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Duane Arnold Energy Center
Operated by Nuclear Management Company, LLC

August 7, 2003

NG-03-0577
10 CFR 50.55a

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

DUANE ARNOLD ENERGY CENTER
DOCKET 50-331
LICENSE No. DPR-49

SUBJECT:	Evaluation of Indication in Dollar Weld HCC-B002
REFERENCE 1:	NG-01-0601, Letter dated May 2, 2001, K. Putnam (NMC) to NRC
REFERENCE 2:	NG-01-0975, Letter dated August 15, 2001, K. Putnam (NMC) to NRC

In April of 2001, during refueling outage (RFO) 17, weld inspections were performed at the Duane Arnold Energy Center (DAEC) in accordance with the DAEC Inservice Inspection (ISI) Program. As discussed in Reference 1, those inspections identified an indication in a circumferential weld in the reactor head (Vessel Head Dollar Weld HCC-B002) that did not meet ASME Section XI IWB-3500 acceptance standards. The indication was evaluated and determined to be acceptable to leave as-is.

The Inservice Inspection Summary Report that was submitted to the NRC (Reference 2) referred to the evaluation, but did not include it for the Staff's review. Submittal of the evaluation to the NRC is required by IWB-3134. Nuclear Management Company, LLC therefore submits the evaluation by this letter (Attachment).

This letter contains no new commitments.

Sincerely,

for

Mark A. Peifer
Site Vice President, Duane Arnold Energy Center

Attachment

CC. Regional Administrator, USNRC, Region III
Project Manager (DAEC)
NRC Resident Inspector (DAEC)

A047

3277 DAEC Road • Palo, Iowa 52324-9785
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Indication in HCC-B002

Summary

A subsurface indication was identified in a circumferential weld in the reactor head (Vessel Head Dollar Weld HCC-B002). A sketch of the indication is provided in this attachment.

The indication in HCC-B002 was evaluated using the Duane Arnold Reactor Pressure Vessel Flaw Evaluation Handbook (SASR 91-44, DRF 137-0010, issued July 1991). The flaw acceptance diagrams contained in the Handbook were developed in accordance with Section XI of the ASME Code (1989). The flaw was determined to be acceptable to leave as is. Completed evaluation worksheets are included in this attachment, along with supporting pages of the Handbook.

An input to the acceptable flaw size is the hydro-test temperature that is determined from the Duane Arnold Energy Center Pressure-Temperature Curves. Since these curves were revised by Amendment 238 (dated April 30, 2001), the flaw acceptance criteria contained in the Handbook required re-evaluation. This re-evaluation is documented in a letter dated May 3, 2001 (enclosed). The allowable flaw size changed from 1.2" to 1.19". As seen in the enclosed evaluation, the size of the indication in HCC-B002 is well below this revised acceptance criteria, and remains acceptable to leave as is.

Duane Arnold
Reactor Pressure Vessel
Flaw Evaluation Handbook

Pages 2-5 –2-9
Pages 2-12 – 2-13
Pages 3-1 – 3-3

2.4 CLASSIFY FLAW

Classify the flaw according to Figure 2.4 and the descriptions below. Record the flaw category on step 4 of the worksheet.

Class	Description
A	An inside surface flaw contained entirely within the cladding.
B	An inside surface flaw which extends beyond the cladding (if present) into the low alloy steel.
C	A subsurface flaw which is analyzed as a surface flaw per step 3d above due to close proximity to the inside surface ($S < 0.4d_1$).
D	An outside surface flaw.
E	A subsurface flaw which is analyzed as a surface flaw per step 3d above due to close proximity to the outside surface ($S < 0.4d_1$).
F	A subsurface flaw remote from the surface according to step 3d above ($S \geq 0.4\ d_1$).

2.5 SIZE FLAW

The flaw dimensions are next recorded on step 5 of the worksheet as follows:

a-e) For Class "A" through "E" flaws (flaws considered as surface flaws), record the surface flaw depth, 'b', (excluding the cladding) to be considered after combining the flaws due to proximity to other flaws or the surface. Also, record the surface flaw length , 'ℓ', to be considered.

f) For a Class "F" (subsurface) flaw, record the measured or combined sub-surface flaw depth, '2d'. Also record the measured or combined length, 'ℓ', and the distance to the surface, 'S'.

2.6 CALCULATE NON-DIMENSIONAL PARAMETERS

The following non-dimensional parameters are to be calculated for each flaw:

a-e) For Class "A" through "E" flaws, the flaw depth (b/t) and flaw aspect (b/ℓ) ratios are to be calculated and recorded on step 6 of the worksheet. If the calculated flaw aspect ratio exceeds 0.5, set it equal to 0.5.

f) For Class "F" flaws, the flaw depth (d/t) and flaw aspect (d/ℓ) ratios are to be calculated and recorded on step 6 of the worksheet. The flaw-to-surface proximity factor, Y = (S/d) must also be calculated and recorded on step 6. If this value exceeds 1.0, set it equal to 1.0.

2.7 IWB-3500 FLAW EVALUATION

The detected flaw is now to be evaluated in accordance with paragraph IWB-3500 of the ASME code, Section XI.

a) Class "A" flaws (contained entirely within the cladding) are automatically acceptable according to IWB-3510.1d. Check acceptable on step 7 of the worksheet and no further analysis is required.

b-e) For Class "B" through "E" flaws plot the flaw aspect (b/ℓ) and flaw depth (b/t) ratios on Figure 2.5 and record the allowable (b/t) ratio for the given flaw aspect ratio. If the plotted point falls below the IWB-3500 acceptance limit, check acceptable on step 7 of the worksheet. No further analysis is required for this flaw. If the flaw exceeds the limit, check unacceptable on the worksheet and continue to step 8.

f) For Class "F" flaws plot the flaw aspect (d/ℓ) ratio and the flaw depth (d/t) ratio on Figure 2.6. Find the correct curve and allowable (d/t) value for the surface proximity factor, Y, recorded on step 6 of the worksheet. If the plotted point falls below the IWB-3500 acceptance

limit for the correct Y value, check acceptable on step 7 of the worksheet. No further analysis is required for this flaw. If the point exceeds the limit, check unacceptable on the worksheet and continue to step 8.

2.8 CALCULATE FLAW DEPTH INCLUDING CLADDING

To compare the flaw against IWB-3600 limits, the flaw dimensions including the cladding are to be determined.

b&c) For Class "B" and "C" flaws, add the cladding depth, 'c', to the surface flaw depth, 'b', to obtain the total surface flaw depth, a = b+c, and record on the worksheet, step 8. Also, calculate and record the new flaw aspect (a/ℓ) ratio using 'ℓ' from step 5 If the calculated value for (a/ℓ) exceeds 0.5, record the value as 0.5.

d&e) For Class "D" and "E" flaws, the flaw depth, 'a', is set equal to the original flaw depth, 'b', since the flaw is not located on or near a clad vessel surface. Record the values of 'a' and '(a/ℓ) on step 8 equal to 'b' and '(b/ℓ) from step 5. The flaw aspect (a/ℓ) ratio shall be limited to a maximum of 0.5.

f) For Class "F" flaws, the subsurface flaw depth, '2d', and flaw aspect ratio, (d/1), are already recorded on steps 5 and 6.

2.9 IWB-3600 FLAW EVALUATION

Flaws which did not pass the IWB-3500 acceptance limits are now to be evaluated against the IWB-3600 limits developed for Duane Arnold. Using the flaw classification, region and orientation, determine the correct flaw acceptance figure to use from Table 3.1 of Section 3. Record the correct figure number on step 9 of the worksheet.

b) For Class B flaws, the most limiting curve which can be met (0, 5, 10 or 20 years), if any, shall be recorded. The allowable flaw depth, a_{all}, for this curve shall be recorded for the flaw aspect ratio of the flaw.

c-e) Record the allowable flaw depth, a_{all} for the aspect ratio of the flaw.

f) Record the allowable flaw depth, $2d_{all}$ for the flaw.

If the flaw meets the IWB-3600 limits, check the box for "Acceptable per IWB-3600". For acceptable Class B flaws, also record which criteria is met (0, 5, 10 or 20 years. Future monitoring of these flaws which exceed IWB-3500 and are found acceptable by IWB-3600 is required to verify that significant growth does not occur.

If the flaw is not acceptable, check the box for "Unacceptable per IWB-3600" and continue to step 10 to investigate further analysis which may be done to show compliance to IWB-3600.

2.10 FURTHER EVALUATION

If a flaw can not be shown to be acceptable according to the flaw acceptance diagrams given in this report, it is possible that a flaw-specific analysis can be completed to show acceptance of this flaw with no repair. Because this analysis considers most of the Duane Arnold vessel, some conservative assumptions were made to make the results bounding for various regions of the vessel. Some conservative assumptions which were made in the IWB-3600 fracture analysis include:

1) The most limiting (highest) RTNDT for any material within a region is assumed for the entire region.

2) Cladding stresses are included, even for the outside surface of the vessel and for subsurface flaws.

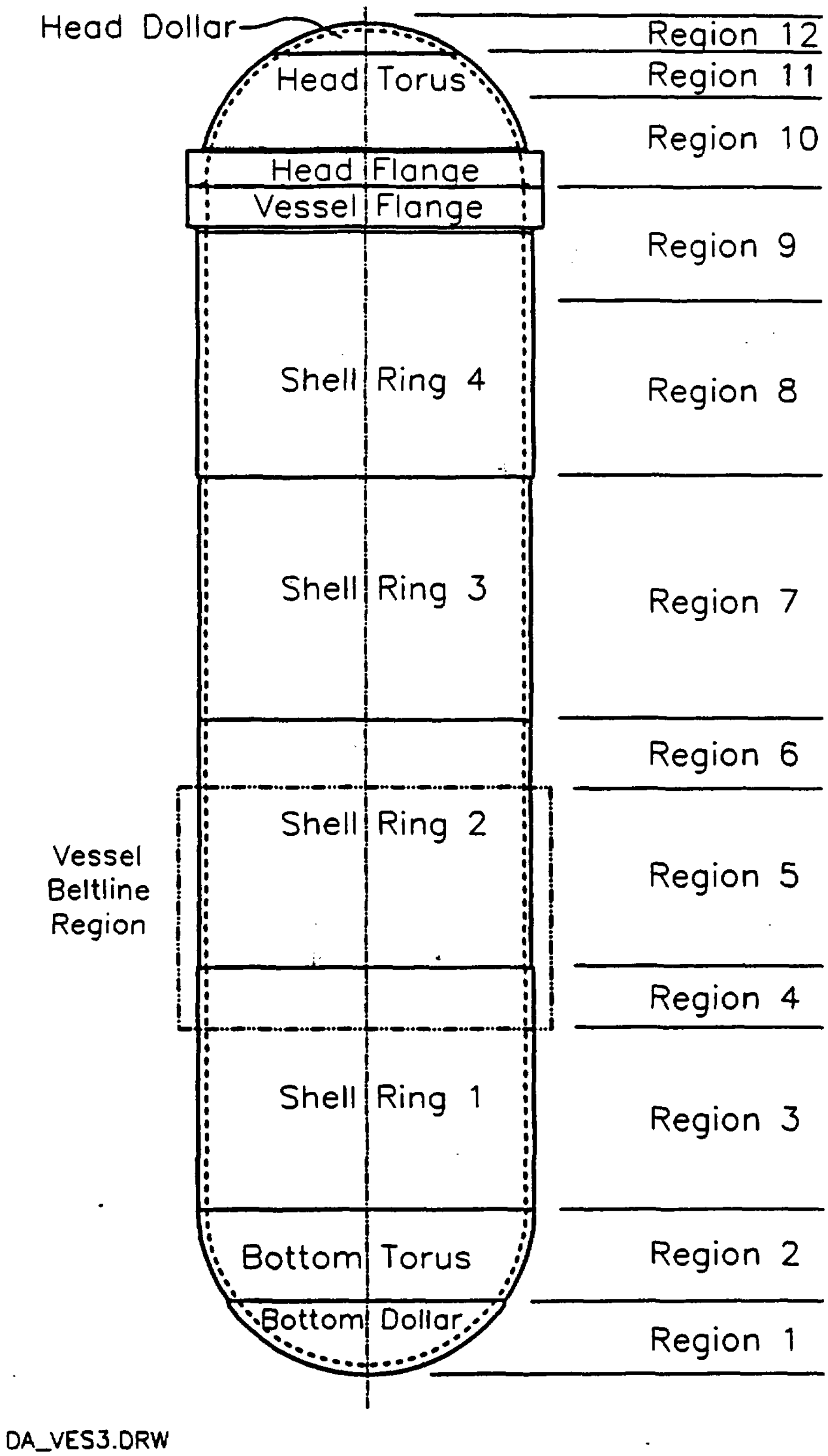
3) Minimum design wall thicknesses are used rather than "as-built" wall thicknesses.

4) The largest bending stresses for the vessel closure flange regions (9 and 10) are assumed to occur over the entire region. Also, the flange region stresses used are for 1250 psig pressure rather than the actual hydrotest pressure of 1100 psig.

Although these assumptions do not add much conservatism to the analysis in most cases, a flaw-specific analysis should first be conducted to eliminate these conservatisms and attempt gain acceptance for the flaw. Another possible alternative may be to increase the hydrotest temperature. This will increase the material toughness during the most severe loading in terms of fracture and increase the allowable flaw depths. The flaw acceptance diagrams for regions 4 and 5 already show the effect for an increased hydrotest temperature.

If the local stress limit (1/3 thickness) region of the acceptance curve is exceeded (the flat portion of the curve) the assumptions made above will not affect the flaw depth limit. For this case, a finite element analysis will likely be able to show additional margin.

If a flaw-specific analysis is not able to resolve the detected flaw, the flaw may have to be ground out or in extreme situations weld repaired.



Region 13 includes region A shown on Figure 2.2 for Nozzles N1-N5, N8, N9, N11 & N16

Region 14 includes region A shown on Figure 2.2 for Nozzles N6 & N7

Region 15 includes region A shown on Figure 2.2 for Nozzles N10 & N12

Figure 2.3 - Vessel Regions Considered in Handbook

Vessel Flaw Classifications

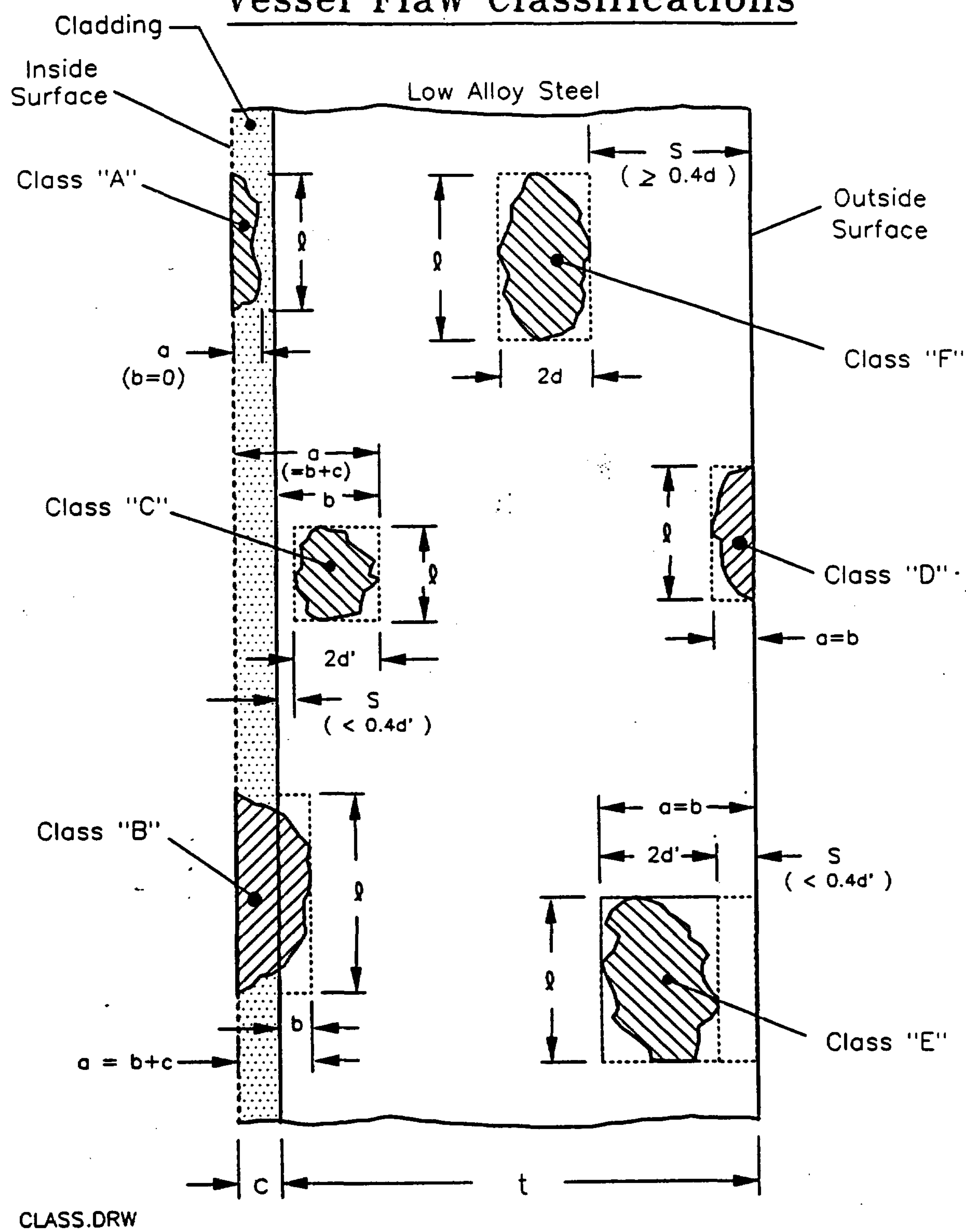


Figure 2.4 - Vessel Flaw Classifications

SECTION 3

FLAW ACCEPTANCE DIAGRAMS

This section contains the flaw acceptance diagrams developed in accordance with section IWB-3600 of the ASME code, Section XI. An example flaw acceptance diagram is shown on Figure 3.1. In order to prevent excessive local stresses in the vessel wall, the allowable flaw depths are also limited to 1/3 of the wall thickness, even when larger flaws can be justified per IWB-3600. The IWB-3500 limits shown for the class B and C acceptance diagrams are given for comparison purposes only. These figures are not to be used for IWB-3500 evaluations, the Figure 2.5 and 2.6 diagrams are more accurate figures used for this purpose. Table 3.1 lists the correct flaw acceptance diagram for each region.

Class B flaw depths are limited to the IWB-3600 criteria or to the depth equal to 1/3 of the low alloy steel wall thickness plus the cladding thickness. For Class B flaws penetrating the inside surface of the vessel, environmentally - assisted fatigue crack growth can be significant. For this reason, the flaw acceptance curves show limits for various periods of time. If the Class B flaw depth plotted on the acceptance diagram is below the "0 year" line, the present flaw depth is acceptable. However, with fatigue crack growth, the flaw could exceed acceptance standards after a certain period of time. If the flaw is below the "10 year" line, the flaw is projected to be acceptable for a period of at least 10 years including conservatively predicted fatigue crack growth.

Class C flaws are limited to the same "0 year" acceptance curves as the Class B flaws. However, fatigue crack growth is not significant for these subsurface flaws isolated from the reactor environment. Therefore, Class C flaws meeting the acceptance criteria will be acceptable indefinitely.

Class D and E flaws are limited to the IWB-3600 criteria or to 1/3 of the low alloy steel wall thickness. For these outside surface flaws or subsurface flaws close to the surface, fatigue crack growth is insignificant.

The stress intensity for a class F subsurface flaw is equal to the stress intensity for a surface flaw with one-half the flaw depth and equal applied stresses. Because of this, the IWB-3600 allowable flaw depths for a subsurface flaw of depth, '2d', are twice the limits for a surface flaw of depth, 'a'. The subsurface flaw depth is still limited to 1/3 of the vessel low alloy steel wall thickness to prevent excessive local stresses.

The acceptance diagrams given for the beltline regions (Regions 4 and 5) were developed for the present (12 EFPY) hydrotest temperature of 195°F and the present predicted RTNDT shifts. Additional analyses were also done assuming a 10°F increase in the hydrotest temperature to show the benefit to be gained by this temperature increase.

Table 3.1 - Flaw Acceptance Diagrams to be used for each Region

Region	Orientation	Flaw Acceptance Diagram Figure# Flaw Class B&C	Flaw Acceptance Diagram Figure# Flaw Class D,E&F
1	N/A	3.2	3.3
2	N/A	3.4	3.5
3	Horiz.	3.6	3.7
	Vertical	3.8	3.9
4	Horiz.	3.10	3.11
	Vertical	3.12	3.13
5	Horiz.	3.14	3.15
	Vertical	3.16	3.17
6	Horiz.	3.18	3.19
	Vertical	3.20	3.21
7	Horiz.	3.22	3.23
	Vertical	3.24	3.25
8	Horiz.	3.26	3.27
	Vertical	3.28	3.29
9	Horiz.	3.30	3.31
	Vertical	3.32	3.33
10	Horiz.	3.34	3.35
	Vertical	3.36	3.37
11	N/A	3.38	3.39
12	N/A	3.40	3.41
13	N/A	3.42	3.43
14	N/A	3.44	3.45
15	N/A	3.46	3.47

Sketch of Indication
(One Page)

$t = 4.0''$

$2a = .232$

$a = .116$

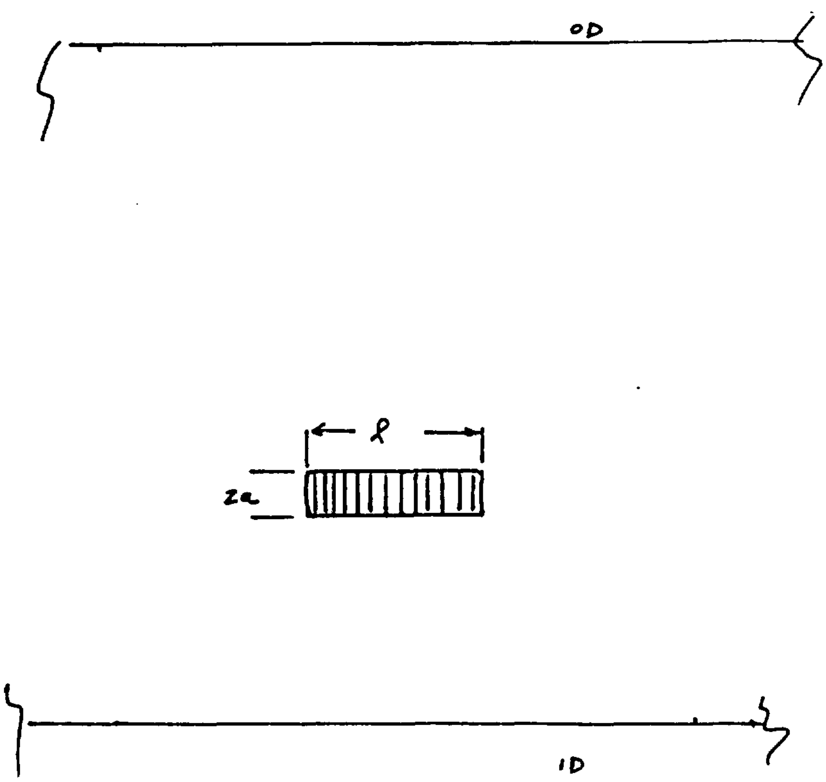
$\ell = 1.0$

$S = 1.214$

$Y = 1.0$

INDICATION IS SUBSURFACE

HCC-B002



Flaw Evaluation
(Four Pages)

Table 2.1 - Duane Arnold Flaw Evaluation Worksheet Flaw ID: HCC-B002

1) Determine Region and Orientation of Flaw. Region: 12
Orientation: N/A

2) Sketch the Flaw Geometry. The flaw sketch is attached on the following sheet. The cladding and low alloy steel thicknesses are:

Cladding Thickness, c = 0 (inches)
Low Alloy Steel Thickness, t = 4.0 (inches)

3) Combine Flaws. Combine flaws in close proximity to other flaws and to the surface per Section 2.3. Draw a rectangle encompassing the combined flaws.

4) Classify Flaw. According to Section 2.4 and Figure 2.4 the flaw is classified as Class: F.

5) Size Flaw. The dimensions of the flaw to be considered are:

Class A-E Flaws			Class F Flaws		
Flaw Depth,	b = ____	(inches)	Flaw Depth,	2d = .232	(inches)
Flaw Length,	ℓ = ____	(inches)	Flaw Length,	ℓ = 1.0	(inches)
			Surface Dist,	S = 1.219	(inches)

6) Calculate Non-dimensional Parameters. The following non-dimensional parameters are to be calculated for each flaw:

Class A-E Flaws		Class F Flaws	
Flaw Aspect Ratio, (b/ℓ) =	____	Flaw Aspect Ratio, (d/ℓ) =	.116
Flaw Depth Ratio, (b/t) =	____	Flaw Depth Ratio, (d/t) =	0.029
		Proximity Factor, Y[1] =	1.0

1) Surface Proximity Factor, Y is calculated as the minimum of 1.0 or (S/d).

Table 2.1 - Duane Arnold Flaw Evaluation Worksheet - (continued)

7) IWB-3500 Flaw Evaluation. Record the allowable IWB-3500 limit below from Figure 2.5 for Class A through E flaws and from Figure 2.6 using the appropriate curve for "Y" from step 6 for Class F flaws. If the (b/t) or (d/t) ratio recorded in step 6 above is below the IWB limit, check the box "Acceptable per IWB-3500" below. Otherwise, check the box "Unacceptable per IWB-3500" and continue to step 8.

Class A-E Flaws	Class F Flaws
Allowable Ratio, (b/t) = ____	Allowable Value, (d/t) = .026

____ Acceptable per IWB-3500.
X Unacceptable per IWB-3500.

8) Calculate Flaw Depth Including Cladding. The cladding depth shall be added to inside surface flaw (Class B & C depths prior to the IWB-3600 analysis to obtain the total flaw depth. For outside surface flaws, there is no cladding. Therefore, no cladding depth is added. The new values shall be recorded below:

NO CLADDING ON VESSEL TOP HEAD

Class B&C Flaws	Class D&E Flaws
Total Flaw Depth, a=b+c = ____	Total Flaw Depth, a = b = ____

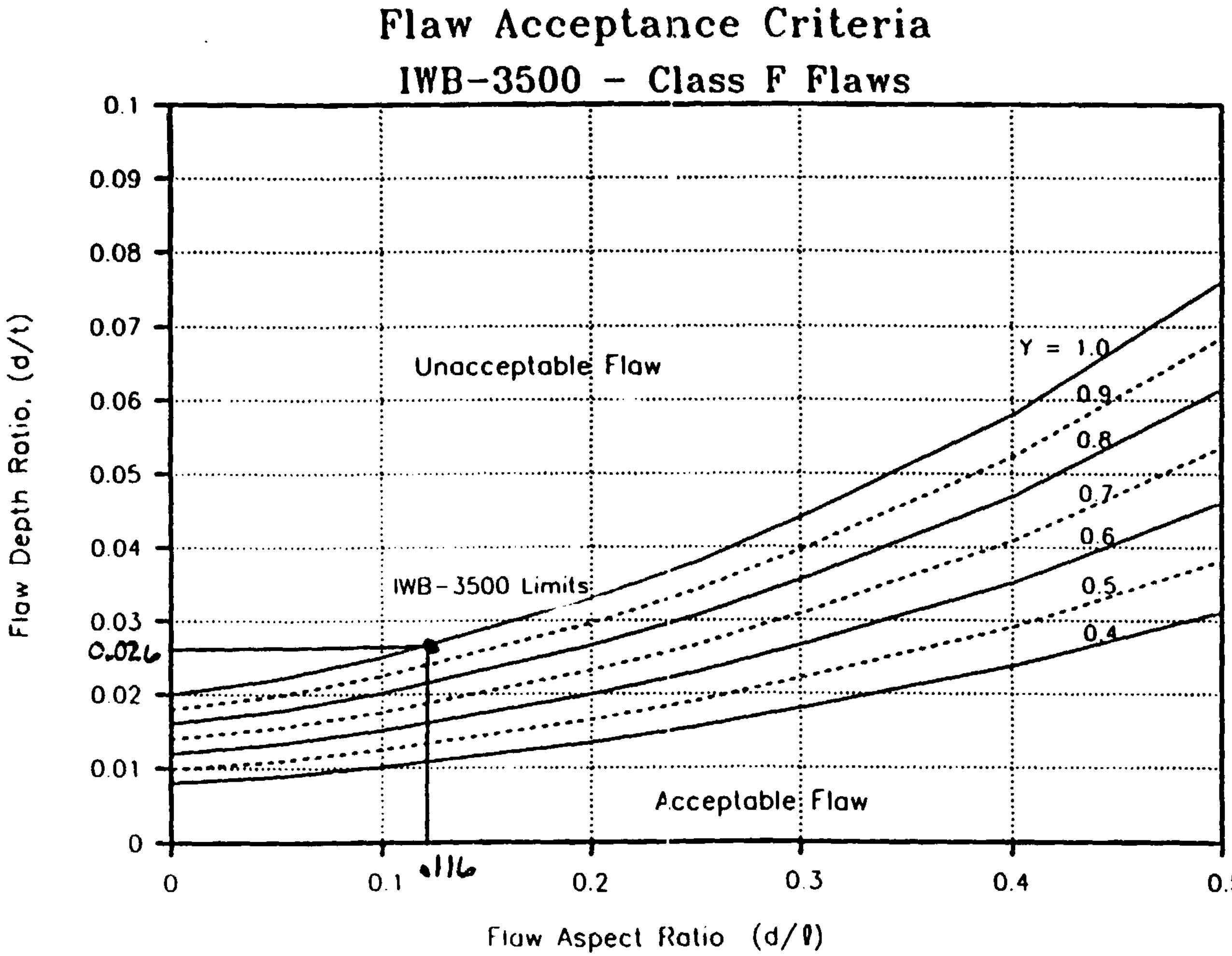
Flaw Aspect Ratio, (a/ℓ) = ____

9) IWB-3600 Flaw Evaluation. Record the appropriate flaw acceptance diagram Figure # from Section 3, determine and record the allowable flaw depth. Also record whether the flaw is acceptable or not and for how many years a class B flaw is acceptable. Figure #: 3.41

Surface Flaw (Class A-E)	Subsurface Flaw (Class F)
Allowable Depth, a_{all} = ____	Allowable Depth, $2d_{all}$ = 1.2

X Acceptable per IWB-3600. for ____ years (Class B)
____ Unacceptable per IWB-3600.

DA_FLEV.WP



IWB-35-2 DRW

Figure 2.6 - IWB-3500 Acceptance Standards for Class F Flaws

SASR 91-44
DRF 137-0010

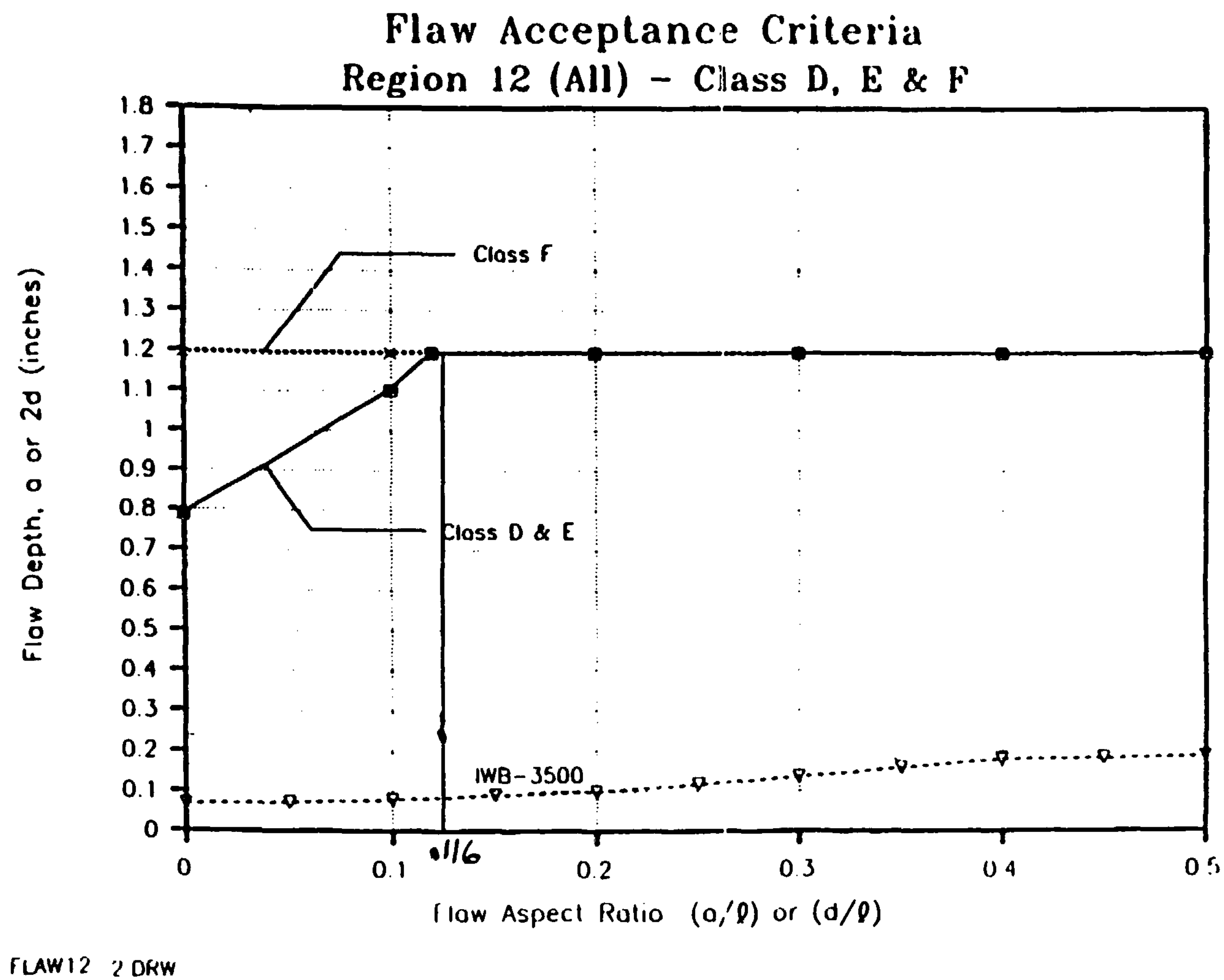


Figure 3.41 - Flaw Acceptance Diagram for Region 12 (All) - Class D,E&F Flaws

SASR 91-44
DRF 137-0010

Letter, B. Branlund to G. Park
Dated May 3, 2001
(Two Pages)

GE Nuclear Energy

Structural Mechanics and Materials
175 Curtner Avenue M/C 747
San Jose, CA 95125
(408) 925-1472

B13-02097-00-07
DRF-B13-02097-00-07
Class II
May 3, 2001

TO:	**Gary Park** **Duane Arnold Energy Center** **3277 DAEC Road** **Palo, IA 52324**
FROM:	**Betty J. Branlund**
SUBJECT:	**Updated RPV Flaw Evaluation of Duane Arnold Region 12 for the Class F Flaw in the Head Dollar Weld**

SUMMARY:

The purpose of this letter is to revise the Reference 1 Duane Arnold Energy Center (DAEC) RPV Flaw Handbook evaluation of Region 12 Class F flaws to incorporate the results of the updated Pressure-Temperature Curves Report (Reference 2).

INTRODUCTION/ BACKGROUND:

The DAEC Flaw Acceptance criteria provided in the Reference 1 report was used to disposition a flaw in Region 12 of the DAEC RPV. A key input to the acceptable flaw size is the hydro-test temperature that is determined from the DAEC Pressure-Temperature curves. Since, these curves were revised in September 2000, the RPV flaw acceptance criteria requires revision and the disposition of the flaw in Region 12 would need to be reevaluated.

METHODS AND ASSUMPTIONS:

The methods are consistent with those used in Reference 1, with the following exceptions:

- Fatigue crack growth was included in the evaluation whereas in the Reference 1 report fatigue crack growth was neglected because the value was insignificant. The fatigue crack growth evaluation is consistent with the methods described in Appendix F of Reference 1, but the allowable flaw size was revised to incorporate the updated Pressure-Temperature Curves hydro-test temperature and the number-of-cycles were increased from 100 cycles to 340 cycles. As a result of these changes the fatigue crack growth was increased from 0.002 inches to 0.01 inches.
- The equation for K_{Ia} was revised to correct an error in the ASME Code. The coefficient 1.233 was changed to 1.223; this change does not result in a significant change in the

results compared to the change in hydro-test temperature nor the number of cycles used in the evaluation.

RESULTS & CONCLUSIONS:

The allowable flaw size was determined using a hydro-test temperature at 1100 psig of 174F at 25 EFPY (Reference 2) rather than 195F at 12 EFPY (Reference 1). In addition fatigue crack growth was included in the allowable flaw size for this Class F (subsurface) flaws. The allowable flaw size for the DAEC Region 12 Class F flaws is reduced from 1.2" to 1.19". GE has reviewed the flaw evaluation worksheet provided by the customer (Reference 3) and concurs that the existing flaw remains acceptable.

VERIFICATION:

Using References 1 through 3, letter B13-02097-00-07 was verified by individual design review. Letter B13-02097-00-07 was verified that it provided accurate documentation of the evaluation performed to determine the allowable flaw size.

Further evidence of verification is included in DRF-B13-02097-00-07.

Verified By: B D Frew
B. D. Frew, Structural Mechanics and Materials

REFERENCES:

1. C.D. Frederickson, "Duane Arnold Reactor Pressure Vessel Flaw Evaluation Handbook," GE-NE, San Jose, CA, June 1991, (SASR 91-44, DRF 137-0010).
2. B.D. Frew, "Pressure-Temperature Curves for Duane Arnold Energy Center," GE-NE, San Jose, CA, September 2000, (GE-NE-A22-00100-08-01a). (This report updates the curves for ASME Code Case N-640 and includes the influence of power uprate).
3. Fax from Ron Ballou to Gon Maxwell, "DAEC RPV Head Flaw," GE-NE/ DAEC-SSM, 4/24/01.