Consumers Energy

A CMS Energy Company

Palisades Nuclear Plant
27780 Blue Star Memorial Highway
Covert, MI 49043

Tel: 616 764 2276
Fax: 616 764 2490

Nathan L. Haskell
Director, Licensing

May 17, 1999

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

DOCKET 50-255 - LICENSE DPR-20 - PALISADES PLANT
INSERVICE INSPECTION PROGRAM - SUBMITTAL OF RELIEF REQUEST NO. 14 FOR NRC APPROVAL

During a routine inspection a slight boric acid residue was found at the lower weep hole of the reinforcement pad of the Spent Fuel Pool Heat Exchanger (SFPHx) E-53B inlet nozzle to shell weld. This dry boric acid residue is an indication of slight leakage at the nozzle to shell weld. After a detailed evaluation it has been concluded that the condition does not impair the structural integrity of the heat exchanger. The heat exchanger remains acceptable as-is for continued service. Since this condition is not in full compliance with ASME Section XI requirements, however, NRC review and approval are required.

Attachment 1 provides Inservice Inspection Program Relief Request No. 14 (RR-14) which is needed to accept the SFPHx E-53B in this condition. Attachment 2 is the analysis report (SIR-99-032, Rev. 0) performed by Structural Integrity Associates, Inc. which provided the justification for the integrity of the heat exchanger with this barely discernable leak. This report, which has been reviewed and accepted by Consumers Energy, fulfills the requirement of IWB-3144(b) to submit the analysis to the NRC.

Relief Request RR-14 is being submitted for NRC approval in accordance with 10 CFR 50.55a(a)(3) as a requirement for which the proposed alternatives provide an acceptable level of quality and safety.

9905250076 990517
PDR ADOCK 05000255
G PDR

A047

SUMMARY OF COMMITMENTS

This letter contains no new commitments and no revisions to existing commitments.

Nathan L. Haskell

Nathan L. Haskell
Director, Licensing

CC Administrator, Region III, USNRC
Project Manager, NRR, USNRC
NRC Resident Inspector - Palisades

2 Attachments

ATTACHMENT 1

CONSUMERS ENERGY COMPANY
PALISADES PLANT
DOCKET 50-255

INSERVICE INSPECTION PROGRAM - SUBMITTAL OF RELIEF REQUEST NO. 14 FOR NRC APPROVAL

RR-14

11 Pages

RELIEF REQUEST NUMBER RR-14

Code Class: ASME Class 3

Subject: Alternative requirements to repair of Spent Fuel Pool Heat Exchanger E-53B inlet nozzle.

Component Numbers:

Spent Fuel Pool Heat Exchanger E-53B. This is the lower heat exchanger of two exchangers arranged in series.

Code Requirements:

For ASME Class 3 components, Article IWB-3000 is referenced for the acceptance standards in the ASME Section XI, 1989 Edition (the Code). Item IWB-3522.1 states:

> "**Visual Examination, VT-2.** The following relevant conditions that may be detected during the conduct of system pressure tests shall require correction to meet the requirements of IWB-3142 and IWA-5250 prior to continued service:
>
> "(a) leakage from noninsulated components (IWA-5241);"

IWB-3142(b) states:

> "Components whose visual examination detects the relevant conditions described in the standards of Table IWB-3410-1 shall be unacceptable for continued service, unless such components meet the requirements of IWB-3142.2, IWB-3142.3, IWB-3142.4 or IWB-3142.5."

IWB-3142.4 states:

> "**Acceptance by Analytical Evaluation.** Components containing relevant conditions shall be acceptable for continued service if an analytical evaluation demonstrates the component's acceptability. The evaluation analysis and evaluation acceptance criteria shall be specified by the Owner. Components accepted for continued service based on analytical evaluation shall be subsequently examined in accordance with IWB-2420(b) and (c)."

IWB-2420(b) and (c) state:

> (b) If flaw indications or relevant conditions are evaluated in accordance with IWB-3132.4 or IWB-3142.4, respectively and the component qualifies as acceptable for continued service, the areas containing such flaw indications or relevant conditions shall be reexamined during the next three inspection periods listed in the schedules of the inspection programs of IWB-2410.
>
> (c) If the reexaminations required by (b) above reveal that the flaw indications remain essentially unchanged for three successive inspection periods, the component examination schedule may revert to the original schedule of successive inspections.

Basis for Relief:

Relief is requested in accordance with 10 CFR 50.55a(a)(3)(i), based on the fact that the proposed alternative provides an acceptable level of quality and safety equivalent to the Code requirements.

The Code imposes corrective action for leakage regardless of the circumstances. The leak at the nozzle connection on the E-53B inlet nozzle was discovered during plant operation. The Code does not allow the Owner to evaluate leakage, detected during plant operation, for acceptability of continued service or corrective action.

Even though cross connection capability to the shutdown cooling (SDC) system is provided, the only occasion where SDC may provide the required spent fuel pool cooling is during a full core offload.

Description of Heat Exchanger E-53B Geometry, Materials and Loads

The spent fuel pool heat exchanger is a shell and tube heat exchanger. The tube-side water communicates with the spent fuel pool. At each end of the heat exchanger, there are heads with nozzles connecting to the spent fuel pool cooling piping.

The heads are made of SA-240, Type 304 stainless steel. The cylindrical head has an inside diameter of 25 inches and a wall thickness of 3/16 inch. The horizontal nozzle, from the side of the cylindrical head, is SA-312, Type 304 made from 12.75-inch OD and 0.18-inch thick wall pipe. The reinforcing pad around the nozzle is SA-240, Type 304. The reinforcing pad has a thickness of 0.25 inches and extends 2.5 inches radially beyond the outer radius of the nozzle, welded to the nozzle and shell with 1/4-inch structural fillet welds. The nozzle, with a SA-182 F304 flange, extends 7.5 inches beyond the ID of the cylindrical head.

The reinforcing pad has two 3/8-inch weep holes located at 6 and 12 o'clock on the nozzle.

The spent fuel pool side of the heat exchanger has a design pressure of 125 psig and design temperature of 150°F. The maximum expected inlet/outlet temperatures of the spent fuel cooling water are 125°F in/110°F out respectively. Actual operating pressures as documented in Technical Specification Surveillance Procedure RT-71H, "Spent Fuel Pool System, Class 3 Inservice Test," range from 40 to 80 psig. As required by Technical Specification 3.8.5, fuel pool temperature is limited to 150°F or less when fuel is in the North Tilt Pit.

Evidence of leakage has been observed at the reinforcing pad of the heat exchanger E-53B inlet nozzle. At the lower weep hole, there is a residue of light-colored materials such as would exist after evaporation of water with boric acid content. Based on this, it is concluded that there has been some leakage from a small flaw in the nozzle to vessel weld. However, there is currently no evidence of any moisture at the weep hole.

There are three mechanisms which may have initiated flaws in austenitic materials - stress corrosion cracking, fatigue cycling, and the original manufacture. As the spent fuel pool heat exchanger inlet lines operate at 150°F or less, IGSCC is not considered a credible mechanism for flaw initiation. Because the nozzle is located some distance from the spent fuel pool pumps, pool temperatures are relatively stable in the range of 80 to 125°F and load cycles do not occur at an unusual rate, fatigue cycling is not considered a probable source of flaw initiation. The cause of weld leakage is most likely due to an original manufacturing defect.

Temporary weep hole plugs were installed in accordance with temporary modification TM-98-031 to stop leakage. This action was considered a temporary measure taken in accordance with the instructions of Generic Letter 90-05. However, the plugs are now removed as a result of the favorable analysis of the structural integrity of the SFPHx E-53B condition. This allows the continued monitoring of the nozzle connection during personnel rounds.

Discussion of Stress Analysis for Heat Exchanger Nozzle

To evaluate the stresses in the vicinity of the nozzle, a three dimensional finite element stress analysis was conducted using the ANSYS computer program. The 3-D model was used so that the non-axisymmetric loading effects of the cylindrical nozzle-to-shell weld could be evaluated and the effects of the nozzle moments could be assessed. The stress analysis was conducted using ANSYS version 5.3, SOLID-45 type 3-D structural solid elements, having 8 nodes and 3 translational degrees of freedom at each node. The 3-D elastic beam (BEAM4) element was used to transfer axial, shear, and moment loads to the face of the nozzle.

The finite element model included the heat exchanger shell, end cap, nozzle neck, nozzle reinforcing pad, and the two structural fillet welds connecting the reinforcing pad to the nozzle neck and shell. The model initially assumed a fully intact double-v weld joining the nozzle neck and shell.

A 125 psi internal pressure was applied, which conservatively represents normal operating conditions. Actual operating pressures range from 40 to 80 psig. The mechanical and seismic loads from the connected piping system are shown in following Table. Material properties were taken from the ASME Code Appendices, evaluated at 150°F.

SFP Inlet Nozzle Load Summary

Equipment: Heat Exchanger E-53B

Load Case	Load or Load Combination	Forces (lbs.)			Moments (ft.-lbs.)		
		Fx	Fy	Fz	Mx	My	Mz
10	Dead Weight (DW)	-23	-314	-54	-336	143	-26
35	OBE SAM (OSAM)	0	0	0	0	0	0
30	Seismic OBE (OBE)	103	171	61	378	255	208
45	SSE SAM (SSAM)	0	0	0	0	0	0
40	Seismic SSE (SSE)	205	343	122	756	509	415

X = Horizontal (transverse to nozzle)
Y = Vertical
Z = Axial to nozzle

An analysis was run to evaluate the stresses in the unflawed component. The purpose of this evaluation was to determine the stresses in the vicinity of the shell-to-nozzle weld. These stresses are important from the standpoint of opening potential cracks that would result in leakage during normal operation. The following Table shows the computed membrane stresses at the shell-to-nozzle weld location. These results were used as input to the calculations.

Membrane Stresses in Transverse to Shell-to-Nozzle Weld

Equipment: Heat Exchanger E-53B

Angle on Nozzle (from horizontal)	Stress in Hx Shell, ksi (across crack in weld)	
	Crack Parallel to Weld	Crack Perpendicular to Weld
0	0.896	18.42
15	1.084	17.33
30	1.393	14.42
45	1.376	10.48
60	0.908	6.38
75	0.420	3.11
90	0.217	2.02

Discussion of Leakage and Size of Leakage Cracks

To evaluate the potential size of the crack that produced the observed leakage at the weep hole, an estimate of the leakage was developed. Then using weld stresses developed from the finite element analysis, crack opening areas and the associated leakage rates were developed.

To estimate the amount of leakage, a mass transfer calculation was conducted assuming that the bottom and sides of the weep hole were wet (100 percent humidity at the surfaces) and that the air surrounding the heat exchanger was dry. To maximize the predicted evaporation rate, it was conservatively assumed that the heat exchanger shell was at 130°F. Performing a pure diffusion mass transfer analysis, a leakage rate of 13.88 lb/year was determined. To determine this effect, the natural convection heat transfer coefficient at the heat exchanger was calculated. The mass transfer determined was conservatively increased by a factor of 50 to arrive at an upper bound estimate of the leakage rate of 694 lb/year (0.000165 gpm). If this amount of water were leaking, there would definitely be clear evidence at the weep hole, since the water could not evaporate into the air this rapidly.

To calculate the crack size in the heat exchanger shell-to-nozzle weld, the SI program pc-LEAK was used. Fundamental fluid mechanics methods are used to calculate leakage of water through the crack based upon the crack opening displacement, surface roughness, and discontinuity losses. Fluid conditions were taken as 120°F and 125 psig. For computing leakage, the membrane stresses across the crack were used consistent with the assumption in the fracture mechanics model. The distribution of the membrane stresses around the shell-to-nozzle weld were presented previously.

The calculation was conducted for leakage from a pipe the size of the heat exchanger shell. In the analysis, there was no correction for the plastic zone at the crack tip so that minimum leakage would be calculated, to maximize the computed crack size. A surface roughness of 0.02 inches was assumed, but this had no effect on the resulting calculations, since the flow was in the laminar flow regime for the very small leakage rates. An entrance loss coefficient of 2.7 was assumed, simulating a sharp-edged entrance to an orifice © = 0.6 and $K = 1/C^2$). This also had very little effect on the results since the pressure drop was mainly due to friction. Two analyses were conducted to evaluate the leakage from a crack parallel and perpendicular to the nozzle to shell weld.

For the crack parallel to the weld, cases were run for a crack length up to 8 inches assuming a range of stresses. The calculated maximum crack size to cause a leak of 0.000165 gpm was approximately 4.5 inches assuming that the crack was over the most lowly stressed region. If the crack were in the more highly stressed region, the crack length would be reduced to about 2 inches.

For the crack perpendicular to the weld, the leakage calculation was conducted using a model for a longitudinal crack in a pipe. The predicted crack size to produce 0.000165 gpm ranges was about 0.18 inches, approximately equal to the shell thickness, for the most highly stressed location. Lower stresses were present at the other locations, which would require larger cracks for the same amount of leakage. Larger cracks were not evaluated since pre-existing cracks in the base material were not considered to be credible.

Discussion of Critical Through Wall Crack Length

An evaluation was done to determine how long a through-wall crack could grow circumferentially and still be able to withstand the applied loads without becoming unstable. The ASME Boiler and Pressure Vessel Code, Section XI, Appendix C, provides rules for evaluating circumferential flaws in austenitic piping. In Subsection C-3300, equations are given for determining the maximum allowable flaw length and depth for a given load, or vice versa. The equations determine the maximum load carrying capability of the remaining ligament, which occurs when the cross section of concern reaches fully plastic action. Subsection C-3200 gives rules for determining flaw growth versus time. Using the design conditions and external piping forces and moments provided, the maximum allowable flaw size for the applied loads was determined.

The evaluation used the highest seismic loads of the SSE case combined with the Code safety factor of 2.77. This is conservative because the 2.77 safety factor is intended for normal operating conditions, while the SSE seismic loads are considered faulted conditions. A lower safety factor is allowed for faulted conditions.

The result of the evaluation indicates that the half angle of circumferential flaw θ= 73.9 degrees. This represents the half crack angle that a through wall flaw can grow circumferentially around the pipe before becoming unstable. The total crack length is double this, about 148 degrees, or 16.4 inches. Thus, the result of this calculation was that if the nozzle to shell double-V weld were to contain a through wall circumferential flaw extending approximately 148 degrees around the circumference, it would still be able to withstand the applied loads without failure. This result conservatively takes no credit for the reinforcing pad.

The leak before break methodology specified by the NRC, in NUREG 1061, Volume 3, dated April 1985, requires a factor of safety of 2 on the stress used in the allowable flaw size evaluation. Another case was run doubling the applied stresses on the flaw. The result was that even with a factor of safety of 2 on stress, a flaw length of about 85 degrees around the circumference, or 9.46 inches, would be acceptable.

The case for a flaw perpendicular to the weld is no longer considered due to the limited growth possibility discussed earlier.

Discussion of Potential Crack Growth

An evaluation was done to determine how much the existing flaw could grow over time under the applied loads. ASME Section XI, Appendix C, Subsection C-3200 [13] gives rules for determining flaw growth in austenitic materials. There are two mechanisms for growing flaws in austenitic piping - stress corrosion cracking, and fatigue cycling. As the spent fuel pool heat exchanger inlet lines operate at 150°F or less, IGSCC is not considered to have the potential to grow the flaw in the nozzle weld.

As for fatigue cycling, there are no significant normal cyclic loading conditions at the nozzle. The spent fuel pool pumps are judged to be too far away to cause vibration at the nozzle. Over the next several years, the number of pressure cycles from system starts will not be significant. The main cyclic loading will be the seismic loading from the attached piping, should a seismic event occur. It will be conservatively assumed that the seismic loads will produce the equivalent of 50 stress cycles.

A load case was also run assuming the flaw would not be repaired. It was conservatively assumed that there would be 50 pressure startup cycles along with the 50 seismic cycles. For 50 cycles, the crack would grow 0.007 inches from an initial length of 4.50 inches, or about 0.1%. The actual crack length is probably much less than 4.50 inches; the rate of crack growth is proportional to the crack length, so the actual percentage increase will also be much less. Thus, it was concluded that the length of the flaw will essentially not change at all.

Discussion of Stress Analysis for the Cracked Nozzle

As a conservative way to evaluate the effect of the flaw on the stress distribution in the nozzle attachment, a finite element analysis model was developed assuming the through wall flaw has grown completely around the pipe. It was desired to determine whether the reinforcing pad and it's structural fillet welds would be able to maintain the pressure boundary integrity of the heat exchanger vessel and the attached piping.

Due to the presence of the two weep holes, it was assumed that the inner shell was still capable of taking the pressure loading, and the exterior fillet welds serve a structural function only. The reinforcing pad-to-vessel fillet weld is known to have a pinhole in it. NDE techniques, visual examination (VT-1), dye-penetrant examination, and replication were used to characterize the indication as a pinhole. Due to the connection configuration, and the fact that the heat exchanger is continuously in service and flooded, ultrasonic testing UT and radiography testing RT are not practical. The pinhole has been determined to be of no consequence, since the stress bearing areas of this structural weld are unaffected by this small pinhole.

For the through-wall, all-around crack condition, pressure was applied in the ANSYS model between the crack and between the nozzle reinforcing pad and vessel outside radius. To evaluate the acceptability of the stresses, the stress allowables given in ASME Section III, Subsection ND-3300 were used. The Level D stress allowables were used for this case because the analysis is interested in demonstrating the reinforcing pad welds will provide pressure boundary integrity.

It was found that the membrane and membrane plus bending stress intensity results for the with-flaw case satisfy the Level D stress limit requirements of the ASME Code. Thus, even if the nozzle to heat exchanger shell weld were to completely rupture, the reinforcing pad and the welds attaching it to the nozzle would be able to maintain the pressure boundary integrity of the nozzle joint.

Discussion of Margins

A comparison was made between the largest flaw that could be present, and the smallest flaw that could be allowed. It was determined by the limit load method that a through-wall flaw in the nozzle to shell double-V weld could extend 148 degrees around the circumference and still withstand the applied loads without rupture. This includes incorporation of the Section XI safety factors for normal and upset conditions, and does not take credit for the resistance offered by the reinforcing pad. Applying the Leak Before Break safety factor on stress, the allowable circumferential flaw length, assuming the flaw is through-wall over its entirety, is reduced to approximately 9.5 inches.

Using conservative assumptions for the rate of evaporation, the maximum possible leak flow rate was determined to be 0.000165 gpm. Applying this flow rate at the location with the least stress available to pull the crack open, a maximum possible flaw length of approximately 4.5 inches was determined. This is more than a factor of 2 smaller than the allowable flaw size. The flow rate associated with the maximum possible flaw length is estimated to be two times larger than flow rate from the maximum existing flaw or 0.000330 gpm.

The calculated growth of the flaw, assuming 50 cycles of both seismic SSE loads and pressure, was less than 1%. The observed flow rate through the flaw has been characterized as being sufficiently low such that the leakage evaporates before it can be measured.

It is concluded, there is ample margin between the probable flaw size and the maximum allowable flaw.

Discussion of Consequences

Discussion of Consequences Regarding Spent Fuel Cooling

As described in DBD-2.07, Section 3.2.1, "System Design," The SFP cooling system is located primarily in the auxiliary building with portions in the containment building. The SFP pumps, heat exchanger, filter, demineralizer, and associated piping and valves are located in the auxiliary building at elevation 590' 0". The suction, discharge, skimmer and tilt pit fill lines enter the spent fuel pool at elevations greater than 644' 5" to assure that failures of downstream piping will not result in unacceptable drainage of fuel pool water inventory. Should E-53B spent fuel pool inlet nozzle become detached, sufficient water inventory would remain in the pool providing a fission product barrier and protecting the spent fuel cladding. Thus, the SIA evaluation demonstrates degradation of one or more fission product barriers would not occur and radiological risk to the general public in excess of 10 CFR Part 100 limits would not be experienced.

Spent fuel pool cooling is assumed to function during the accidents described in FSAR 14.11 and 14.19. Using the criteria of ASME Section XI, Appendix C and NRC NUREG 1061, Volume 3, the SIA evaluation demonstrates sufficient structural integrity for the degraded E-53B nozzle connection and provides assurance of cooling capability in the unlikely event of a fuel handling or cask drop accident.

System Operating Procedure SOP-27, “Spent Fuel Pool,” controls the operating requirements for the SFP system. This procedure describes methods for filling the spent fuel pool with water from the Safety Injection and Refueling Water (SIRW) Tank T-58 and Fire Protection System. Make up rates range from 100 gpm using Safety Injection and Refueling Water Tank T-58 to more than 3000 gpm using shutdown cooling. Even if the cooling system were to fail, sufficient makeup can be provided to maintain the water level sufficiently to keep the fuel covered.

Consequences of Failure on Equipment Flooding

Loss of spent fuel cooling system could occur as a result of piping failures or equipment operation failures (ie, pumps don’t start). Piping failures could result in flooding which may cause a loss of pumping capability. However, as described in FSAR 5.4, the safety related functions associated with the Emergency Power System, Component Cooling System or Engineered Safeguards System would be maintained during any analyzed flooding scenario.

Should E-53B nozzle fail, a significant amount of flooding in the heat exchanger room and Auxiliary Building 590 elevation would occur. FSAR 5.4.2 states, SEP Topic VI-7.D considered the effects of flooding on safety-related equipment required for safe shutdown or accident mitigation due to postulated failures in Non-Class 1 systems. Ten types of equipment were determined to require protection. This equipment is listed in FSAR Table 5.4-1 along with its general location. The NRC's review of this subject considered the potential for flooding from both within and without the equipment compartments. Postulated failures in the circulating water system and the fire protection system represented the controlling cases. In accordance with FSAR Table 5.2-3, the spent fuel pool heat exchangers are Consumers Energy Design Class 1 components; thus, the discussion of FSAR 5.4.2 is not entirely applicable to a failure of E-53B nozzle. However, such a failure in the spent fuel pool heat exchanger room would not result in greater flooding of safety equipment than that associated with a SIRW Tank failure as described in FSAR 5.4.2.

Conclusions

Based on analysis, review of design bases documents and approved procedures the following conclusions can be justified:

1. There is a margin greater than 2 between the maximum possible existing flaw and the critical flaw size, thus assuring continued structural adequacy for E-53B spent fuel pool inlet nozzle.
2. Make up capacities ranging from 100 to greater than 3000 gpm assure the leak flow rate associated with the critical flaw size will not result in spent fuel pool drainage.
3. Complete failure of the nozzle to vessel weld will not result in failure of the nozzle assembly as evidenced by the connection meeting ASME Section XI, Appendix C stress limits.
4. Failure of the degraded nozzle will not result in unacceptable equipment flooding or in uncovering spent fuel.

Proposed Alternative:

Plant Auxiliary Operators are certified in accordance with ANSI N45.2.6 as Visual Examination VT-2, Level 2 Examiners. A periodic action will be scheduled to inspect this connection at an initial frequency of weekly.

Inspection frequency shall initially be established at once per week for an initial period of six months. Following this six month period and based on observation that the leak remains essentially unchanged, the inspection period may be doubled each inspection until an inspection frequency of no less than once each six months is reached.

Leakage from either weep hole shall be limited to less than or equal to a measurable leak flow rate of 0.000165 gpm or 37 ml/hr, based on the maximum leak rate associated with a critical flaw size. If leakage exceeds 0.000165 gpm (37 ml/hr), repairs will be performed no later than the next refueling outage.

Applicable Time Period:

Relief is requested for the third ten-year Inservice Inspection Program interval which concludes August 2005 or until repairs are made. This relief request requires NRC approval in accordance with 10 CFR 50:55a(a)(3)(i).