ATTACHMENT A

Calculation CMED-060298,
"Flaw Evaluation for Core Plate Support Ring for Unit 3 Core Shroud."

COMED NUCLEAR DESIGN INFORMATION TRANSMITTAL

☒ SAFETY-RELATED ☐ NON-SAFETY-RELATED ☐ REGULATORY RELATED	Originating Organization: Section: CMED Company: Sargent & Lundy	NDIT No.: S040-D[illegible]-0453 Upgrade: 0 Page 1 of 1

Station: Dresden Station Units: 3

Design Change Authority No.: N/A

System: 0200

To: G. Whitman - ComEd/Dresden Station

Subject:

Flaw Evaluation for Core Plate Support Ring for Core Shroud
Project No. 10128-052

Preparer: J. W. Johnson	Position: System Engineer	Signature: [signature]	Date: 5/17/97
Reviewer: S. N. Lansford	Position: Component Engineer	Signature: [signature]	Date: 5/17/97
Approver: T. J. Behringer	Position: Senior Project Engineer	Signature: [signature]	Date: 5/17/97

Status of Information: ☒ Approved for Use ☐ Unverified ☐ Engineering Judgment

Verification Method:

Schedule:

Purpose of Issuance:

Transmit results of flaw evaluation for the core plate support ring for the Unit 3 core shroud.

Source of Information:

Sargent & Lundy Calculation No. CMED-060298, Revision 0

Description of Information:

Attached is S&L Calculation No. CMED-060298, Rev. 0 which is an evaluation of the vertical flaws in the core plate support ring of the Unit 3 core shroud. These flaws are identified in the letter of 4/29/97 from S. Stanford (GE Nuclear Energy) to G. Whitman (ComEd), which is Attachment A of the calculation. Based on this calculation, it is determined that the remaining uncracked cross-section of the ring which is required to maintain structural integrity for all design basis loads is 7.4 $in.^2$. When the estimated crack growth for four 24 month operating cycles is added to this, the required uncracked section area becomes 21.4 $in.^2$.

The actual uncracked section area is conservatively calculated to be 40.7 $in.^2$, based on a crack 4" long by 0.50" deep. Since the actual uncracked section area exceeds the required uncracked section area (including the allowance for crack growth), these flaws will be acceptable for a period of 4 operating cycles of 24 months each.

Distribution:

G. H. DeBoo - ComEd
C. Morris - Sargent & Lundy
D. Bianchini - S&L
CN Petropoulos - S&L
R. Greeman - ComEd

File No.: N/A CHRON No.: N/A

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CALCULATION TITLE PAGE

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[X] SAFETY RELATED [ ] REGULATORY RELATED [ ] NON-SAFETY RELATED

CALCULATION TITLE:

Flaw Evaluation for Core Plate Support Ring
for Unit 3 Core Shroud

STATION/UNIT: Dresden Unit 3 SYSTEM ABBREVIATION: 0200

EQUIPMENT NO.: (IF APPL.) PROJECT NO.: (IF APPL.) 10128-052

REV: 00 STATUS: Approved QA SERIAL NO. OR CHRON NO. DATE:

PREPARED BY: Jay W. Johnson [signature] DATE: 05/17/97

REVISION SUMMARY: Initial Issue

ELECTRONIC CALCULATION DATA FILES REVISED:
(Name ext/size/date/hour: min/verification method/remarks)

060298R0.MCD/28645/5/17/97/11:52

DO ANY ASSUMPTIONS IN THIS CALCULATION REQUIRE LATER VERIFICATION YES [ ] NO [X]

REVIEWED BY: Henry J. Guerriero II [signature] FOR S. LANSFORD DATE: 05/17/97

REVIEW METHOD: Detailed design review method COMMENTS (C OR NC OR CI): NC

APPROVED BY: Thomas J. Behringer [signature] DATE: 05/17/97

Exhibit D
NEP-12-02
Revision 4

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1.0 PURPOSE/OBJECTIVE:

The purpose of this calculation is to evaluate flaws identified by ultrasonic examination in or near Core Shroud Segment Vertical Welds V23 and V25. These welds are located in the Core Plate Support Ring. The flaws are documented in the GE letter dated 4/29/96 (Reference 5.1). This evaluation will demonstrate that the ring will maintain structural integrity, with an appropriate factor of safety, considering a crack growth rate of $5X10^{-5}$ inches per hour for 4 fuel cycles (96 months).

2.0 METHODOLOGY AND ACCEPTANCE CRITERIA:

The flaw evaluation methods specified in the BWRVIP inspection and evaluation guidelines (Reference 5.2) are used in this evaluation. These guidelines specify limit load and linear elastic fracture mechanics (LEFM) methods to establish that the remaining uncracked material is sufficient to meet the structural requirements of the section being evaluated. In addition to these methods, a primary stress check consistent with the requirements of Subsection NG of the ASME B&PV Code is performed to ensure that the structural margins inherent in the original design of the shroud are maintained. This is the same methodology used in Reference 5.3 to develop vertical weld inspection critieria for the core shroud.

As indicated in Reference 5.2, the LEFM evaluation is only required where high fluence levels, greater than $3 X 10^{20}$ n/cm^2, may reduce the toughness of the core shroud material. This is not of concern below the H5 welds (Reference 5.3); therefore, the LEFM evaluation is not performed.

The subject flaws are located in a radial-vertical plane which is affected by the hoop stress generated primarily by the pressure differential. Other stresses in the vertical or radial directions will not contribute to crack growth or instability for flaws in this plane. The hoop stresses are based on output from the ANSYS finite element analysis of the core shroud prepared by General Electric Nuclear Engineering (Reference 5.4) for the core shroud repair modification. This analysis includes seismic and LOCA loads as well as the pressure differential loads. From these hoop stresses a maximum hoop load was calculated for the upset and faulted conditions (Reference 5.3).

The maximum hoop loads are used to determine the critical crack length and the required remaining ligament. The expected crack growth is added to the required remaining ligament to determine the size of the uncracked section required to maintain structural stability for a 96 month period. This is compared to the actual uncracked section left after deducting the maximum flaw depth reported in Reference 5.1 to determine acceptability.

3.0 ASSUMPTIONS:

Assumptions for this calculation are stated in the calculation where they are used. They are conservative and require no further verification.

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4.0 DESIGN INPUT:

4.1 Material Properties

The core shroud components and welds being evaluated are type 304 stainless steel at 550°F (Reference 5.5). The following material properties at 550°F are used for this evaluation and are taken from Reference 5.6:

Design Stress Intensity: S_m 16900.0·psi

Yield Strength: σ_y · 18800.0·psi

Modulus of Elasticity: $E = 25.5 \cdot 10^6 \cdot psi$

Flow Stress: σ_f $3 \cdot S_m$ $\sigma_f = 5.07 \cdot 10^4 \cdot psi$

4.2 Safety Factors:

As required in Section XI of Reference 5.6 and recommended in Reference 5.2, the following Safety Factors are used to maintain design margins:

Normal/ Upset Condition: $SF_U = 2.8$

Emergency/Faulted Condition: $SF_F = 1.4$

4.3 Loads:

The pressure differentials provided below are the upper bound limits taken from Reference 5.7 for welds below the H5 weld. These are the pressure differentials used to calculate the hoop stress from pressure alone. This pressure hoop stress is compared to the combined loading hoop stress from the finite element analyses to ensure the larger of the two values is used to establish the required remaining ligament.

Pressure Differential for Upset Conditions: P_U 25.0·psi

Pressure Differential for Faulted Conditions: P_F · 30.0·psi

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The combined loading hoop stress was previously calculated in Reference 5.3 for both the bounding upset and faulted conditions. The bounding upset load case combines dead weight, normal pressure differential and OBE loads. The bounding faulted load case combines dead weight, LOCA pressure differential and SSE loads. In Reference 5.3 the stresses from the finite element results, presented in Attachments F and G of Reference 5.3, are in a global coordinate system and were translated to the hoop direction for the evaluation. The following equation, taken from Reference 5.8 was used to calculate the hoop stress for each element.

$$\sigma_{hoop} = \frac{\sigma_x + \sigma_y}{2} - \frac{\sigma_x - \sigma_y}{2} \cdot \cos(2\cdot\theta) - \tau_{xy} \cdot \sin(2\cdot\theta)$$

The total hoop direction stress acting on the ring segment section is found in Attachments D and E of Reference 5.3 for the upset and faulted conditions respectively. The largest total hoop stress from the 180^{O} model is used in the flaw evaluations. The following table presents a comparison of the maximum combined load hoop stress to the pressure hoop stress, PD/2t, for each ring.

	Pressure Hoop Stress	Combined Load Hoop Stress
Upset Condition:	230 psi	2795 psi (DW + ΔP_{NORMAL} + OBE)
Faulted Condition:	276 psi	5877 psi (DW + ΔP_{LOCA} + SSE)

4.4 Estimated Crack Growth

The estimated crack growth is based on the very conservative growth rate of 5 x10^{-5} in/hour, Reference 5.2, for 4 fuel cycles with the reactor over 200°F, i.e. 70000.0 hours. In Reference 5.3, the crack growth was multiplied by 2 because double edge cracks and center cracks with two crack tips were postulated. In this case, crack growth and the flaw length determination affects only one end of a flaw. The projected crack growth is added to the minimum required length of material to define the required remaining ligament.

$$ECG := 70000.0 \cdot hr \cdot 5 \cdot 10^{-5} \cdot \frac{in}{hr} \qquad ECG = 3.5 \cdot in$$

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4.5 Inspection Results and Flaw Characterization:

The subject flaws occur in the core plate support ring of the core shroud in the vicintiy of vertical welds V23 and V25 (Reference 5.1). Eac flaw lies in a vertical-radial plane. The visible portion of each flaw extends downward from the circumferential flaw adjacent to the H5 weld.

At V23 the vertical length of the flaw is 2.8" and the maximum radial depth of the flaw is 0.50". The average depth of the flaw is approximately 0.25" to 0.40" over the major length of the flaw.

At V25 the vertical length could not be determined due to shallow depth and orientation; however, the area of flaw length sized was 1.2". The maximum radial depth measured was 0.25". The average depth of the flaw is approximately 0.15" to 0.25" over the major length of the flaw.

5.0 REFERENCES:

5.1 Letter Dated 4/29/96 from S. Sanford (GE Nuclear Energy) to J. Whitman (CECo Reactor Engineering), Subject: Preliminary UT Results of Shroud Vertical Welds V23 and V25.

5.2 BWRVIP Document GENE-523-113-0894, "BWR Core Shroud Inspection and Evaluation Guidelines," September 1994.

5.3 S&L Calculation No. CMED-059112, Rev. 0, Dated 6/9/95, "Core Shroud Vertical Weld Flaw Evaluation for Inspection Acceptance Criteria".

5.4 GENE DRF B13-01749, ANSYS Finite Element Analysis Results Output, Provided by General Electric Nuclear Engineering (See Attachments F & G of Reference 5.3).

5.5 GENE-771-82-1194, Rev 1, "Backup Calculations for Dresden Shroud Repair Shroud Stress Report," May 1995.

5.6 ASME B&PV Code 1989 Edition

5.7 SL-4971, Rev. 0, "Final Evaluation of the Core Shroud Flaws at the H5 Horizontal Weld For Dresden Unit 3," December 12, 1994.

5.8 Nash, William A.; "Schaum's Outline of Theory and Problems of Strength of Materials", 2nd Edition, McGraw-Hill Book Co.

5.9 S&L Report No. SL-4999, Rev. 0, Dated 6/12/96, "Dresden Units 2 & 3 Core Shroud Repair, Design Reliant Structures Inspection Requirements and Acceptance Criteria".

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6.0 CALCULATIONS:

Area of Uncracked Section:

Assuming a conservative flaw size of 4 inches vertical (full ring height) by 0.50 inches radial, the area of the uncracked section is calculated as follows:

Plate Thickness (Vertical Dimension):	$t := 4.0 \cdot in$	
Plate Width (Radial Dimension):	$L := 10.685 \cdot in$	
Uncracked Section Area:	$A_{uc} := t \cdot (L - 0.5 \cdot in)$	$A_{uc} = 40.7 \cdot in^2$

Total Ring Hoop Loads:

Normal/Upset Total Ring Hoop Stress:	$\sigma_U := 2795 \cdot psi$	(Ref. 5.3)
Total Load on Vertical Plane Due to Normal/Upset Total Hoop Stress:	$T_{TU} := \sigma_U \cdot L \cdot t$	$T_{TU} = 1.195 \cdot 10^5 \cdot lb$
Emergency/Faulted Total Ring Hoop Stress:	$\sigma_F := 5877 \cdot psi$	(Ref. 5.3)
Total Load on Vertical Plane Due to Emergency/Faulted Total Hoop Stress:	$T_{TF} := \sigma_F \cdot L \cdot t$	$T_{TF} = 2.512 \cdot 10^5 \cdot lb$

Limit Load Evaluation:

Limit Load evaluation for an edge crack on a semi-infinite plate subjected to a uniform tensile load based on the hoop stress from the combined upset condition loads and the faulted condition loads:

Normal/Upset Conditions:

Limit Load Normal/Upset Critical Crack Length:	$c_c := L - \dfrac{T_{TU} \cdot SF_U}{\sigma_f \cdot t}$	$c_c = 9.036 \cdot in$
Required Remaining Ligament:	$b := L - c_c$	$b = 1.649 \cdot in$
Required Normal/Upset Remaining Ligament Based on Limit Load:	$LL_u := b + ECG$	$LL_u = 5.149 \cdot in$

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<u>Emergency/Faulted Conditions:</u>

Limit Load Emergency/Faulted critical crack length for membrane load only	$c_c = L \frac{T_{TF} \cdot SF_F}{\sigma_f t}$	$c_c = 8.951 \cdot in$
The required remaining ligament is b:	$b \quad L - c_c$	$b = 1.734 \cdot in$
Required Emergency/Faulted Remaining Ligament Based on Limit Load:	$LL_f \cdot b \cdot ECG$	$LL_f = 5.234 \cdot in$

<u>Primary Stress Evaluation:</u>

<u>Normal/Upset Condition:</u>

Primary Stress Critical Crack Length:	$c_{psc} = L \frac{T_{TU}}{S_m \cdot t}$	$c_{psc} = 8.918 \cdot in$
Required Remaining Ligament:	$b = L - c_{psc}$	$b = 1.767 \cdot in$
Required Remaining Ligament for Normal/Upset Conditions Based on Primary Stress Requirements:	$PS_u = b + ECG$	$PS_u = 5.267 \cdot in$

<u>Emergency/Faulted Condition:</u>

Primary Stress Critical Crack Length	$c_{psc} = L - \frac{T_{TF}}{2 \cdot S_m \cdot t}$	$c_{psc} = 8.827 \cdot in$
Required Remaining Ligament:	$b = L - c_{psc}$	$b = 1.858 \cdot in$
Required Remaining Ligament for Emergency/Faulted Conditions Based on Primary Stress Requirements:	$PS_f = b + ECG$	$PS_f = 5.358 \cdot in$

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Required Area of Uncracked Section:

The primary stress emergency/faulted condition yields the largest required remaining ligament. Using this value the required uncracked section of the core plate support ring is:

$A_{req} \quad PS_f t \qquad A_{req} = 21.4 \cdot in^2$

This required area of uncracked section includes the estimated crack growth for 4 fuel cycles of 24 months each. The uncracked section required to withstand the design basis loads, exclusive of crack growth is:

$A_{req} \quad b \cdot t \qquad A_{req} = 7.4 \cdot in^2$

7.0 SUMMARY AND CONCLUSIONS:

The uncracked section, A_{uc}, of the core support plate ring is 40.7 in.^{2} based on a conservative calculation. This exceeds the required uncracked section of 21.4 in.^{2} (including expected crack growth) by a 90% margin; therefore, the flaws identified in Reference 5.1 in the core support plate ring will be acceptable for a period of 4 operating cycles (96 months).

GE Nuclear Energy

Commonwealth Edison Company
Dresden Nuclear Power Station D3R14 Shroud Vertical Weld UT Project 1GQ3J

To: Jerry Whitman - CECo Reactor Engineering
From: Steve Stanford - GE UT Level III
Date: 29 April 98
CC: R. Keck, T. Rockwood

Sub: Preliminary UT Results of Shroud Vertical Welds V23 and V25

Core Shroud Ring Segment Vertical Welds V23 and V25 flaw indications, believed to be transverse components extending from the circumferential flaw adjacent to the H5 weld, were documented by the Visual Examination Method during IVVI Inspections. The vertical segment weld locations are not confirmed, as they cannot be visually seen due to the machined surface of the ring. Exact flaw location could not be determined in regards to vertical segment weld proximity by the visual method. Ultrasonic examinations were performed with the GE Suction Cup Scanner in the areas of these recorded indications to determine the following:

a) the thru-wall depth of the flaws
b) the proximity of the flaws to the ring segment welds
c) the possibility of the flaws not being associated with the circumferential flaw adjacent to the H5 weld

Ultrasonic data revealed the following information to address the topics above:

V23
The flaw is contained within an area of localized grinding, evident in the visual examinations, and is believed to be a connected transverse component to the H5 circumferential flaw adjacent to the H5 weld. The acquired flaw data is directly adjacent to the circumferential weld and flaw. The maximum thru-wall depth recorded was 0.50" and was in the portion of the flaw next to the circumferential weld H5. The average depth of the flaw is approximately 0.25" to 0.40" for the major length of the flaw. Total flaw length recorded was 2.8", extending downward from the H5 circumferential weld. There was no supportive evidence provided by ultrasonics that the ring segment weld is in close proximity to the recorded flaw (see note below).

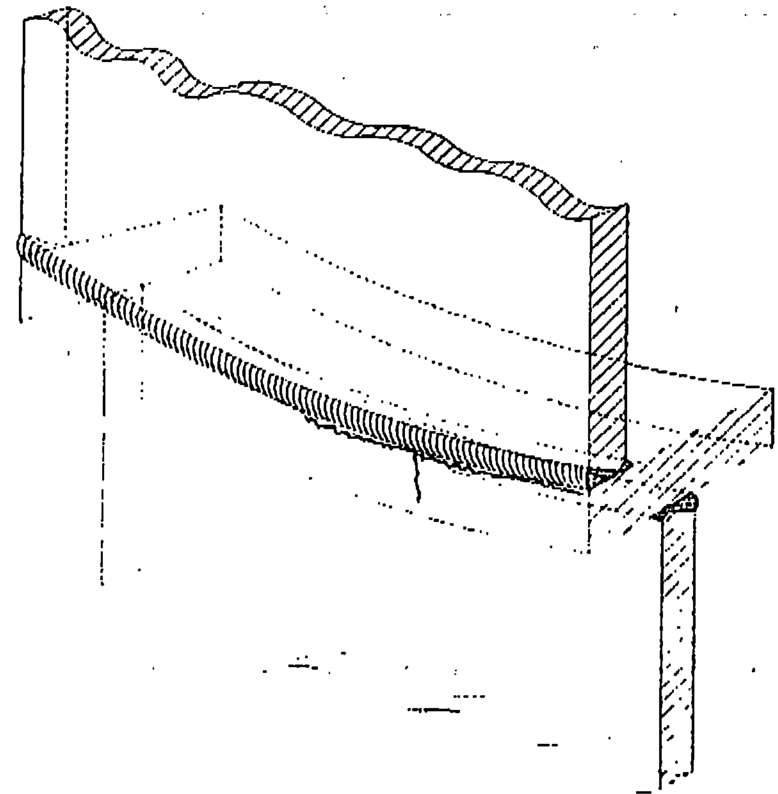
V25
The flaw is contained within an area of localized grinding, evident in the visual examinations, and believed to be a connected transverse component of the H5 circumferential flaw adjacent to the H5 weld. The acquired flaw data is directly adjacent to the circumferential weld and flaw. The maximum thru-wall depth recorded was 0.25" and was in the portion of the flaw next to the circumferential weld H5. The average depth of the flaw is approximately 0.15" to 0.25" for the major length of the flaw. Actual flaw length could not be ultrasonically determined due to the absence of continuous data (believed to be caused from shallow flaw depth and flaw orientation). The area of flaw length sized was 1.2" from the H5 weld, extending downward from the H5 circumferential weld. There was no supportive evidence provided by ultrasonics that the ring segment weld is in close proximity to the recorded flaw (see note below).

Note: Weld material response comparisons were performed utilizing BWRVIP qualification data obtained from scans performed on a ring segment weld mock-up. The ring segment weld was discernable in the qualification data. Based upon this comparison, it is believed that evidence of a ring segment weld would have been seen if weld material was present in the vicinity of the recorded flaws.

GE Nuclear Energy

ComEd

Commonwealth Edison Company
Dresden Nuclear Station April 1997 Shroud Vertical Weld Project 1GQ3J



Recordable Indications Con't.

Scan of Indication at approximately 225° Az. Displaying Flaw Tip Signal