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February 7, 2000
NG-00-0111

Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station 0-P1-17
Washington, DC 20555-0001

Subject: Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49
Relief Requests NDE-028, Revision 1 and MC-R008;
RRF-F002 Flaw Evaluation

References: 1. Letter dated October 19, 1999, from NRC to E. Protsch (IES Utilities Inc.), Safety Evaluation for the Proposed Alternative to ASME XI Requirements for Containment Inservice Inspection for the Duane Arnold Energy Center
2. Letter dated October 18, 1999, from NRC to E. Protsch (IES Utilities Inc.), Safety Evaluation of Third 10-Year Interval Inservice Inspection Program Plan Requests for Relief for Duane Arnold Energy Center
3. Licensee Event Report (LER) 1999-006, dated December 6, 1999, Indications in Recirculation Riser Nozzle-to-Safe End Welds

File: A-100, A-286

By Federal Register Notice dated August 8, 1996 (61 Federal Register 41303), the NRC amended 10CFR50.55a to incorporate by reference the 1992 Edition with 1992 Addenda of Subsection IWE of Section XI of the ASME Boiler and Pressure Vessel Code. Subsection IWE provides requirements for inservice inspection (ISI) of Class MC (metallic containments). Reference 1 approved Duane Arnold Energy Center (DAEC) Containment Inspection Program Relief Requests MC-R002 through MC-R007, MC-P001 and NDE-R015, Revision 1.

While performing inspections during Refueling Outage (RFO) 16, IES Utilities identified the need for an additional Containment Inspection Program Relief Request. A section of well water piping located near a drywell stabilizer prevents the removal of the bolting associated with the stabilizer. As discussed in attached Relief Request MC-R008, performance of the Code-required visual examination would have a disproportionate impact on expenditures of plant manpower and radiation exposure with only a small potential for increasing plant safety margins.

A04

IES Utilities also requests approval of Revision 1 to Inservice Inspection (ISI) Program Relief Request NDE-R028. NDE-R028 was approved by Reference 2 and allows relief from performing 100% examinations of nozzle-to-vessel welds. NDE-R028 was revised to include additional welds that were examined during RFO 16. The relief request was also updated to refer to the latest revision of Regulatory Guide 1.147. The "List of Nozzle-to-Vessel Welds" in the relief request was modified to include the period in which each weld was examined. As discussed in the attached relief request, the configurations of the nozzle-to-vessel welds do not allow 100% examination. Pursuant to the provisions of 10CFR50.55a, IES Utilities requests approval of Relief Requests MC-R008 and NDE-R028, Revision 1 prior to March 1, 2001.

Reference 3 informed the NRC of indications identified in three recirculation riser nozzle-to-safe end welds during RFO 16. The indications in two of the welds were found to be indicative of intergranular stress corrosion cracking (IGSCC) and were repaired with weld overlays. The indication reported in weld RRF-F002 was determined to be a subsurface flaw, was evaluated under the ASME Code and was determined to be acceptable to leave as-is. In accordance with the Code (IWB-3134), the analytical evaluation performed on the subsurface flaw is included as Attachment 2.

Should you have any questions regarding this matter, please contact this office.

Sincerely,

for

Kenneth E. Peveler
Manager, Regulatory Performance

Attachment 1: Relief Requests MC-R008 and NDE-R028, Revision 1
Attachment 2: Flaw Evaluation for RRF-F002

cc: C. Rushworth (w/a)
E. Protsch (w/o)
D. Wilson (w/o)
G. VanMiddlesworth (w/o)
B. Mozafari (NRC-NRR) (w/a)
J. Dyer (Region III) (w/a)
NRC Resident Office (w/a)
Docu (w/a)

RELIEF REQUEST NUMBER: MC-R008

COMPONENT IDENTIFICATION

Code Class:	MC
References:	Table IWE-2500-1
Examination Category:	E-A
Item Number:	E1.12
Description:	Limited Examination
Component Numbers:	Drywell Stabilizer X-58A

CODE REQUIREMENT

ASME Section XI, 1992 Edition, 1992 Addenda, IWE-2500-1 requires the VT-3 visual examination be performed on 100% of the accessible areas each interval.

BASIS FOR RELIEF REQUEST

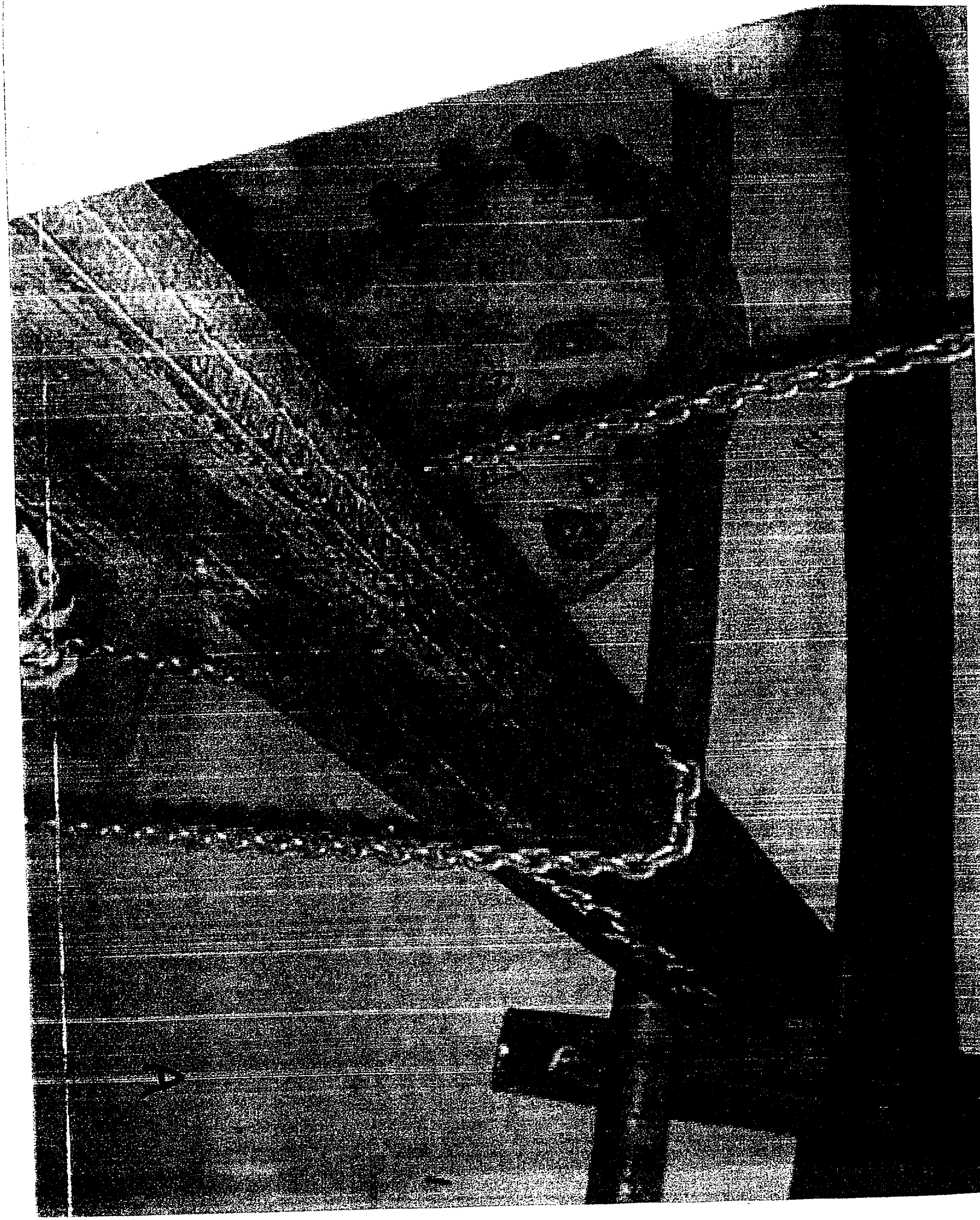
During RFO 16, the Drywell Stabilizer X-58A with the associated bolting was scheduled for examination. It was discovered that the well water piping associated with the 7A cooler prohibited the removal of the bolting. Without removal of the bolting, the integral attachment and the associated reinforcing structure cannot be examined. (See attached photos). In order to perform the VT-3 visual examination, the well water piping would need to be cut and re-welded into place. This would require draining of the well water system, hot work permit, welding, and additional personnel exposure to complete the work. Based on dose measurements obtained during work activities during RFO 16, dose rate in the general area is about 28 to 50 mr per hour. Allowing 8 person-hours to perform the aforementioned activities, the total dose would be approximately 300 millirem. Examination of the Drywell Stabilizer X-58A, which includes the reinforcing structure and the integral attachment to the outside diameter (OD) of the Drywell, has only a small potential of increasing plant safety margins and a very disproportionate impact on expenditures of plant manpower and radiation exposure.

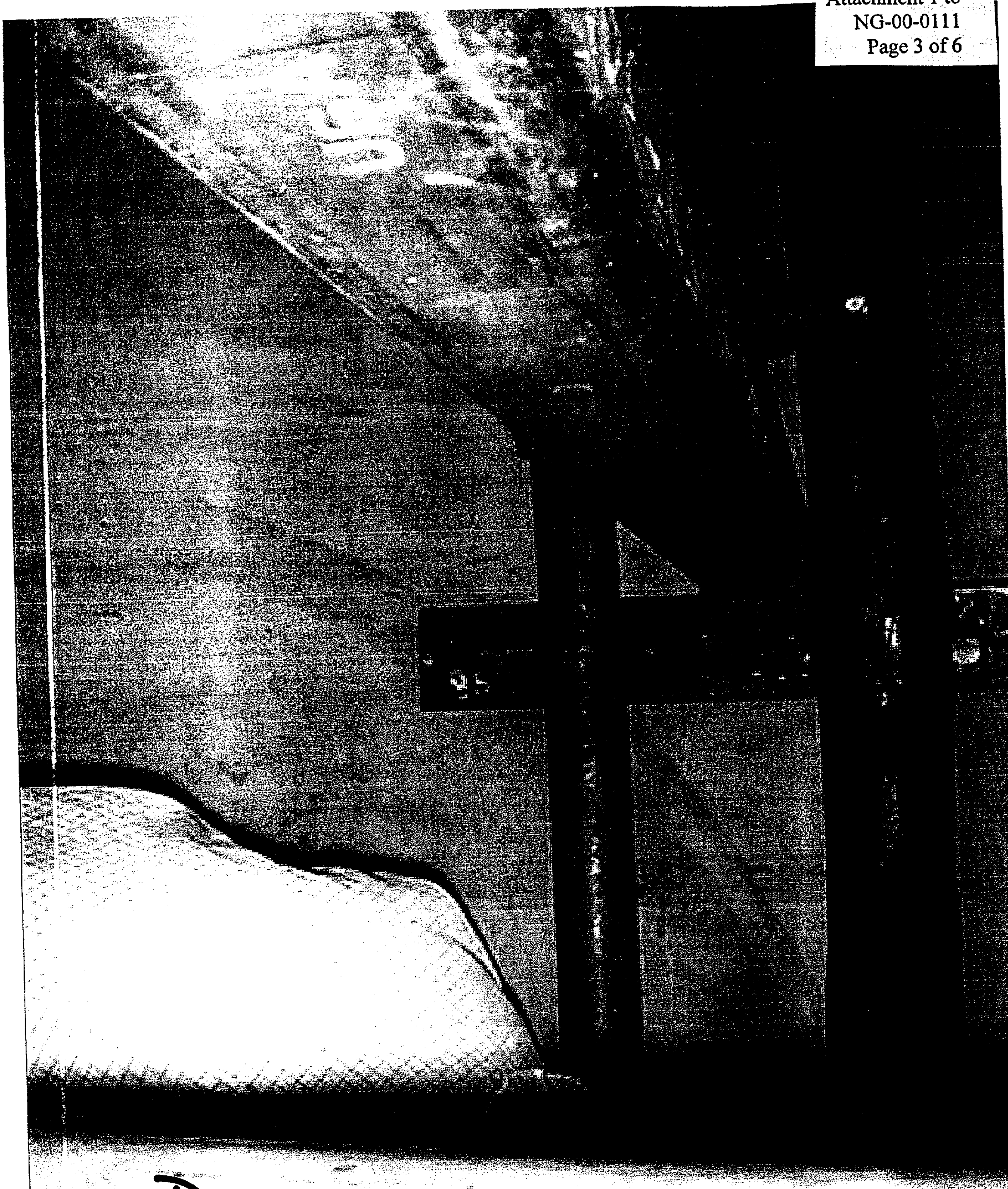
ALTERNATIVE EXAMINATION(S):

Pursuant to 10CFR 50.55a(a)(3)(ii), the DAEC requests relief from the VT-3 visual examinations of the reinforcing structure and integral attachment of the Drywell Stabilizer X-58A. Once per period, the General Visual Examination of the accessible surfaces will be performed. Once per interval, the associated bolting will be examined in-place under tension as allowed by Relief Request MC-R003.

APPLICABLE TIME PERIOD

Relief is requested for the first ten year interval of the Containment Inspection Program for the DAEC.





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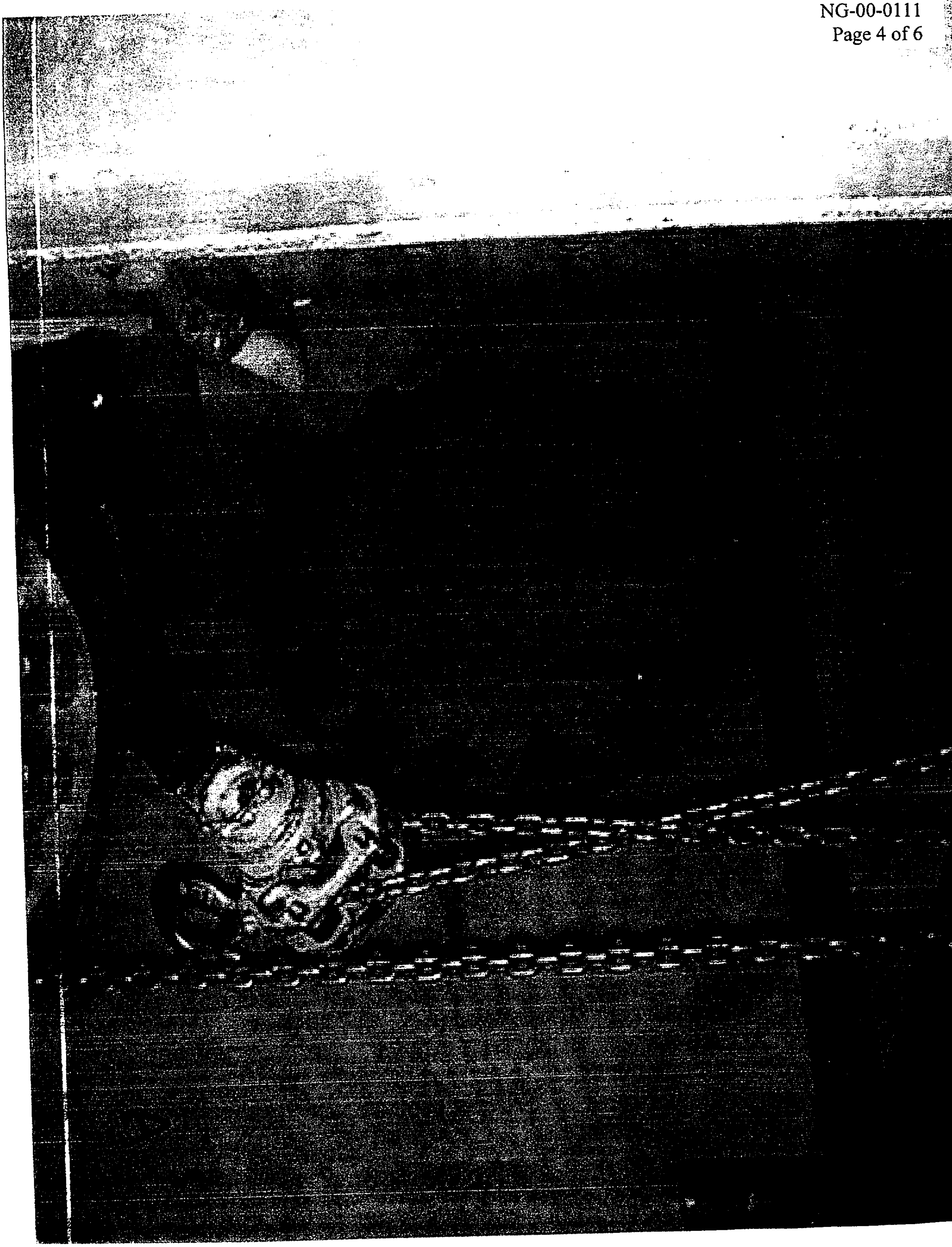

RELIEF REQUEST NUMBER: NDE-R028, REVISION 1

COMPONENT IDENTIFICATION

Code Class:	1
References:	IWB-2500 Table IWB-2500-1
Examination Category:	B-D
Item Number:	B3.90
Description:	Nozzle-to-Vessel Welds
Component Numbers:	See "List of Nozzle-to-Vessel Welds" for Component Identification

CODE REQUIREMENT

Section XI (1989 Edition), Table IWB-2500-1 Category B-D, Item B3.90, requires a volumetric examination, which includes essentially 100% of the weld, once during the ten year interval. The examination volume is defined in Figure IWB-2500-7(b).

Code Case N-460 permits a reduction in examination coverage of Class 1 welds provided the coverage reduction is less than 10%. The Duane Arnold Energy Center (DAEC) has adopted Code Case N-460 in the Inservice Inspection (ISI) Program Plan, as permitted by USNRC Regulatory Guide 1.147, Revision 12.

Relief is requested from performing essentially 100% of the weld length for those welds identified in the "List of Nozzle-to-Vessel Welds."

BASIS FOR RELIEF

Due to the design of these welds it is not feasible to effectively perform a volumetric examination of 100% of the volume as described in IWB-2500-7(b). The nozzle-to-vessel welds are accessible from the vessel side, but examination cannot be performed from the nozzle side because of the forging curvature. In addition to component configuration certain nozzle-to-vessel weld examinations are further limited by reactor pressure vessel (RPV) design obstructions (such as RPV appurtenances). In accordance with 10CFR 50.55a(6)(i) relief requests may be granted when the examination requirements are shown to be impractical.

ALTERNATE EXAMINATION

The DAEC proposes to perform volumetric examination from the vessel side of the nozzle-to-vessel welds identified in the "List of Nozzle-to-Vessel Welds." Because of the design of these welds, there are no alternative examination techniques currently available to increase the examination volume.

List of Nozzle-to-Vessel Welds

Nozzle ID	Period Examined	Code Coverage*	Remarks
CRA-D001	1	61.3%	Control Rod Drive
CSA-D001	1	63%	Core Spray
CSB-D001	1	66%	Core Spray
FWA-D001	1	56.5%	Feedwater
HVA-D001	1	66.0%	Head Vent
JPA-D001	1	61.1%	Jet Pump
MSA-D001	1	59.6%	Main Steam
MSB-D001	2	63%	Main Steam
RHA-D001	1	65.7%	Head Spray
RCA-D001	2	59%	Recirculation Suction
RCB-D001	1	57%	Recirculation Suction
RRA-D001	1	63%	Recirculation Inlet
RRB-D001	1	63%	Recirculation Inlet
RRC-D001	1	63%	Recirculation Inlet
RRD-D001	1	51.4%	Recirculation Inlet
RRE-D001	1	64%	Recirculation Inlet
RRH-D001	1	64%	Recirculation Inlet
VID-D001	2	63%	Vessel Instrumentation
VIE-D001	1	66%	Vessel Instrumentation

*Due to the nozzle design it is not feasible to effectively exam 100% of the required code volume as defined in Figure IWB-2500-7(b).

APPLICABLE TIME PERIOD

Relief is requested for the third ten-year interval of the Inservice Inspection Program for DAEC.

Attachment 2 to NG-00-0111
Flaw Evaluation for RRF-F002

ENGINEERING CALCULATION COVER SHEET

IES UTILITIES INC.

DUANE ARNOLD ENERGY CENTER

Calculation Number (If Required): AR 17482

Calculation Title: EVALUATION OF FLAW IN RECIRCULATION INLET NOZZLE N2F

Project Description: REACTOR PRESSURE VESSEL RECIRCULATION NOZZLE
(Include Structure,
System or Component)

Reference Documents: AR 17482 DDC________ ECP/PMP________

Other ________

Method of Verification: ☒ Design Review ☐ Alternate Calculation

☐ Qualification Testing

4			
3			
2			
1	[signature] 11/20/99	Dave Lemm 11/20/99	[signature] 11-20-99
Revision	Prepared/Date	Verified/Date	Approved/Date

NG-007Z Rev 7

DESIGN VERIFICATION SUMMARY REPORT

Sheet 1 of 2

DOCUMENTTYPE/NUMBER: AR 17482 REVISION 1

VERIFIER: Dave Lemm DISCIPLINE: Mechanical

METHOD OF VERIFICATION:

☑ DESIGN REVIEW ☐ ALTERNATE CALCULATIONS ☐ QUALIFICATION TESTING

Design Inputs Considered: Stress Report Recirc Inlet Nozzle Safe End, Aug 1978 (Ref. 1) Written Correspondence from Robert Healey (GE) to Frank Dohmen (Alliant) 11/16/99
Document(s) Reviewed: Stress Report (See above) Calculation for AR 17482
Conclusions & Comments: Calculation demonstrates acceptability of flaw in N2F safe-end to nozzle weld.

Dave Lemm Dave Lemm — 11/20/99

Verifier — Date

Marc A [signature] — 11/20/99

Team Leader — Date

DESIGN VERIFICATION COMMENT SHEET

Sheet 2 of 2

DOCUMENT TYPE/NUMBER: AR 17482 REVISION: 1

LINE/ ITEM NO	VERIFIER'S COMMENTS	PREPARER'S RESOLUTION	VERIFIER'S RESOLUTION
–	Comments resolved with preparer.	N/A	N/A

Verifier: [signature] Date: 11/20/99 Preparer: [signature] Date: 11/20/99

AR 17482
Evaluation of Flaw in Recirculation Inlet Nozzle N2F

Introduction

This calculation documents the results of a fracture mechanics evaluation of a subsurface flaw in the safe end-to-nozzle weld of Recirculation Inlet Nozzle N2F (Figure 1). The flaw has a depth of 0.30 in and a length of 0.50 in. The flaw is located at the weld-base metal interface between the Alloy 82 weld and the Alloy 600 safe end. The flaw has been interpreted as a lack of fusion during safe end replacement in 1978 and is not considered to be a service-induced flaw.

Summary of Results

The flaw in Recirculation Nozzle N2F was evaluated in accordance with the flaw evaluation procedures of IWB-3641 of ASME Section XI (1989 Ed.). The allowable flaw depth was determined to be 0.720 in, which is greater than the actual flaw depth of 0.300 in. Therefore, it is acceptable to leave the flaw in the nozzle.

A fatigue analysis was performed to determine the expected growth of the flaw by fatigue from the time the flaw was detected (beginning of Fuel Cycle 17) to end-of-license (2014). The analysis indicated that the expected flaw growth by fatigue is negligible during the evaluation period. Since the flaw is a subsurface flaw that is completely contained within the weld, there would be no flaw growth by stress corrosion cracking (SCC). Therefore, the flaw is not expected to grow inservice beyond its current size.

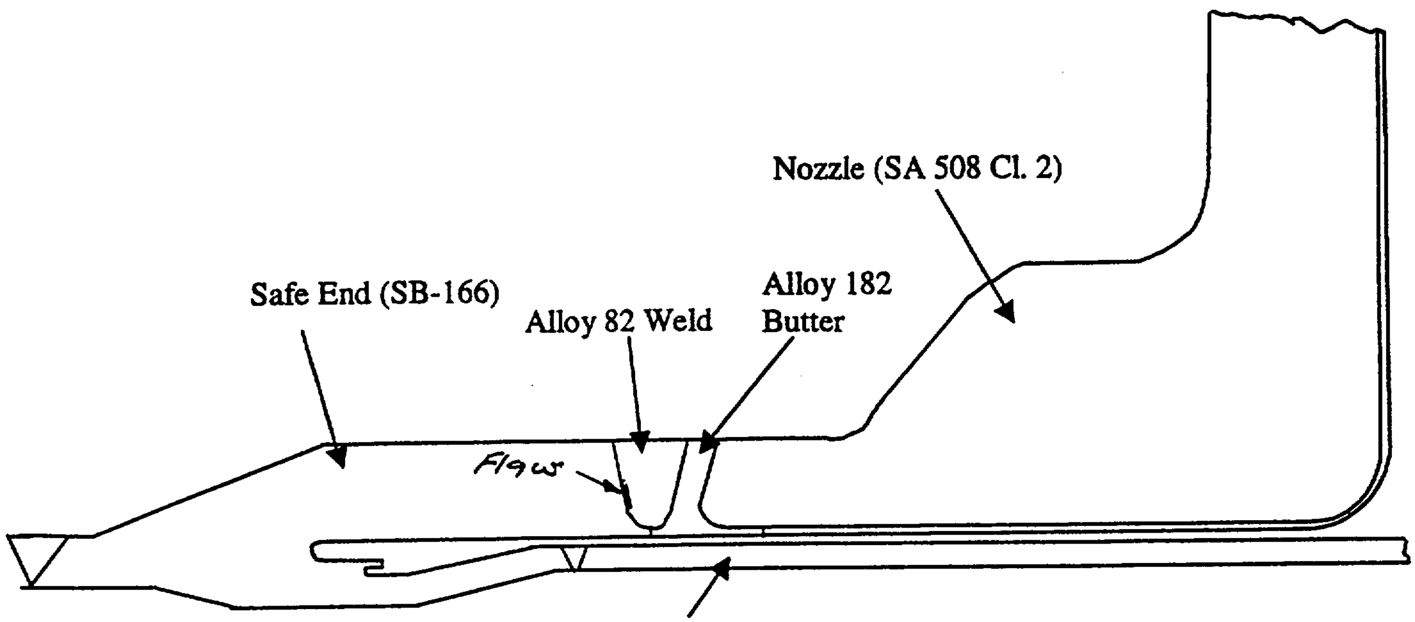

Figure 1. Flaw in Recirculation Inlet Nozzle N2F

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IES UTILITIES CEDAR RAPIDS, IOWA	DEPT. DAEC PROJECT AR 17482 Sheet No. 1 of SUBJECT Evaluation of Flaw in N2F Computed by [signature] Date 11/19/99 Checked by Dave Lemon Date 11/20/99

EVALUATION OF FLAW IN N2F

Purpose

To evaluate the subsurface flaw in Recirc Inlet Nozzle N2F. The flaw has a depth (2a) of 0.30 in and a length (l) of 0.5 in. The flaw is located in the safe end-to-nozzle weld at the weld-base metal interface between the Alloy 82 weld and the Alloy 600 safe end. The flaw has been interpreted as a lack of fusion during safe end replacement in 1978 and is not considered to be a service induced flaw.

References

1. Stress Report Recirc Inlet Nozzle Safe End Replacement - Duane Arnold Nuclear Plant, CBI Nuclear Company, Aug 1978.
2. CAL-M98-008, R1, Duane Arnold Reactor Pressure Vessel Transient Design.

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IES UTILITIES
CEDAR RAPIDS, IOWA

DEPT. DAEC
PROJECT AR 17482 Sheet No. 2 of
SUBJECT Evaluation of Flaw in N2F
Computed by [signature] Date 11/19/99 Checked by Dave Lemm Date 11/20/99

Calculations

The flaw is evaluated in accordance with the flaw evaluation procedures of IWB-3641 of ASME Section XI (1989 Ed.)

1. Flaw Growth

Stress Corrosion Cracking

Since the flaw is a subsurface flaw that is completely contained within the weld, the flaw is not subject to growth by SCC.

Fatigue

From the Design Report for the 1978 safe end replacement (Ref. 1), the stresses in the nozzle safe end are relatively low.

$P_m = 3.48$ ksi
$P_b = 3.54$ ksi
$P_m + P_b = 7.02$ ksi

Stresses were obtained from:
Sh. 14 – P + Nozzle Loads
Sh. 21 – Reaction load from thermal sleeve

(See Attachment 2)

For flaw evaluation purposes, the stress in the safe end-to-nozzle weld will be taken as 1.5 × the calculated stress.

$$P_m + P_b = 1.5 \cdot 7.02 = 10.5 \text{ ksi}$$

The allowable stress intensity for the safe end material (Inconel 600) is 23.3 ksi (Table I-1.2 from ASME Section III for SB166 at 540 F)

$$\frac{P_m + P_b}{S_m} = \frac{10.5}{23.3} = 0.451$$

$$P_m + P_b = 0.451 \, S_m$$

The crack tip stress intensity factor K_I is calculated in accordance with Article A-3000 of ASME Section XI (1989).

$$K_I = \sigma_m M_m \sqrt{\pi} \sqrt{a/Q} + \sigma_b M_b \sqrt{\pi} \sqrt{a/Q}$$

σ_m, σ_b = membrane and bending stress (ksi)

a = half depth (subsurface flaw)

Q = shape factor

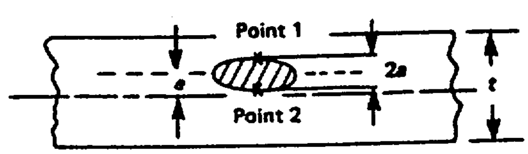
For $\frac{\sigma_m + \sigma_b}{S_y} = \frac{10.5}{28.4} = 0.370$ ← S_y for SA516 @ 540F Table I-2.2 ASME Section III

$\frac{a}{l} = \frac{.15}{0.5} = .30$

$Q = 1.58$ (see p. 6)

(Fig. A-3300-1)

M_m = membrane stress correction factor



$t = 0.960$ in

$2a = 0.30$ in

$e = 0.05$ in

Flaw Eccentricity Ratio = $\frac{2e}{t} = \frac{2 \cdot 0.05}{0.96}$

$= 0.104$

$\frac{2a}{t} = \frac{0.30}{0.96} = 0.313$

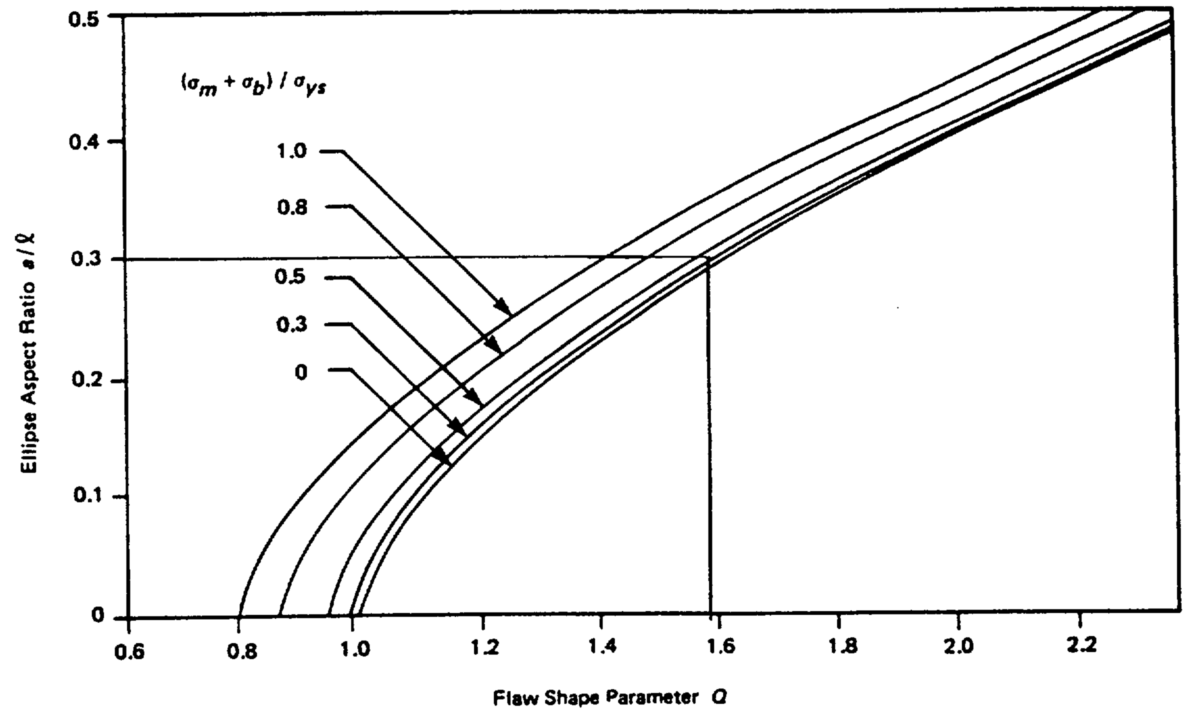
$M_m \doteq 1.08$ for $\frac{2a}{t} = 0.35$ curve (see p. 7)
(Fig. A-3300-2)

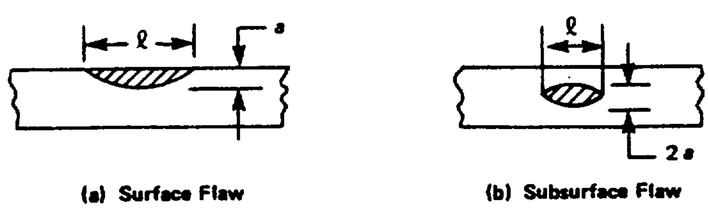
M_b = bending stress correction factor

$\frac{2e}{t} = 0.104$

$\frac{2a}{t} = 0.313$

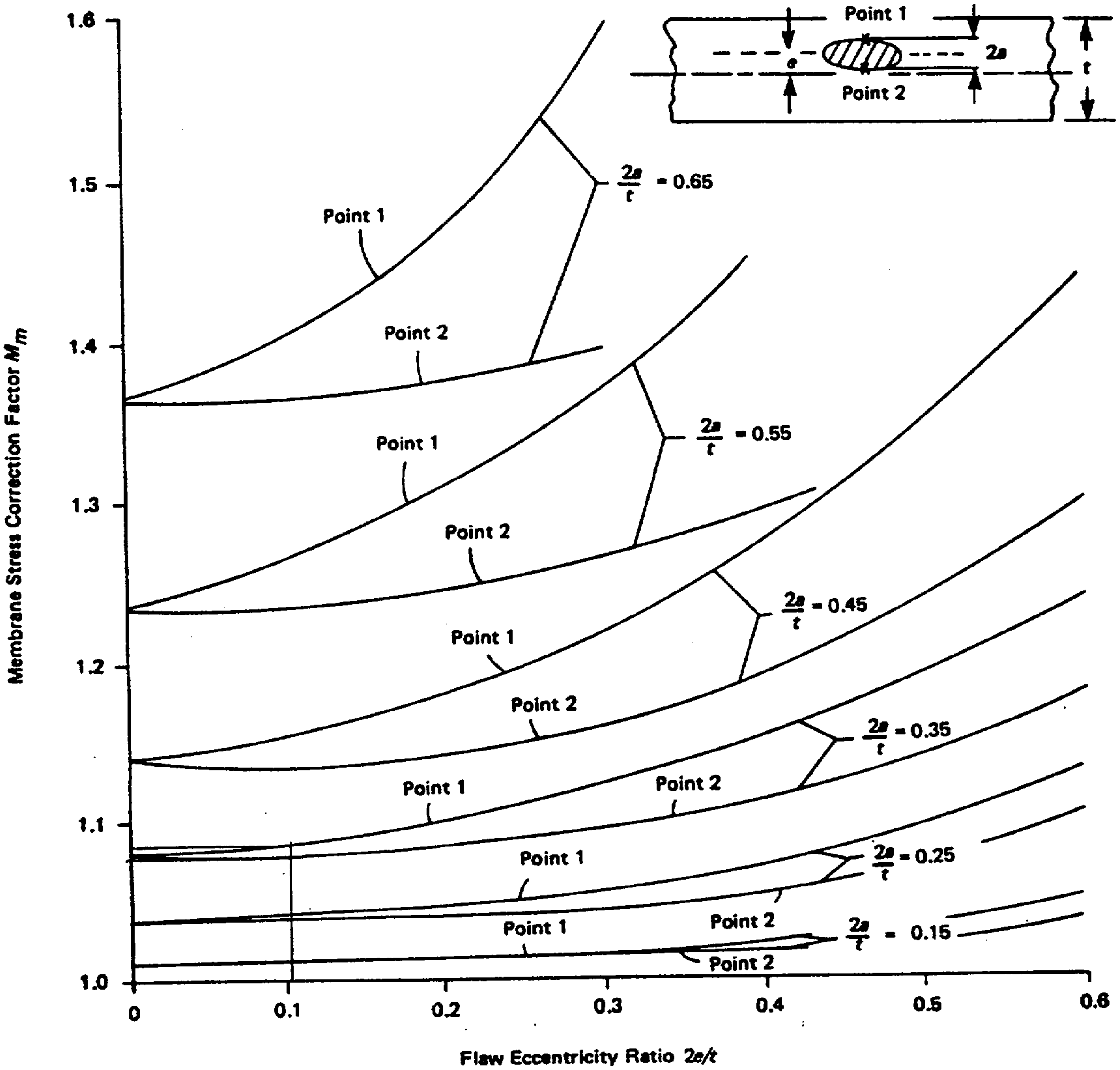
$M_b \doteq +0.27 / -0.04$
(Fig. A-3300-4)





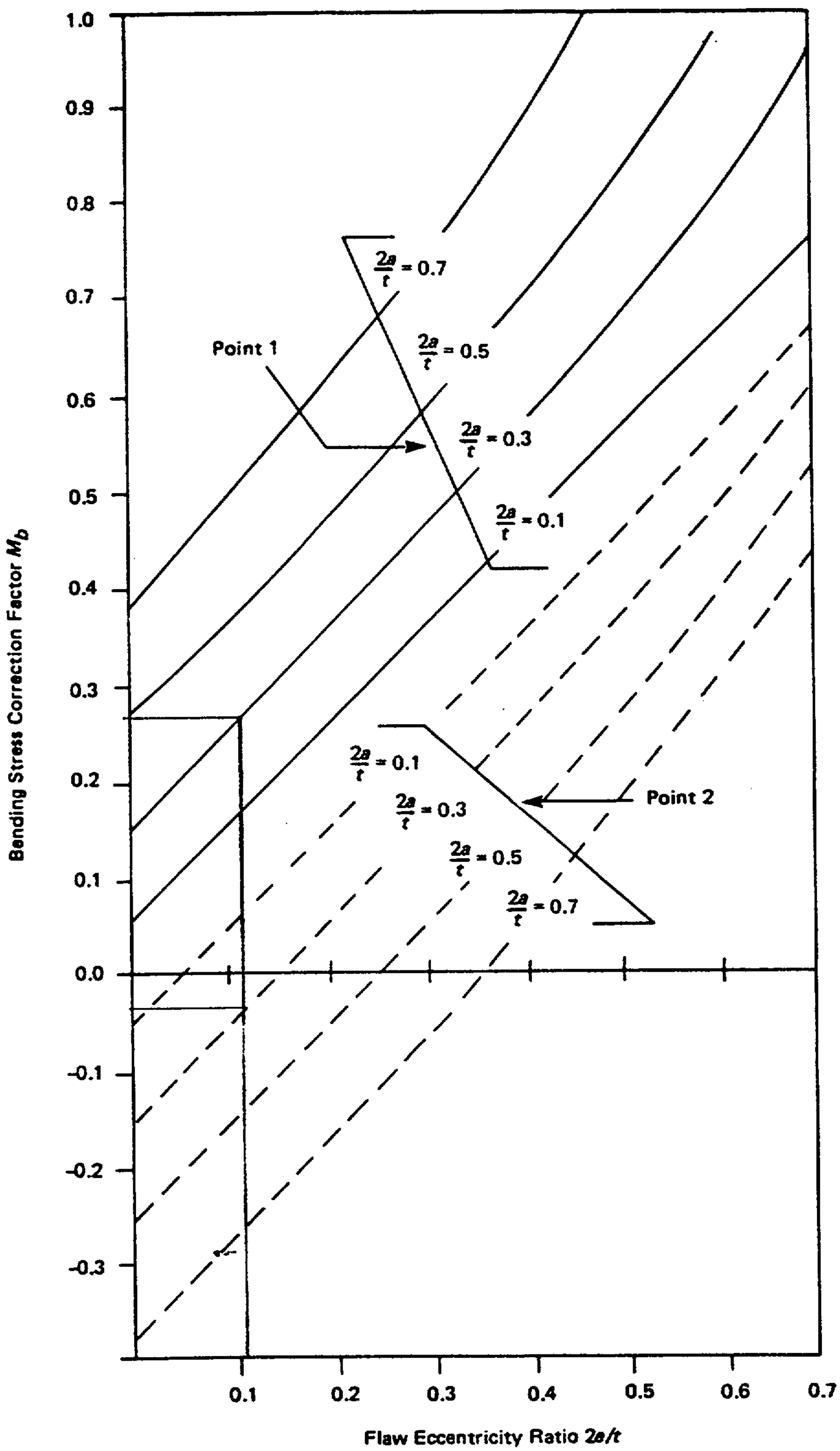
σ_{ys} = specified minimum yield strength
ℓ = major axis of ellipse circumscribing the flaw

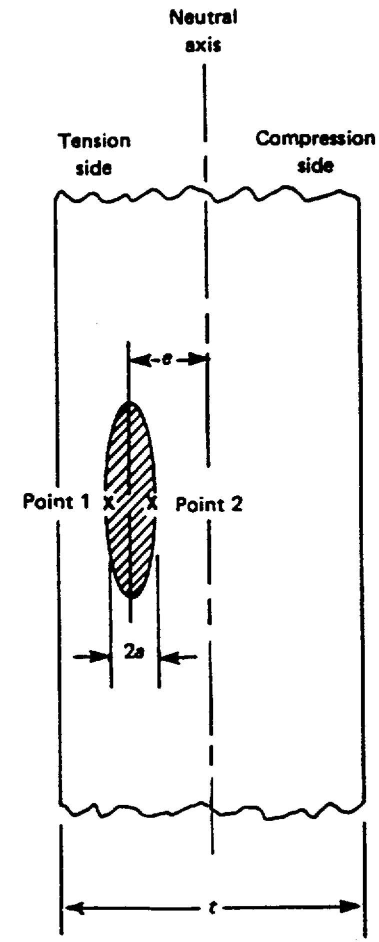
FIG. A-3300-1 SHAPE FACTORS FOR FLAW MODEL



t = wall thickness
e = eccentricity
Point 1 = outer extreme of the minor diameter of ellipse (closer to surface)
Point 2 = inner extreme of the minor diameter of ellipse (further from surface)

FIG. A-3300-2 MEMBRANE STRESS CORRECTION FACTOR FOR SUBSURFACE FLAWS





GENERAL NOTE:
If the flaw center line is on the compressive side of the neutral axis, the sign of σ_b should be negative.

FIG. A-3300-4 BENDING STRESS CORRECTION FACTOR FOR SUBSURFACE FLAWS
(For Definitions of Nomenclature, See Fig. A-3300-2)

Because the flaw is near the center of the weld, the bending stress does not contribute as much to K_I as the membrane stress. A conservative answer can be obtained by assuming all the stress is membrane (P_m) stress.

On this basis,

$$K_I = \sigma_m M_m \sqrt{\pi} \sqrt{a/Q} + \sigma_b M_b \sqrt{\pi} \sqrt{a/Q} \quad (\sigma_b \to 0)$$

$$= 0.451 S_m M_m \sqrt{\frac{\pi a}{Q}} = 0.451 \cdot 23.3 \cdot 1.08 \sqrt{\frac{\pi \cdot 0.15}{1.58}}$$

$$= 6.19 \text{ ksi} \sqrt{\text{in}}$$

Based on a_i - Flaw depth at beginning of evaluation period

The crack growth rate is given by

$$\frac{da}{dN} = C_o (\Delta K_I)^n \quad \text{(C-3210 of ASME Section XI)}$$

The fatigue flaw growth rate for Ni-Cr-Fe (Inconel 600) will be taken as that for austenitic stainless steel in an air environment.

$C_o = C(S)$

$C = 10^{(-10.009 + 8.12E{-4}\,T - 1.13E{-6}\,T^2 + 1.02E{-9}\,T^3)}$

$T = 540\ F$

$C = 1.822\ E{-10}$

For $R \leq 0$

$S = 1.0$

$\therefore\ C_o = 1.822\ E{-10}$

$n = 3.3$

$\frac{da}{dN} = 1.822\ E{-10} \cdot (6.19)^{3.3}$

$= 7.50\ E{-8}\ \frac{in}{cycle}$

<u>Expected No. of SS Cycles</u>

From Ref. 2, the number of expected significant S/S events from Fuel Cycle 15 to end-of-life is

(from Table 1 of Ref. 1)

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IES Utilities, Cedar Rapids, Iowa	
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Checked by	Dave Lemm Date 11/20/99

Event	No. of Events 15-to-EOL	15-16	16-EOL	
S/S	85	8	77	
Scram	94	2	92	
Aborted S/S	10	0	10	
Hydro	103	2	101	No Thermal
			276	

Number of significant cycles for recirc nozzles between beginning of Fuel Cycle 17 and End-of-Life is 276.

Assuming constant fatigue flaw growth of 8.165 E-8 m/cycle, the flaw extension is predicted to be

$$\Delta a = 7.50\text{E-}8 \frac{m}{cycle} \cdot 276 \text{ Cycles}$$
$$= 2.07\text{E-}5 \text{ in} \quad (0.0000207 \text{ in})$$

$2\Delta a \cdot 0.0000414$

While the fatigue flaw growth rate would not be constant, i.e., it would increase as flaw depth(a) increases, this calculation shows that expected fatigue growth of the flaw in N2F between the beginning of Fuel Cycle 17 and End-of-Life is negligible.

2. Allowable Flaw Depth

Allowable flaw depth is calculated in accordance with Table IWB-3641-1.

$$\frac{P_m + P_b}{S_m} = 0.451$$

Ratio Flaw length to Pipe circumference

$$\frac{\ell}{\pi D} = \frac{0.5}{\pi \cdot 13.12} = 0.012$$

Allowable $\frac{2a}{t} = 0.75$

$$2a = 0.75\,t = 0.75 \cdot 0.96$$
$$= 0.720 \text{ in}$$

Therefore flaw size is acceptable.

GE Nuclear Energy

12200 Herbert Wayne Court, Suite 100, Huntersville, NC 28078

November 16, 1999
Mr. Frank Dohmen
Alliant Energy
3277 DAEC Road
Palo, IA 52324

SUBJECT: Flaw Evaluation for RRF-F002
Reference: GE-RWH-DAEC-99004

Dear Frank:

During the automated examination of RRF-F002, one flaw indication was recorded. The flaw was determined to be a lack of fusion left from the welding process.

The flaw has the following characteristics:

Flaw 1

$\mathcal{T} = 1.0"$

$\ell = 0.5"$

$2a = .30"$

$a = .15"$

$S = .4$

$Y = 1$

$a/\ell = .3$

$a/t = 15\%$

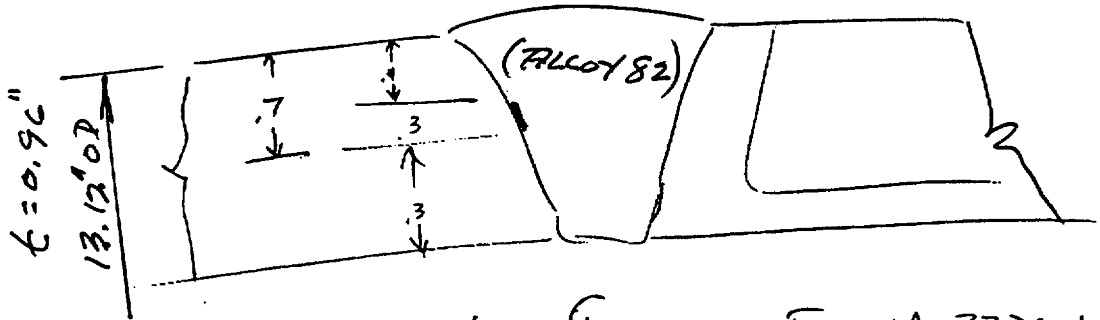
Code Allowable = 11.7%

This flaw is classified as a sub-Surface Planar Flaw per IWA-3320.
The flaw exceeds the acceptance standards of IWB-3514-2.

Sincerely,

Robert W. Healey
Project Level III
GE Nuclear Energy

Dissimilar Metal Weld



IWA-3320 Subsurface flaw → Fig IWA-3320-1

Flaw 2 $\quad S \geq .4a$ then subsurface

$S = .3$ $\quad$ .3 is greater than $.4 \times .15$ or $(.06)$

$.3 > .06$ therefore subsurface

→ S is smallest distance from surface

$2a = .3$ (flaw height)

$a = .15$ $\qquad$ Table IWB-3514.2

$l = .5$

$a/l = .3$ (Aspect Ratio)

Inservice $\quad$ 1.0" thick nominal wall

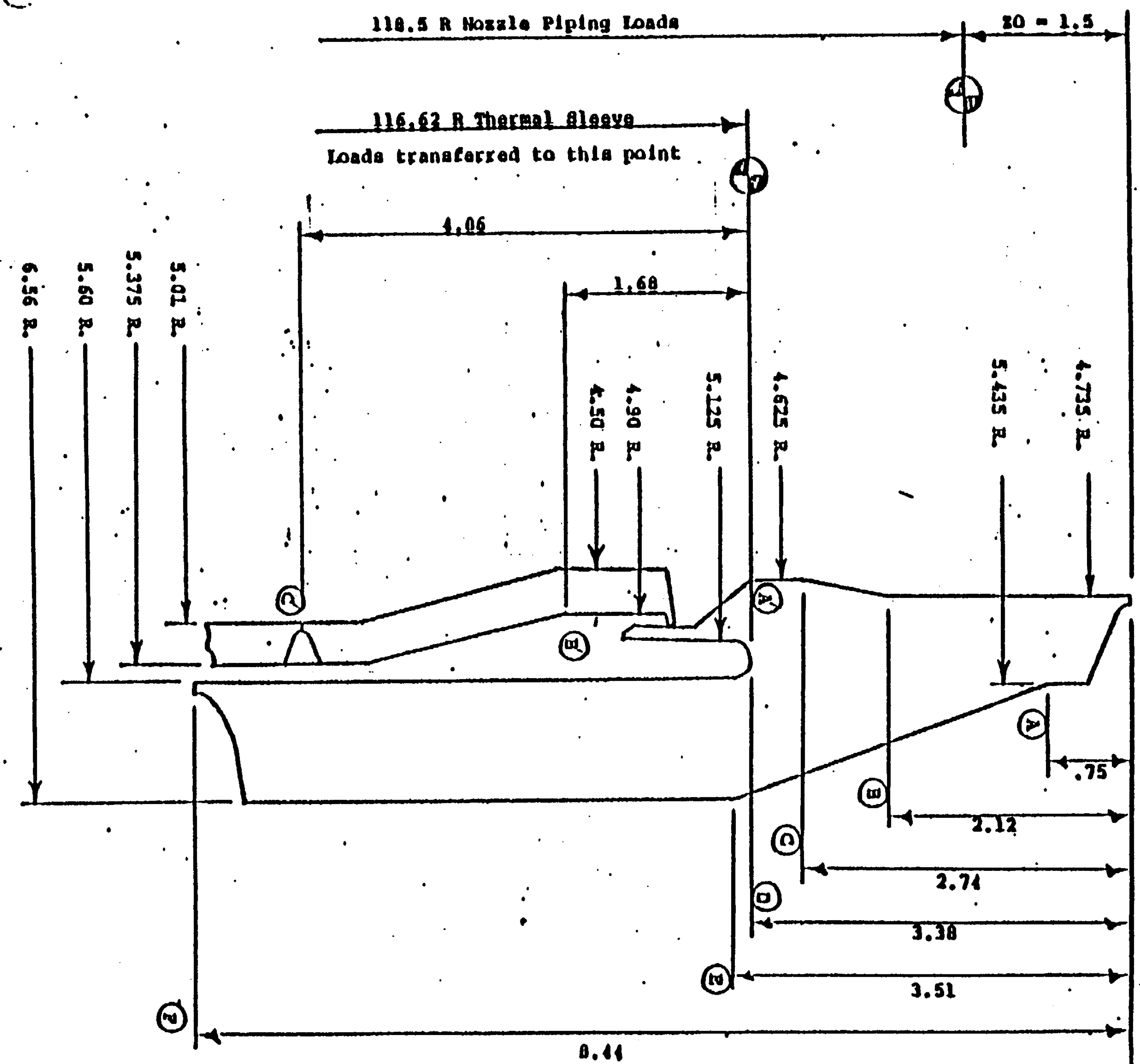
$a/t =$ Code Allowable $= 11.7\% \times Y = \underline{11.7\%}$

$Y = 1$ because $\quad Y = \dfrac{S/t}{a/t} = \dfrac{.3/1}{.15/1} = 2$

$Y = 1$

$a/t = \dfrac{.15}{1} = 15\%$ Actual flaw

15% exceed 11.7%



MODEL FOR PROGRAM 948

ATTACHMENT 3
1 of 3

CBI NUCLEAR COMPANY

(F)

CBI NUCLEAR COMPANY

9-CN245 DUANE ARNOLD RECIRC. INLET NOZZLE ANALYSIS

DIST. FROM SAFE END OF NOZZLE TO PT. OF ANALYSIS Z= 3.44 IN
PRESSURE P= 1250. PSI

QUANTITY	UNITS	OUTSIDE SURFACE	INSIDE SURFACE	MEMBRANE SURFACE
MAXIMUM STRESS INTENSITY	PSI	7045.	9331.	9139.
THETA	DEGREES	144.	124.	133.
FX	LBS	-1100.	-1100.	-1100.
FY	LBS	7300.	7300.	7300.
FZ	LBS	2300.	2300.	2300.
MX	IN-LBS	-250000.	-250000.	-250000.
MY	IN-LBS	96000.	96000.	96000.
MZ	IN-LBS	-47000.	-47000.	-47000.
LONG. STRESS(PRESSURE)	PSI	3358.	3358.	3358.
LONG. STRESS(AXIAL LOAD)	PSI	43.	43.	43.
LONG. STRESS(BENDING)	PSI	2873.	1932.	2404.
SHEAR STRESS(FORCES + TORSION)	PSI	407.	555.	549.
CIRC. STRESS(PRESSURE)	PSI	4714.	7956.	7341.
S1	PSI	7045.	8031.	7514.
S2	PSI	5944.	5233.	5457.
S3	PSI	0.	-1250.	-625.

===================NO THERMAL SLEEVE LOADS APPLIED==================

INSIDE DIAMETER (IN) ID= 11.200
OUTSIDE DIAMETER (IN) OD= 13.120
DIST. FROM PT. OF APPL. OF LOADS TO SAFE END (IN) ZO= -1.500
CLAD, INSIDE ONLY (IN) CL= 0.0
CORROSION ALLOWANCE INSIDE (IN) CAI= 0.0
CORROSION ALLOWANCE OUTSIDE(IN) CAO= 0.0

SUBJECT CONT. DATE 8/5/78 BY [signature]
CHECKED BY RL DATE 8-8-78 REV.NO. BY DATE SHT 14

(F)

CBI NUCLEAR COMPANY

8-CN245 DUANE ARNOLD NOZZLE ANALYSIS

DIST. FROM SAFE END OF NOZZLE TO PT. OF ANALYSIS Z= 8.44 IN
PRESSURE P= 0. PSI

QUANTITY	UNITS	OUTSIDE SURFACE	INSIDE SURFACE	MEMBRANE SURFACE
MAXIMUM STRESS INTENSITY	PSI	720.	667.	494.
THETA	DEGREES	360.	336.	249.
FX	LBS	0.	0.	0.
FY	LBS	0.	0.	0.
FZ	LBS	0.	0.	0.
MX	IN-LBS	0.	0.	0.
MY	IN-LBS	0.	0.	0.
MZ	IN-LBS	0.	0.	0.
LONG. STRESS(PRESSURE)	PSI	0.	0.	0.
LONG. STRESS(AXIAL LOAD)	PSI	354.	354.	354.
LONG. STRESS(BENDING)	PSI	365.	285.	-121.
SHEAR STRESS(FORCES + TORSION)	PSI	-0.	-95.	-218.
CIRC. STRESS(PRESSURE)	PSI	0.	0.	0.
S1	PSI	720.	653.	364.
S2	PSI	0.	-14.	-131.
S3	PSI	0.	0.	0.

THERMAL SLEEVE LOADS APPLIED WHEN Z IS GREATER THAN OR EQUAL TO 8

INSIDE DIAMETER (IN)	ID= 11.200
OUTSIDE DIAMETER (IN)	OD= 13.120
DIST. FROM PT. OF APPL. OF LOADS TO SAFE END (IN)	ZO= -1.500
CLAD, INSIDE ONLY (IN)	CL= 0.0
CORROSION ALLOWANCE INSIDE (IN)	CAI= 0.0
CORROSION ALLOWANCE OUTSIDE(IN)	CAO= 0.0

SUBJECT *DUANE ARNOLD RECIRC. INLET* CONT *8-CN245* DATE *7-14-78* BY *ARE*
CHECKED BY *RL* DATE *8-8-78* REV.NO. BY DATE SHT *21*