane stress produced by pressure or other mechanical loading and associated with a primary and/or discontinuity effect produces excessive distortion in the transfer of load to other portions of the structure. Conservatism requires that such a stress be classified as a primary local membrane stress even though it has some characteristics of a secondary stress...An example of a primary local membrane stress is the membrane stress in a shell produced by external load and moment at a permanent support..." In the same Appendix, thermal stress is discussed and all the examples discuss differences in material temperatures within the structure of the component. These include hot spots in the vessel wall, differences in temperature in the cladding and wall, and differences in temperature at a branch connection.

3. It is my opinion that this issue was not processed as required by the ROP. Since the over stressed condition would have required the postulation of a break as required by a combination of the Giambusso letter, MEB 3.1, GDC 4 and the licensee's licensing basis, and the effects of a break at this location would have rendered multiple mitigation systems inoperable, the Phase 1 and Phase 2 analyses would have required the issue to be evaluated with a Phase 3 analysis. The unresolved item was put on hold for years while the licensee tried various approaches to eliminate the issue.

SUPPORTING DETAILS

a. NRR concluded the following, "The high thermal stresses caused by the bound rods resulted in an increased probability of a pipe break at the whip restraint location. EMEB does not have a procedure to quantify the increase in pipe break probability for this condition." This memo was dated October 27, 2003. On the same date, Mr. Embro (NRR) stated that "I agree with John that the probability of a pipe break is increased. It's not really possible to quantify with any precision what that increase would be." Another memo stated, "The procedure that would correlate piping stresses accedence beyond Code allowable limits with increased probability of piping break, sounds like something ideal to initiate a user need to RES for. I think it is an issue that we confronted often in the past, and will continue to see more of as long as plants continue to operate in degraded conditions.."

It is my opinion that if the tools are not in place to evaluate the condition and it has been concluded that there is an increased probability of failure, the tightened whip restraint issue should not have been closed until it could be properly evaluated.

b. I received information from a Mr. William J. O'Donnell, Ph. D, P.E., Chairman of the ASME Boiler and Pressure Vessel Code Subgroup for Fatigue Strength. He stated that "Pipe rupture would be anticipated when the combined bending, pipe whip restraint and pressure loads exceeded the plastic load of the pipe with appropriate fatigue usage under 0.2." Again note that the NRC's requirements in MEB 3.1 limits the usage factor to less than 0.1. Based on the revised calculations, the licensee clearly exceeded the usage factor of .2.

It is the inspector's opinion that this would indicate that the piping was in a degraded condition where there was a possibility of piping failure, not as stated by Region II DRS and NRR that the piping would not fail.

c. The licensee performed the analysis in file OSC-8370. The inspector found that the "first step" of the analysis was performed improperly, in that the licensee improperly calculated the differences in thermal expansion of the rod and feedwater pipe. (This was the second time the

inspector noted problems with this part of the calculation) This specific calculation determines the tensional load in the rods. The tensional load was determined by the licensee's calculation to be 44,181 psi and based on this the total loading from the rods was determined to be 83,944 pounds. However, because of this specific error in the calculation, the tensional load should have been 51,301 psi and the total loading from the rods should have been 97,473 pounds per rod. (16% increase)

The calculation was performed by the licensee's engineers, it was checked by a engineering consulting firm, and it was checked by NRC experts. Since the difference in thermal expansion was performed improperly, I can only question the value of their review. This error in the calculation was provided to DRS, but was apparently ignored since it was not considered in DRS's final conclusion.

The inspector noted that the material of the whip restraint rods was unknown and the rods were hardened. The DRS inspector and the licensee both concluded that use of the same carbon steel thermal expansion coefficient for both the rod and feedwater piping was appropriate. Based on the licensee's analysis of the rod material, the inspector concluded that a different coefficient of thermal expansion should have been used. Using the ASME 1989 Section III coefficient of thermal expansion tables and based on the material analysis, a lower thermal expansion coefficient (carbon steel material group C) should have been used for the rods. Based on using the more accurate thermal expansion coefficient for the restraint rods, the tensional load would now be 53,163 psi and the total loading from the rods would be 101,011 pounds per rod. This correction adds another 4% increase to the licensee's original calculation.

The licensee's calculation used a Modulus of elasticity value of 27,700,000 psi. This value was based on earlier ASME codes which were not highly specific for the material and its alloys. Based on a review of current industry information, using the material alloys, a more accurate Modulus of Elasticity can be obtained. Based on industry information obtained from "Mat Web Material Property Data" the Modulus of Elasticity value for low carbon steel with similar alloys, should be 29,700,000 psi. Mat Web stated that for these type of alloys the 29,700,000 psi is "Typical for Steel." Reevaluating the stress again, the tensional load would now be 58,654 psi and the total loading from the rods would be 111,444 pounds per rod. This correction adds another 10% increase to the licensee's original calculation.

The licensee's calculation was based on "no" pretensioning of the rods. The inspector noted that the rods appeared to have been pretensioned. This conclusion was based on the licensee having to use a wrench to loosen the rods when the rods were in a cold condition. The licensee argued that the rods were rusted. This did not appear to be reasonable since there was no visual evidence of rusting, the nuts with "proper clearance" could be moved by hand, the nuts that were found tightened could be moved by hand once they were detensioned, and the rods were in an environment that was not conducive to rusting (high temperature >200 degrees F, in the overhead of the room, and covered with lagging). So based on this, the inspectors concluded that some amount of pretensioning should be included in the calculation to bound the effects of pretensioning. Based on experimental test data, a person with an eighteen inch wrench could apply in excess of 12,000 pounds of tension on the rods. Using this as a bounding number, the load in the rods could have been as high as 123,444 pounds per rod. This adds about 11% to the original calculation.

Based on this calculation, with 8 rods in this condition, the total load applied to the outside of the feedwater pipe at the attachment of the whip restraint would have been 987,552 pounds. In the inspector's opinion, this is not an insignificant amount of loading, even on a 30 inch feedwater line.

The licensee's analysis provided a calculated loading on the feedwater line at the point of attachment of the whip restraint and the piping. Based on the incorrect tensional loading of 44,181 psi, the local welded attachment stresses were calculated to be 48,186 psi plus 16,083 psi for seismic, pressure and dead weight loading, for a grand total of 64,268 psi. Based on the revised tensional loading of 58,654 psi plus 16,083 for seismic, pressure and dead weight loading, and an additional 6,316 psi for prestressed loading, the grand total becomes 81,053 psi.

Based on the ultimate strength of 69,100 psi and 72,000 psi documented in the US Steel Certified Test Report for the feedwater piping, it appears to the inspector that enough stress could be applied such that the pipe could break. Even disregarding the prestress loading of 6,316 psi, it appears that enough stress could be applied such that the pipe could break.

It should also be noted that ANSI B31.1, 1973, states that "Safety is the basic consideration of this Code...The designer is cautioned that the Code is not a design handbook." The Code also allows the licensee to perform a more detailed analysis if they do not meet the actual Code requirements. Since the code is not a design handbook, it should not be used to perform a more detailed analysis. The licensee clearly exceeded the Code of record stress requirements and admitted to this fact in their calculation. When performing a more detailed analysis of the condition it is only appropriate that the licensee use the most up to date information to calculate the potential stresses as I did up above.

Based on recalculating the fatigue usage factor using the recalculated stress above and adding in the stress from pressure only, the usage factor would be 1.48 as calculated by B31.1 and .62 for actual usage assuming the condition existed since original construction, not .16 an .07 respectively as calculated by the licensee.

The fact that the piping will not break due to fatigue should not be the end of the discussion. It may take care of one mechanism for failure but neglects the potential failure due to being in an over stressed condition. However, even the fatigue argument appears to be subject to a different opinion by an outside expert.

ADDITIONAL CONCERNS WITH THE LICENSEE'S CALCULATION

ASME Code Section NB-3213.9 defines secondary stress and notes two types, "General" and "Local". ASME Code NB-3213.13 states that "For the purposes of establishing allowable stresses, two types of thermal stress are recognized, depending on the volume or area in which the distortion takes place." For local stresses, it goes on to state that "such stresses shall be considered only from the fatigue standpoint and are therefore classified as local stresses in Table NB-3217-1...Examples of local thermal stresses are 1) the stress in a small hot spot in a vessel wall." For General thermal stress, it states that "If a stress of this type exceeds twice the yield stress of the material, the elastic analysis may be invalid and successive thermal cycles may produce incremental distortion...Examples of general thermal stress are 2) stress produced by the temperature difference between a nozzle and shell to which it is attached or 3) the equivalent linear stress produced by the radial temperature distribution in a cylindrical shell."

Since the whip restraint applied stress is applied completely around one section of the feedwater piping, it appears that this would make it a General stress and the elastic analysis may not be valid.

The licensee is using nominal piping thickness from the original material purchase specifications to determine the stresses in the calculation. The feedwater piping at the whip restraint is

downstream of piping elbows and a check valve, however, no NDE piping measurements have been taken at this exact location since the piping was installed over 32 years ago.

The whip restraint bolts were supposed to be made of ASTM A490 steel. However, the ASTM code does not allow A490 to be used for bolting material as large as 1 3/4 in diameter. The licensee's analysis found that the hardness of the actual bolting material was below the minimum specified for ASTM A490. In addition, the licensee could not identify the material specification (such as A193 or A490) for the rods based on the rod alloys. This calls into question the quality of the rods.

The clearances/gaps were re-established by being set at normal operating temperature. Subsequent inspections have found the clearances missing. It is not clear as to why, since the nuts were staked in 15-20 places. The licensee committed to inspect the feedwater and steam line supports every 10 year interval but have not inspected the feedwater line terminal end containment support since original installation in 1973.

THE SDP PROCESS:

When DRS and NRR state that the pipe would not break due to fatigue, it is not clear where we are in the process.

The licensee clearly did not meet the design requirements for setting the proper gaps on the whip restraint that were intended to prevent having excessive stress on the pipe. This would be a violation.

The licensee clearly did not meet the ASME Code of record B31.1 in that stresses exceeded the code allowable of 30,000 psi.

The licensee clearly did not meet the NRC's requirements for fatigue usage of less than 0.1 contained in MEB 3.1.

Once the calculation was corrected, the licensee did not appear to meet the usage factor of 1.0 contained in the later additions of the ASME/ANSI codes.

Based on the stresses, the licensee would be required by GDC 4 to assume a break on the feedwater line at the attachment of the whip restraint and to be able to mitigate the consequences of that break.

At what point do we try to determine the risk associated with the deficiency? Based on DRS and NRR's conclusion that the pipe would not break (due to fatigue) means that there is no risk. If the piping cannot break, then there are no consequences, no consequences then the issue can only be minor. However, even NRR conceded the fact that the increase in stress on the pipe increased the probability of failure.

For this adverse condition, we need to know how much the initiating event failure probability changes. The 1999 Oconee ASP analysis for failure of feedwater piping in the turbine building concluded that the frequency of failure would be 8.3 E-4 and this was based on 300 welds. Therefore, the failure frequency per feedwater line weld would be 2.77 E-6. If we assume one weld per feedwater line is at risk in the east penetration room, then the baseline failure frequency would be 5.54 E-6. This would be the baseline failure probability at the whip restraint location. If we

assume that the over stressed condition increases the probability of failure as stated by NRR, then we have a starting point. [redacted] Ex. 2

If the initiating event probability for a failure of a feedwater piping weld is 2.77 E-6, then how much would be reasonable to assume the initiating event probability would change when the piping is placed under high stress? Using "the piping would not fail" and therefore no change in the initiating event probability, does not make any sense.

PREVIOUS HELB ISSUES

IN 2000-20, Potential Loss of Redundant Safety-Related Equipment Because of the Lack of High-Energy Line Break Barriers, noted 4 examples where conditional core damage frequencies were greater than 1 E-6 because specific safety related components were not protected from HELB. [redacted] Ex. 2

VC Summer documented a similar finding for HELB in IR 98-06 (URI 98-06-01) that subsequently became a White finding. A door between safety related cabinets and the feedwater lines was left open for a short period and this increased the risk to the White threshold. [redacted] Ex. 2

[redacted] The licensee clearly did not meet the requirements for HELB, but the issue at Oconee is going to be dispositioned as Green because if the piping cannot fail, there are no consequences. This does not make any sense to me and does not appear to be a consistent and repeatable methodology as advertised for the ROP.

CONSEQUENCES OF NOT ADOPTING POSITION

The NRC does not have a process for dealing with degraded piping conditions (wall thinning, missing restraints, overstress conditions..etc). As the plants age, more issues of this type will surface and have to be dealt with. The failure to develop a reasonable methodology will result in continued misrepresentation and inconsistency of the risk determinations for these future issues. In addition, since every issue takes a significant amount of resources by both the licensee and the NRC to resolve, without development of a simplified process for evaluating degraded piping conditions, this waste of resources will continue.

If piping that is significantly over stressed, stressed beyond that allowed by the ASME Code, and stressed beyond that allowed by NRC requirements such as MEB 3.1, and the NRC concludes that it "cannot fail", then what is the basis for assuming that ruptures of feedwater lines, steam lines and RCS LOCAs (Initiating Events) could ever occur. If ruptures of over stressed piping cannot

happen, then the line rupture SDPs used to evaluate inspection findings should be removed. Taking the position that the line cannot fail because it has not experience enough fatigue cycles prevents the inspectors from addressing these types of issues in the future.

If the usage factor is as high as I calculated, then there is potential for a piping failure at much lower stress levels than are presently assumed (fatigue usage of greater than .2). This concern is based on comments from an outside expert from the ASME Code committee on Fatigue Strength. He also recommended inspections of the piping to ensure the piping was not degraded due to the affects from the whip restraint induced stress.

OPENED

IR 2002-05

4OA2 Identification and Resolution of Problems

.1 Annual Sample Review - Uncontrolled Design Change to the Feedwater Pipe Whip Restraints

a. Inspection Scope

The inspectors performed an in-depth review of the Unit 2 feedwater pipe whip restraint design requirements in order to verify proper implementation and to determine if deviations were being properly identified and documented in the licensee's corrective action program. Following the field inspections, the inspectors verified that conditions adverse to quality were properly documented in the licensee's corrective action program.

b. Findings

Introduction

The inspectors identified that clearances between the Unit 2 feedwater pipe whip restraint nuts and structural mounting plates were not in accordance with the gap

requirements specified in the design drawing. The consequences of not maintaining the specified gap between these components is currently under review and is identified as an unresolved item (URI).

Description

The two feedwater lines for each Oconee unit enter containment from the east penetration room. Each feedwater line has a rupture whip restraint which is attached to the piping and is adjacent to the containment penetration. The restraint is located between the containment penetration and the feedwater line check valve. The restraint has eight threaded rods, with each rod being pinned on one end to the support structure and the other end being connected by a nut to a mounting plate that is welded to the feedwater piping. Note (7) on Design Drawing O-494 specifies that final tightening of the nuts shall be performed when the feedwater piping is at normal operating temperature (465 degrees F). The note continues to indicate that the nuts shall be drawn snug, then backed off one-quarter turn. Rod threads shall then be jammed to prevent rotation of the nuts. In earlier discussions with the licensee, the inspectors had been informed that during shutdown conditions, with the feedwater system at ambient (cold) temperature, a gap of 1/8-1/10 of an inch should exist between each whip restraint nut and its associated mounting plate.

During the fall 2002 (EOC 19) Unit 2 refueling outage, the inspectors inspected the Unit 2 feedwater pipe whip restraints while at ambient temperature. For the restraint associated with feedwater penetration 25, the inspectors found that no gap existed for six of the eight nuts. The licensee had to use a wrench to loosen these nuts. The remaining two nuts could be loosened by hand; however, the inspectors noted that there was no visual indication of any gap. For the restraint associated with penetration 27, five of the eight nuts could be loosened by hand; however, the inspectors noted that there was no visual indication of any gap. In addition, it was noted that the licensee did not attempt to measure any of the gaps. The remaining three nuts were covered by asbestos insulation and the licensee elected not to remove the insulation and inspect them. The licensee subsequently adjusted the nuts to provide gaps at ambient conditions.

The inspectors noted that the feedwater whip restraints were installed in response to the "Giambusso Letter" of December 1972, which implemented 10 CFR 50 General Design Criteria (GDC)- 4. This letter required the licensee to analyze and to protect the plant from piping breaks at the terminal ends of high energy piping. Per Branch Technical Position MEB 3.1, terminal ends are defined as "Extremities of piping runs that connect to structures, components, or pipe anchors that act as rigid restraints to piping motion and thermal expansion." The design of the feedwater line whip restraint is such that the stationary end of the restraint (feedwater piping welded to support) is a terminal end, which is enclosed by the remainder of the whip restraint. In theory, if a pipe break were to occur, the location would be at the terminal end and the whip restraint would restrict movement of the piping and prevent excessive damage to nearby components and systems. Because the feedwater pipe restraint nuts were tightened when the feedwater system was at ambient conditions, the inspectors concluded that the restraints could have acted as rigid restraints to piping motion during normal (hot) conditions and caused a partial moment restraint similar to that created by a pipe anchor. As a consequence,

the whip restraint created local stresses similar to the local stress created by a terminal end at a pipe location that is not protected by a whip restraint. Based on this change, the feedwater pipe whip restraint may not have been capable of mitigating the effects of a pipe break at a terminal end.

In response to these as-found conditions, the licensee performed an engineering evaluation and documented the results in a position paper. The inspectors, along with NRC Regional and Nuclear Reactor Regulation (NRR) engineering personnel reviewed the evaluation. The licensee concluded that the location of the terminal end had not changed. They stated that if the nuts had been overly tightened and if the maximum thermal expansion differences between the feedwater piping and restraint actually existed, the whip restraint would experience "enormous loads" such that component damage would have been obvious. The various types of damage mentioned included failure of the clevises that connect the rods to the stationary part of the restraint, failure of the mounting plate, and deformation of the rod threads. The licensee stated that no damage was noted that would indicate a bound condition had existed. The inspectors noted no damage to the restraint or piping during their inspection. The inspectors and appropriate NRC engineering personnel are continuing to review and discuss with the licensee their evaluation and conclusion that the lack of clearances for the feedwater piping restraints did not adversely impact the feedwater system.

Analysis: The inspectors are continuing to review and assess the potential impact of an unrestrained feedwater piping break in the east penetration room. The inspectors noted that feedwater pipe whip following a pipe break would damage safety-related piping and electrical components in the area. In addition, an unrestrained break in feedwater piping between the check valve and SG would cause the amount of escaping steam flow to exceed the analyzed amount and may exceed the pressure rating of structures. The full extent of possible damage from a change in the location of the terminal end has not been fully assessed.

Enforcement: 10 CFR 50, Appendix B, Criterion V, requires that activities affecting quality shall be prescribed by documented instructions, procedures, or drawing, of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings. The design drawing requirements for feedwater piping restraint clearances were not met. Final disposition of this issue is pending determination of the consequences for not maintaining the clearances and any corresponding increase in plant risk. This issue is identified as URI 50-270/02-05-05: Determination of Consequences for not Maintaining Design Clearances on Feedwater Piping Restraints and Corresponding Risk.

CLOSED
IR 2004-05

Cornerstone: Initiating Events

- <u>Green</u>. The inspectors identified a non-cited violation of 10 CFR 50, Appendix B, Criterion V, Instructions, Procedures and Drawings, for the failure to maintain design clearances on Unit 2 feedwater piping whip restraints. Specifically, the inspectors identified that clearances between the Unit 2 feedwater pipe whip restraint nuts and structural mounting plates were not in accordance with (i.e., significantly less than) the gap requirements specified in the associated design drawing; thereby, creating additional piping stresses while at normal operating conditions.

  This finding was greater than minor because it is associated with the configuration control attribute and affected the objective of the Initiating Events Cornerstone to limit the likelihood of events that challenge critical safety functions. In addition, if left uncorrected, this finding could have become a more significant safety concern, in that continued increased stresses on the feedwater piping and the uncertainties in the analyses could have resulted in a piping failure. The finding was evaluated using the Reactor Safety SDP and determined to be of very low safety significance because the inspectors determined that the licensee's conclusion, that the pipe would not have failed at the time of discovery, was reasonable. (Section 4OA5.11)

.11 (Closed) URI 50-270/2002-05-05, Determination of Consequences for not Maintaining Design Clearances on Feedwater Piping Whip Restraints and Corresponding Risk

The performance deficiency associated with this URI was discussed in detail in Inspection Report 05000269,270,289/2002005 and was characterized as being contrary to the requirements of 10 CFR 50 Appendix B, Criterion V, Instructions, Procedures and Drawings. The inspectors reviewed the associated licensee calculation for a mis-configured feedwater whip restraint (i.e., lack of hot gap between nuts and mounting plates during the operation), discussed the calculation and problems with the licensee's engineer and the licensing personnel, and walked down the restraint during cold and hot conditions. The calculation reviewed was Oconee Calculation OSC-8370, Analysis of

Main Feedwater Rupture Restraints with Bounded Rods, Revision 1, for all three units. The purpose of the review was to determine whether or not the calculation was adequate to conclude that the feedwater pipe would not have failed with the mis-configured whip restraint.

This pipe was originally classified by Duke as Class F and reclassified as ASME Class 2 for Inservice Inspection (ISI) purpose. Therefore, the record of code for this pipe was USAS B31.1, Power Piping, 1967 edition. Based on the calculation, the licensee concluded that the pipe would not meet the B31.1 code allowable stresses and NRC MEB 3-1 requirements when the additional stress due to the bounded rods, thermal stresses, and postulated seismic event were added. The pipe would have been overstressed by 62 percent.

NOT A SAFETY FACTOR

The licensee considered that the B31.1 code allowable stresses are based upon 7000 fatigue cycles. The licensee used conservatism built into the Markl curve (or equation) and a factor of safety of 2, to determine that 2268 cycles would have been required for failure. The licensee determined a cumulative fatigue usage factor (0.16) for the life of the plant based on 360 thermal cycles. The licensee also used the same curve to calculate the actual fatigue usage factor (.07) by using the actual number of plant thermal cycles (150). The licensee concluded that the fatigue usage factors for the pipe were less than 1.0 and acceptable. Therefore, although the pipe would not meet the B31.1 stress requirements, the licensee concluded that the pipe would not fail using the conservatism in the Markl curve and the calculated fatigue usage factors.

WRONG NUMBERS

The licensee also performed an ASME fatigue analysis in order to evaluate the pipe based on Class 1 piping criteria. The result showed that the maximum stress ratio, the actual stress divided by the allowable stress, was .97 which was below the allowable ratio 1.0. The total cumulative fatigue usage factor was .92 for the life of the plant (if the deficient condition was not corrected) which was also below the allowable ratio 1.0. The licensee concluded that the pipe would not fail since the pipe met the ASME fatigue analysis limits.

WRONG NUMBERS

The calculation assumed surface contact without a hot gap between the nuts and attached bracket plates for the rods, but did not assume the nuts were torqued. The licensee encountered difficulty loosening the nuts. The inspectors questioned why the licensee did not assume the nuts were torqued. The licensee's justification was that the lab report indicated that the rod threads were corroded, which could explain the difficulty in loosening the nuts.

The inspectors noted that the calculation did not consider thermal expansion coefficients for quenched hardened properties of the rods. The licensee stated that the B31.1 code does not provide any requirements to consider the material's quenched hardened properties and only considers chrome (Cr) content for the different thermal expansion coefficients. The licensee used low chrome content for the thermal expansion coefficients. Based on the inspector's observation, the licensee revised the modulus of elasticity by using carbon content greater than .3 percent.

The inspectors questioned the temperatures, thermal expansion coefficients, and moduli of elasticity used for the rods and/or pipe for relative movement between 70 degrees F

NOT TRUE [redacted]

to 450 degrees F. The licensee had used parameters associated with thermal expansion from 200 degrees F to 450 degrees F. The licensee revised the calculation in revision 2 based on the inspector's comments and included a pipe length reduction of 3.5 inches measured in the field. The total applied stresses between the pipe and rods in revision 2 were slightly less than those calculated in revision 1, as the increase in the thermal stress was reduced by the shorter pipe length.

The inspectors consulted with the NRR Mechanical and Civil Engineering Branch regarding the licensee's conclusions, the use of the Markl curve, and the ASME analysis. The NRR expert indicated that it was reasonable to use the Markl curve as a basis to determine the fatigue usage factor and higher allowable stress as a result of having an actual lower number of cycles than the 7000 cycles assumed in the B31.1 code. The expert indicated that it was appropriate to conclude that the pipe would not fail since the fatigue usage factor was less than 1.0. The expert also indicated that the use of the ASME analysis to evaluate past operability, (though not to qualify the current or future designs), is reasonable, even though the materials were procured and examinations were performed under the B31.1 code. This is because fatigue tests and resultant fatigue curves are based on the material properties only. The stresses due to fatigue are limiting and if the fatigue is evaluated as acceptable, it can be concluded that the pipe would not fail.

This finding was determined to be greater than minor because it is associated with the configuration control attribute and affected the objective of the Initiating Events Cornerstone to limit the likelihood of events that challenge critical safety functions. In addition, if left uncorrected, this finding could become a more significant safety concern in that continued increased stresses on the feedwater piping and the uncertainties in the analyses, could result in a piping failure. The finding was evaluated using the Reactor Safety SDP and determined to be of very low safety significance (Green) because the inspectors determined that the licensee's conclusion, that the pipe would not have failed at the time of discovery, was reasonable. Based on the very low safety significance and because the issue was entered into the licensee's corrective action program as PIP O-02-6240, this violation of 10 CFR 50 Appendix B, Criterion V is being treated as a NCV, consistent with Section VI.A.1 of the NRC Enforcement Policy: NCV 05000270/ 2004005-03, Failure to Maintain Design Clearances on Feedwater Piping Whip Restraints. Accordingly, URI 50-270/2002-05-05 is closed.