ATTACHMENT A

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



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KI SAFETT-RELATED	Originating Organizatio	n:	NDIT No.: S040-DM-0453		
NON-SAFETY-RELATED	Section: <u>CMED</u>		Upgrade: 0		
REGULATORY RELATED	Company: <u>Sargent & Lu</u>	ndy	Page 1 of 1		
Station: Dreaden Station	Units: 3	System:	To: G. Whitman - Cor	mEd/Dresden Statio	
Design Change Authority No .:	N/A	0200			
Subject:					
Flaw Evaluation for Core Plat Project No. 10128-052	e Support Ring for Core Shroud				
J. W. Johnson	System Engineer	Signat	W Johnson	<u>5/17/97</u>	
S. N. Lansford	Component Engineer	Sionat	Landad	<u>5/17/97</u>	
T. J. Behringer	Senior Project Engineer	Signat	Behinger	<u> </u>	
Source of Information:					
Sargent & Lundy Calculation	No. CMED-060298, Revision 0				
Description of Information:	······································				
Description of Information: Attached is S&L Calculation I ring of the Unit 3 core shroud G. Whitman (ComEd), which uncracked cross-section of th When the estimated crack gr becomes 21.4 in. ² .	No. CMED-060298, Rev. 0 which is These flaws are identified in the Is Attachment A of the calculation. Is ring which is required to maintai owth for four 24 month operating c	s an evaluation letter of 4/29/s Based on thi n structural int ycles is addeo	o of the vertical flaws in 97 from S. Stanford (GE s calculation, it is deter egrity for all design bas to this, the required un	the core plate supp E Nuclear Energy) to mined that the rema is loads is 7.4 in. ² . hcracked section are	
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CALCULATION NO. CMED-060298	PAGE NO.: 1
SAFETY RELATED REGULATORY RELATED NO.	N-SAFETY RELATED
CALCULATION TITLE:	
Flaw Evaluation for Core Plate Support Ring for Unit 3 Core Shroud	
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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 AW Johnson	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	
REVIEWED BY: Henry J. Guerriero II Stangland FOR	DATE: 05/17/97
S.LANSFORD REVIEW METHOD: Detailed design review method COMMENTS (C OR	NC OR CI): <u>NC</u>
PROVED BY: Thomas J. Behringer 7. J. Schungi	DATE: 05/17/97

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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 10²⁰ n/cm², 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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CALCULATI	DN N	O. CMED-060298		PROJECT NO. 101	28-052	PAGE 4 OF 9					
4.0	4.0 DESIGN INPUT:										
	4.1	Material Properties									
		The core shroud compone (Reference 5.5). The follow taken from Reference 5.6:	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:	\$ _m	16900.0·psi							
		Yield Strength:	σy	- 18800.0 · psi							
		Modulus of Elasticity:	E۰	25.5-10 ⁶ -psi	-						
		Flow Stress:	σf	3.5 m	$\sigma_{\rm f} = 5.07 \cdot 10^4 {\rm *psi}$						
	4.2	Safety Factors:									
		As required in Section XI of Factors are used to mainta	f Refei In desi	rence 5.6 and recommo	ended in Reference	5.2, the following Safety					
		Normal/ Upset Condition:		SF _U = 2.8							
		Emergency/Faulted Conditi	ion:	SF $\mathbf{F} = 1.4$							
	4.3	Loads:									
•		The pressure differentials p welds below the H5 weld. from pressure alone. This from the finite element anal required remaining ligament	provide These pressu lyses t it.	ed below are the upper are the pressure differ are hoop stress is comp o ensure the larger of t	bound limits taken entials used to calc pared to the combin the two values is us	from Reference 5.7 for culate the hoop stress ned loading hoop stress sed to establish the					
		Pressure Differential for Up	set Co	onditions: 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.

$$\sigma_{\text{hoop}} = \frac{\sigma_{\mathbf{x}} \cdot \sigma_{\mathbf{y}}}{2} - \frac{\sigma_{\mathbf{x}} - \sigma_{\mathbf{y}}}{2} \cdot \cos(2\cdot\theta) + \tau_{\mathbf{xy}} \cdot \sin(2\cdot\theta) \mathbf{e}$$

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 180⁰ 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 + ∆P _{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 hr 5 10 5 m

ECG = $3.5 \cdot in$



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CALCU		ON N	O. CMED-060298	PROJECT NO. 10128-	052	PAGE 6 OF 9			
		4.5	Inspection Results and Flaw Ch	aracterization:					
	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	REFI	ERENCES:						
	5.1 Letter Dated 4/29/96 from S. Sanford (GE Nuclear Energy) to J. Whitman (CECo Reactor Engineering), Subject: Prellminary UT Results of Shroud Vertical Welds V23 and V25.								
		5.2	BWRVIP Document GENE-523 Guldelines," September 1994.	3-113-0894, "BWR Core S	ihroud Inspection	n and Evaluation			
		5.3	S&L Calculation No. CMED-05 Flaw Evaluation for Inspection	9112, Rev. 0, Dated 6/9/9 Acceptance Criteria".	5, "Core Shroud	Vertical Weld			
		5.4	GENE DRF B13-01749, ANSY: General Electric Nuclear Engin	S Finite Element Analysis eering (See Attachments	Results Output, F & G of Refere	Provided by nce 5.3).			
		5.5	GENE-771-82-1194, Rev 1, "Ba Stress Report," May 1995.	ackup Calculations for Dre	esden Shroud Re	epair Shroud			
		5.6	ASME B&PV Code 1989 Editio	n					
	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 O 2nd Edition, McGraw-Hill Book	utline of Theory and Prob Co.	lems of Strength	of Materials",			
4	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·in							
	Plate Width (Radial Dimension):	L - 10.685 in							
	Uncracked Section Area:	A_{uc} it (L 0.5 in)	$A_{\rm uc} = 40.7 \cdot in^2$						
	Total Ring Hoop Loads:								
	Normal/Upset Total Ring Hoop Stress:	o _U . 2795 psi	(Ref. 5.3)						
	Total Load on Vertical Plane Due to Normal/Upset Total Hoop Stress:	T _{TU} =σ _{U'} L·ι	T _{TU} = 1.195-10 ⁵ •lb						
	Emergency/Faulted Total Ring Hoop St	tress: σ _F . 5877-psi	(Ref. 5.3)						
	Total Load on Vertical Plane Due to Emergency/Faulted Total Hoop Stress:	T _{TF} = o _F .r.1	T _{TF} = 2.512•10 ⁵ •lb						
	Limit Load Evaluation:								
	Limit Load evaluation for an edge crack based on the hoop stress from the com	on a semi-infinite plate subjected to a ubined upset condition loads and the fau	uniform tensile load Ited condition loads:						
	Normal/Upset Conditions:		,						
	Limit Load Normal/Upset Critical Crack Length:	$c_{c} = L - \frac{T_{TU}SF_{U}}{\sigma_{f}t}$	c _c = 9.036 • in						
	Required Remaining Ligament:	$\mathbf{b} = \mathbf{L} - \mathbf{c}_{\mathbf{c}}$	b = 1.649•in						
-	Required Normal/Upset Remaining Ligament Based on Limit Load:	LL _u ≓b ⊨ ECG	LL $_{\rm u}$ = 5.149 · in						
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CALCULATION NO. CMED-060298		PROJECT NO. 10128-052	PAGE 8 OF 9
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	Emergency/Faulted Conditions:		
	Limit Load Emergency/Faulted critical criticae criticae criticae criticae criticae criticae criticae c	$\operatorname{ack} c_{c} = L \frac{T T F SF_{F}}{\sigma_{f} t}$	c _c = 8.951 •in
	The required remaining ligament is b:	b L - c _c	b = 1.734 •in
	Required Emergency/Faulted Remaining Ligament Based on Limit Load:	LL _f b ECG	LL $f = 5.234 \cdot in$
	Primary Stress Evaluation:		
	Normal/Upset Condition:		
	Primary Stress Critical Crack Length:	$c_{psc} = L - \frac{T_{TU}}{S_{m'}}$	c _{psc} = 8.918 • in
	Required Remaining Ligament:	b - L - c psc	b = 1.767 •in
	Required Remaining Ligament for Normal/Upset Conditions Based on Primary Stress Requirements:	PS _u ·· b · ECG	PS _u = 5.267 • in
	Emergency/Faulted Condition:		
	Primary Stress Critical Crack Length	$c_{psc} = L - \frac{T_{TF}}{2 \cdot S_{m} \cdot t}$	c _{psc} = 8.827 • in
	Required Remaining Ligament:	b = L c psc	b = 1.858 •in
	Required Remaining Ligament for Emergency/Faulted Conditions Based on Primary Stress Requirements:	PS _f = b + ECG	PS _f =5.358 • in
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CALCULATION NO. CMED-060298	PROJECT NO. 10128-052	PAGE 9 OF 9			
Required Area of Uncracked S	ection:				
The primary stress emergency/five value the required uncracked set	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:				
$A_{req} PS_{f}t A_{req} =$	$21.4 \cdot \mathrm{in}^2$	·			
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} b.t $A_{req} =$	• 7.4 •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).					
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No.001 P.12 Project No. 10128-052 Attachment A, Pg, A1 of A2



GE Nuclear Energy

Commonwealth Edison Company Dresden Nuclear Power Station D3R14 Shroud Vertical Weld UT Project 1GO3J

To: Jerry Whitman - CECo Reactor Engineering Steve Stanford - GE UT Level III 🚓 From: Date: 29 April 96 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).

<u>V25</u>

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.



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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