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PEACH BOTTOM 2,3 SHROUD VERTICAL SEAM WELD EVALUATION

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1.0 OBJECTIVE

The objective of this report is to document the allowable flaw sizes at the vertical welds in the shroud. This report is expected to serve as technical basis for recommendations regarding the in-service inspection of these welds.

2.0 BACKGROUND

Cracking in axial welds has been limited and where it has occurred, the crack lengths are small (less than 3 inches in all plants except one where a 15-inch crack was observed). This compares with instances where virtually continuous 360° circumferential cracks (approaching 600 inches) were found. The more extensive cracking in the horizontal welds could be due to the presence of the end grain orientation, cold work due to machining and the higher residual stresses due to the circumferential welds. On the other hand, the vertical welds have somewhat lower residual stresses because of the greater compliance of the vertical welds. The presence of the fluence could reduce the residual stresses further. Also, there is less likelihood of cold work when compared to the circumferential welds.

The allowable crack lengths for axial welds given in the screening criteria reports are based on the assumption that the circumferential welds are not fully (360 degree through thickness) cracked. The more limiting assumption of full cracking is the design basis for the shroud repair, not a realistic assumption. For the realistic assumption of no severed circumferential welds, it can be shown that the allowable crack length is greater than the length of the entire weld seam[(1)]. However, if the objective is to determine the required minimum uncracked ligament, it is reasonable to assume that the different sections of the shroud are in fact free standing cylinders (i.e., fully cracked circumferential welds). With this assumption, it is possible to determine the required uncracked weld length. The calculation results are discussed in the next section.

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(1) The screening criteria report gives a very conservative length of 59 inches based on LEFM. However, that length was calculated based on the shroud pressure loading and geometry below the core plate. Strictly speaking, the LEFM consideration applies only to the shroud sections between welds H3 and H5. If the circumferential stress corresponding to welds H3-H5 is used, the allowable length is 102 inches. This length exceeds the weld seam lengths between the H3-H4 and H4-H5 welds.

3.0 FRACTURE MECHANICS CALCULATION RESULTS

Figure 1 shows the details of the shroud welds. For welds V3 through V6 the required ligament is governed by linear elastic fracture mechanics (LEFM). In calculating the allowable crack lengths (and from that, the required ligament) a correction factor was applied for the finite length of the cylinder. For the V1-V2 welds, faulted condition was governing with a safety factor of 1.5. The same was the case for the V3 through V6 welds also. For welds V7-V8, the normal/upset condition was governing with a safety factor of 3.0.

The LEFM calculation results were conducted without the use of safety factors. The use of the safety factor in the LEFM calculation may not be warranted since (i) the ends of the crack are likely to be outside the high fluence location and therefore not subjected to the maximum embrittlement, and (ii) just because we verify the uncracked ligament length it does not mean that the rest of the weld is fully cracked. , (iii) actual faulted condition pressures, as shown by many TRACG analyses, are lower than those used here.

The calculation results are shown in Table 1. It is seen that the largest required ligament length is for welds V5-V6 and is 18.3 inches including a crack growth allowance of 3.2 inches (for two fuel cycle of 2 year duration). This works out to be 18.3/2 or approximately 9.2 inches of uncracked length needed at each end of these welds. However, the required ligament length at the H3 and H5 ends of the vertical welds is expected to be more like that reported for V1-V2 and V7-V8 welds since the fluence there is expected to be low enough that a limit load method is applicable. Thus, a 4.6-inch uncracked length at the H3 and H5 ends of the vertical welds is expected to be adequate. Note that an inspection to assure the presence of these uncracked vertical weld lengths is necessary only if it is determined that the installation of shroud repair hardware is warranted.

4.0 EFFECT OF SHROUD REPAIR

Shroud repair involves the installation of hardware including tie rods. A review of the finite element stress analyses on the effect of the tie rod spring loads (during a seismic event) on the hoop stress in the shroud show that the crack driving force for axial cracks is small. Thus, the impact on the allowable LEFM crack lengths calculated in the preceding section is expected to be insignificant.

5.0 CONCLUSION

Based on the fracture mechanics based allowable flaw length calculation results presented in the preceding sections, it is concluded that the vertical seam welds in the shroud have large flaw tolerance and thus extensive examination of these welds is not needed.

Table 1

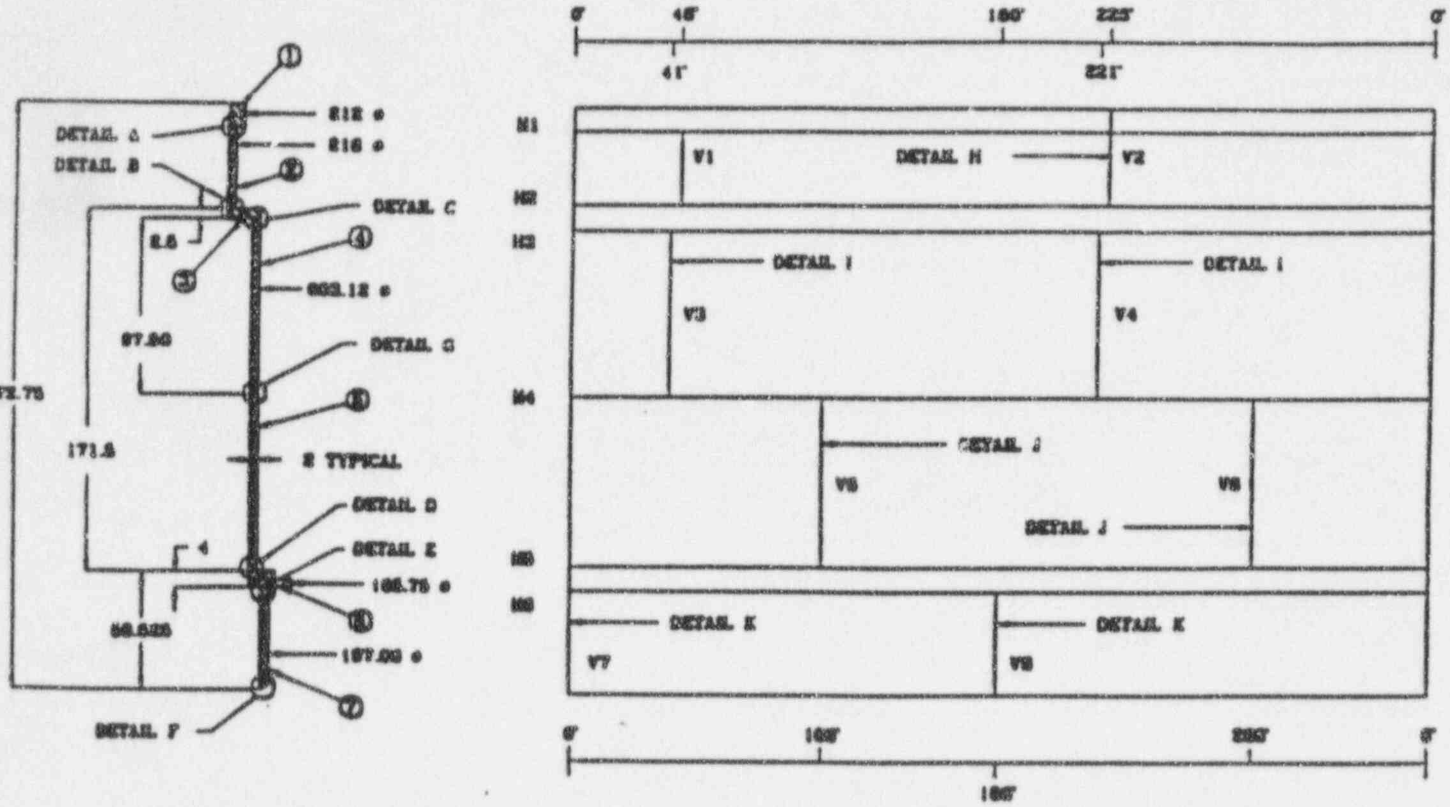
Weld ID	Memb Stress (ksi)[1]	Weld Length (in.)	Applicable Method[2]	Min. Length[3] (in.)	With Corrosion Allow[4].
V1-V2	2.71	35.6	LL	1.9	5.1
V3-V4	2.56	71.2	LEFM	5.8 (w/o sf)	9.0
V5-V6	2.56	97.5	LEFM	15.1 (w/o sf)	18.3
V7-V8	5.37	55.6	LL	5.9	9.1

Notes: (1) Includes Code safety factor; 3.0 for normal/upset condition and 1.5 for emergency/faulted condition.

(2) Controlling method; LL=Limit Loac., LEFM=Linear Elastic Fracture Mechanics.

(3) Required uncracked ligament length.

(4) Required uncracked ligament length plus allowance for crack growth of 1.6x2 or 3.2 inches (for two fuel cycle of 2 year duration)



Geometry of Shroud Showing Vertical Welds

Figure 1

Inspection Recommendations for Vertical Seam Welds

Inspections Prior to Shroud Repair

Conduct enhanced VT-1 of vertical welds V3 through V6. Examine 4.6 inch lengths intersecting H3 and H5 welds, and 9.2 inch lengths intersecting H4 weld.

Alternately, (9.2+4.6) or approximately 14 inch lengths intersecting H4 weld can be examined.

Inspections Following Repair

Visually inspect the weld sections intersecting H4 weld once every two fuel cycles or three years, whichever is longer.

Note: UT can be substituted for any of the visual examinations.