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U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Stop O-P1-17
Washington, DC 20555-0001

Donald C. Cook Nuclear Plant Unit 1
AMERICAN SOCIETY OF MECHANICAL ENGINEERS CODE,
SECTION XI REPAIR REQUIREMENTS
PREEMPTIVE WELD OVERLAY – STRESS SUMMARIES

Reference: Letter from Mark A. Peifer, Indiana Michigan Power Company, to Nuclear Regulatory Commission Document Control Desk, "Donald C. Cook Nuclear Plant Unit 1, Supplement to Proposed Alternative to the American Society Of Mechanical Engineers Code, Section XI Repair Requirements," AEP:NRC:6055-17, Accession Number ML062780203, dated September 26, 2006.

In the referenced letter, Indiana Michigan Power Company (I&M), the licensee for Donald C. Cook Nuclear Plant Unit 1, proposed an alternative to the repair requirements of the American Society of Mechanical Engineers Code, Section XI. Approval of the proposed alternative was requested to allow I&M to apply full structural preemptive weld overlays (PWOLs) on pressurizer nozzle safe end to nozzle welds where NiCrFe Alloy 82/182 was originally used to weld the safe ends thereto. In requesting approval of the proposed alternative, I&M committed to providing the Nuclear Regulatory Commission with the stress summaries for the PWOLs. The attachment to this letter provides the PWOL stress summaries and the associated flaw growth evaluation, which has been conservatively calculated by assuming that a 360 degree circumferential flaw would propagate by primary water stress corrosion cracking through the thickness of the Alloy 82/182 weld, to the interface with the Alloy 52/52M overlay material.

This letter contains no new commitments. Should you have any questions, please contact Ms. Susan D. Simpson, Regulatory Affairs Manager, at (269) 466-2428.

Sincerely,

Joseph N. Jensen
Vice President Site Support Services

RGV/rdw

A047

Attachment: Donald C. Cook Unit 1, Preemptive Weld Overlay Structural Evaluation Summary

c: R. Aben – Department of Labor and Economic Growth
J. L. Caldwell – NRC Region III
K. D. Curry – AEP Ft. Wayne, w/o attachment
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ATTACHMENT TO AEP:NRC:6055-19

Donald C. Cook Unit 1
PREEMPTIVE WELD OVERLAY STRUCTURAL EVALUATION SUMMARY

Abbreviations and Symbols Used in this Attachment

ASME	American Society of Mechanical Engineers
B&PV	Boiler and Pressure Vessel Code
CNP	Donald C. Cook Nuclear Plant
DM	Dissimilar Metal
FCG	Flaw Crack Growth
HUCD	Heatup Cooldown
in.	inches
ksi	thousand pounds per square inch
OBE	Operating Basis Earthquake
psi	pounds per square inch
PWSCC	Primary Water Stress Corrosion Cracking
SI	Stress Intensity
SS	Stainless Steel
=	Equal to
<	Less than
>	Greater than

PRESSURIZER PIPING WELD OVERLAY STRESS ANALYSIS SUMMARY
ASME SECTION III CRITERIA

1.0 Introduction

Due to the susceptibility of Alloy 600 and its associated weldments, Alloy 82/182, to PWSCC, Indiana Michigan Power Company applied full structural weld overlays to the safety, relief, spray, and surge nozzles of the CNP Unit 1 pressurizer. A repair procedure was developed where the DM Alloy 82/182 weld and butter, the SS safe end and weld, and a portion of both the nozzle and attached pipe were overlaid with PWSCC resistant Alloy 52/52M material.

ASME B&PV Code, Section III stress analyses were performed for the CNP Unit 1 pressurizer nozzles repaired with weld overlays in compliance with ASME Code Case N-504-2, Paragraph g (1). Three dimensional ANSYS computer code finite element models for the three nozzles with weld overlays were developed, and detailed finite element analyses (thermal and structural) were performed. The purpose of these calculations was to qualify the weld overlay design to the requirements of the 1998 ASME B&PV Code, including Addenda through 2000, Section III criteria. The weld overlay size (thickness and length) was calculated per ASME B&PV Code, Section XI, Division 1 and ASME Code Case N-504-2.

Thermal stresses were determined for the appropriate design transients and a fatigue analysis was performed. The design conditions as well as the thermal transients were evaluated with the finite element models. The results of the thermal analysis were reviewed by examining the magnitude of the temperature difference between critical locations in the models at times when the maximum thermal stresses would develop. The stresses due to the nozzle external loads were calculated and added to the stresses resulting from internal pressure and thermal gradients. The applicable criteria of the 1998 ASME B&PV Code, Section III requirements were met.

2.0 Results

2.1 Primary Stress Intensity Criteria for Design Conditions and All Service Level Loadings

The weld overlay applied on the outside surface relieves the nozzle primary stress burden resulting from the applied internal pressure and external loads. Therefore, ASME B&PV Code, Section III primary stress requirements for design conditions and all service level loadings as specified in Paragraphs NB-3221, NB-3222, NB-3223, NB-3224, and NB-3225 have been satisfied for the nozzles, welds with overlays, safe ends, and piping elbows that were evaluated. Therefore, the primary stress intensity criteria for design conditions and all service level loadings are bounded by the original design.

2.2 Minimum Required Pressure Thickness and Reinforcement Area Criteria

Adding the weld overlay will increase the nozzle wall thickness. As a result the ASME B&PV Code Section III requirements contained in Paragraphs NB-3324 and NB-3330 are satisfied.

2.3 Primary Plus Secondary Stress Intensity

The final SI range is obtained by adding the maximum membrane plus bending SI range during transients to that due to the applied external loads (thermal plus OBE). Per ASME B&PV Code, Section III, Subparagraph NB-3222.2, the SI range limit is $3S_m$. Although the final SI range at most locations evaluated is below the $3S_m$ limit, there are several locations where the limit is exceeded. When the $3S_m$ limit is exceeded, the shear bending SI range was subtracted from the total membrane plus bending SI range. The highest SI range in each nozzle is listed as follows:

Safety/Relief Nozzle = 69.66 ksi < $3S_m$= 69.90 ksi

Spray Nozzle = 97.57 ksi > $3S_m$= 49.38 ksi

Surge Nozzle = 121.30 ksi > $3S_m$= 56.10 ksi

As can be seen, the spray nozzle and the surge nozzle have locations that exceed the $3S_m$ limit. Per the ASME B&PV Code, Section III, the $3S_m$ limit on the primary plus secondary SI range may be exceeded provided that the requirements of Subparagraph NB-3228.5 (a) through (f) are met. The evaluations of the spray and surge nozzles are provided in the following paragraphs.

2.3.1 Spray Nozzle

The spray nozzle meets all criteria at all locations where the $3S_m$ limit is exceeded.

2.3.2 Surge Nozzle

The surge nozzle did not meet the requirement (a) criterion that the primary plus secondary membrane plus bending SI range, excluding thermal bending stresses, shall be less than $3S_m$. The $3S_m$ limit is still exceeded at the thermal sleeve, 87.6 ksi > $3S_m$ = 56.1 ksi. Therefore, the ASME B&PV Code, Section III requirement is not met at this location and a detailed evaluation based on the elastic-plastic approach was performed for the HUCD transients with an insurge-outsurge fluid temperature difference of 320 degrees Fahrenheit.

Elastic – Plastic Analysis of the Surge Nozzle Weld Overlay for HUCD Transients: The elastic-plastic analysis was performed in accordance with ASME B&PV Code, Section III, Subparagraph NB-3228.4, "Shakedown Analysis." The Subparagraph NB-3228.4 criteria are met.

2.4 Fatigue Analysis

The fatigue usage factor of the three nozzles is conservatively calculated for 60 years of operation (40 design life plus 20 years life extension). Below is a summary:

Safety/Relief Nozzle: the highest cumulative fatigue usage factor = 0.025 < 1.0 (ASME Criteria)

Spray Nozzle: the highest cumulative fatigue usage factor = 0.890 < 1.0 (ASME Criteria)

Surge Nozzle: the highest cumulative fatigue usage factor = 0.214 < 1.0 (ASME Criteria)

3.0 Conclusion

Based on the above results, the requirements of Paragraph (g)(1) of ASME Code Case N-504-2 are met, and the repair has been shown to be acceptable for the remaining service life of CNP Unit 1.

PRESSURIZER PIPING WELD OVERLAY
FATIGUE CRACK GROWTH ANALYSIS SUMMARY

1.0 Introduction

The overlays applied to the pressurizer piping were analyzed for potential growth of a worst case flaw in the nozzle/pipe welds. It was postulated that a 360 degree circumferential flaw would propagate by PWSCC through the thickness of the Alloy 82/182 weld, to the interface with the Alloy 52/52M overlay material. Although PWSCC would not continue to occur in the Alloy 52/52M overlay, it was postulated that a small fatigue initiated flaw forms in the Alloy 52/52M overlay and combines with the PWSCC crack in the Alloy 82/182 weld to form a large part-through-wall full circumferential flaw that would propagate into the Alloy 52/52M overlay by fatigue crack growth under cyclic loading conditions.

Fracture mechanics analyses were performed to evaluate this worst case flaw in the repair configuration in compliance with ASME Code Case N-504-2, Paragraph (g)(2). These evaluations considered the residual welding, steady state, and normal/upset condition transient stresses with the associated number of transient cycles to predict the final flaw size at the end of license extension at CNP Unit 1, which equates to a 29 year service life. These evaluations demonstrated that the postulated circumferential flaw met the 1989 ASME B&PV Code, Section XI, Appendix C acceptance criteria. An additional check was made on the applied membrane stresses in the remaining ligament under normal operating conditions. These analyses were performed for both the Alloy 82/182 weld as well as the SS weld joining the safe end to the piping.

2.0 Results

2.1 Safety/Relief Nozzles

2.1.1 Flaw Growth Results

	DM Weld	SS Weld
Minimum Weld Overlay Thickness, in.	0.5370	0.4850
Additional Weld Overlay Thickness for FCG, in.	0.0300	0.0000
Initial Flaw Size, in.	1.4800	0.7150
Final Flaw Size after 29 Years, in.	1.4858	0.7150
Flaw Growth, in.	0.0058	0.0000
Final Crack Depth to Thickness Ratio	0.7497	0.5958

2.1.2 Limit Load Analysis Results

At the final crack depth, the plastic collapse stress calculated in accordance with ASME B&PV Code, Section XI, Appendix C is compared to the failure bending stress in the pipe, accounting for safety factors for normal/upset and emergency/faulted conditions. At both overlaid locations (the DM and SS welds), the requirement that the plastic collapse stress exceed the failure bending stress is met.

	Normal/Upset	Emergency/Faulted
Plastic collapse stress at DM weld, psi	30,473	30,349
Failure bending stress at DM weld, psi	9,347	8,980
Plastic collapse stress at SS weld, psi	45,788	45,602
Failure bending stress at SS weld, psi	15,761	15,828

2.1.3 Applied Membrane Stress Considerations

The applied membrane stress in the remaining ligament is less than the operating temperature yield stress.

Yield stress at DM weld, psi	27,500
Membrane stress at DM weld, psi	10,588
Yield stress at SS weld, psi	27,500
Membrane stress at SS weld, psi	9,057

2.2 Spray Nozzle

2.2.1 Flaw Growth Results

	DM Weld	SS Weld
Minimum Weld Overlay Thickness, in.	0.397000	0.35140
Additional Weld Overlay Thickness for FCG, in.	0.023000	0.00000
Initial Flaw Size, in.	1.060000	0.44000
Final Flaw Size after 29 Years, in.	1.060004	0.44003
Flaw Growth, in.	0.000004	0.00003
Final Crack Depth to Thickness Ratio	0.7491	0.5560

2.2.2 Limit Load Analysis Results

At the final crack depth, the plastic collapse stress calculated according to ASME B&PV Code, Section XI, Appendix C is compared to the failure bending stress in the pipe, accounting for safety factors for normal/upset and emergency/faulted conditions. At both overlaid locations (the DM and SS welds), the requirement that the plastic collapse stress exceed the failure bending stress is met.

	Normal/Upset	Emergency/Faulted
Plastic collapse stress at DM weld, psi	30,300	30,091
Failure bending stress at DM weld, psi	12,959	10,064
Plastic collapse stress at SS weld, psi	49,474	49,123
Failure bending stress at SS weld, psi	23,369	18,557

2.2.3 Applied Membrane Stress Consideration

The applied membrane stress in the remaining ligament is less than the operating temperature yield stress.

Yield stress at DM weld, psi	27,500
Membrane stress at DM weld, psi	11,169
Yield stress at SS weld, psi	27,500
Membrane stress at SS weld, psi	8,732

2.3 Surge Nozzle

2.3.1 Flaw Growth Results

	DM Weld	SS Weld
Minimum Weld Overlay Thickness, in.	0.5200	0.7600
Additional Weld Overlay Thickness for FCG, in.	0.0120	0.0000
Initial Flaw Size, in.	1.5600	1.3900
Final Flaw Size after 29 Years, in.	1.5678	1.3900
Flaw Growth, in.	0.0078	0.0000
Final Crack Depth to Thickness Ratio	0.7494	0.6465

2.3.2 Limit Load Analysis Results

At the final crack depth, the plastic collapse stress calculated according to ASME B&PV Code, Section XI, Appendix C is compared to the failure bending stress in the pipe, accounting for safety factors for normal/upset and emergency/faulted conditions. At both overlaid locations (the DM and SS welds), the requirement that the plastic collapse stress exceed the failure bending stress is met.

	Normal/Upset	Emergency/Faulted
Plastic collapse stress at DM Weld, psi	27,490	27,130
Failure bending stress at DM weld, psi	11,165	20,808
Plastic collapse stress at SS weld, psi	39,800	39,493
Failure bending stress at SS weld, psi	10,724	20,157

2.3.3 Applied Membrane Stress Consideration

The applied membrane stress in the remaining ligament is less than the operating temperature yield stress.

Yield stress at DM weld, psi	27,500
Membrane stress at DM weld, psi	17,844
Yield stress at SS weld, psi	27,500
Membrane stress at SS weld, psi	11,633

3.0 Conclusion

Based on the above results, the requirements of Paragraph (g)(2) of ASME Code Case N-504-2 are met, and the repair has been shown to be acceptable for the remaining service life of CNP Unit 1.