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United States Nuclear Regulatory Commission
Region I
631 Park Avenue
King of Prussia, PA 19405

ATTENTION: MR. BOYCE H. GRIER, DIRECTOR

SUBJECT: Beaver Valley Power Station - Unit No. 2
Docket No. 50-412
Linear Indications in Gib Gusset Welds in Reactor Vessel Structural Support (Neutron Shield Tank)
Significant Deficiency 80-03

Gentlemen:

Enclosed is "Interim Report No. 2 on Linear Indications in Gib Gusset Welds in Reactor Vessel Structural Support (Neutron Shield Tank) at Beaver Valley Power Station - Unit No. 2". We plan to issue the final report when the weld rework effort is completed, which is presently scheduled for July 15, 1981. If you have any questions concerning this report, we are available to meet with Nuclear Regulatory Commission personnel at their convenience.

DUQUESNE LIGHT COMPANY

By E. J. Woolever
E. J. Woolever
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cc: Dr. V. Stello (15)

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Interim Report No. 2

on

Linear Indications In Gib Gusset Welds in Reactor Vessel Structural Support (Neutron Shield Tank)

at

Beaver Valley Power Station - Unit No. 2

1.0 SUMMARY

A major portion of an extensive reinspection of the Reactor Vessel Structural Support (RVSS) has been completed and the extent of weld deficiencies appears to be limited to the top section of the RVSS. A program for replacement of all gibs and gib gussets has been prepared and the selection of a qualified fabricator is underway.

2.0 IMMEDIATE ACTION ITEMS

Additional magnetic particle inspection and exploratory ultrasonic inspection, beyond the NDE identified in the previous interim report, has provided further evidence that the deficiencies in the gib and gib gusset welds are extensive and that major rework is required. A non-destructive examination program was initiated to inspect the entire RVSS, to establish the integrity of all of the welds on this support structure. The NDE program was implemented as described below:

1. A volumetric (ultrasonic) inspection of the skirt-to-base flange weld was partially completed to verify that no defects exist in this area which would jeopardize the load carrying capability of the structure. The inside reinforcing fillet weld has been subjected to extensive repair, as reported in the final report "Weld Discrepancies in RVSS (Neutron Shield Tank)" submitted on June 11, 1980. Preliminary volumetric

inspection results of the skirt-to-base flange weld provided further assurance that all previously detected unacceptable indications were removed from the inside portion of the weld. In addition, MP inspection of the exterior portion of the skirt-to-flange weld was found to be acceptable with only minor grinding, requiring no further weld repair.

2. An ultrasonic reinspection was performed on approximately 5 percent (minimum) of all welds previously UT inspected by the vendor (to the same acceptance criteria imposed on the vendor). The random selection and reinspection verified the vendor's compliance with the specified acceptance criteria.

3. A detailed review was conducted of all the radiograph film generated by the vendor during fabrication. This review produced some 27 films that were difficult to interpret out of a total of 260 views taken on 20 welds. The weld areas, represented by these 27 films, will be radiographically reinspected to the same specified acceptance criteria imposed on the vendor. All the radiographed weld areas, except the areas that will be reinspected, proved to be acceptable.

4. A reinspection of all accessible welds was initiated by magnetic particle examination, including the welds volumetrically inspected by the vendor. The MT acceptance criteria was the same as those imposed on the vendor. The reinspection effort is continuing; however, all discovered defects have been successfully removed by limited grinding with a final MT acceptance. A final review of all defect excavations will determine if any weld repair will be required.

Based on the reinspection completed to date, it appears that the significant weld deficiencies are limited to the gib and gib gusset welds. Exclusive of the gib/gusset weld problem and the areas noted above, the overall quality of the welds appears to be good and the NDE procedures/results provided by the vendor are valid.

The reinspection results provide an improved level of confidence in the vendor's ability to produce and inspect sound welds and also restore credibility to the vendor's quality control program. The overall acceptable quality of the welds may be attributable, in part, to S&W's PQA inspectors who witnessed some 25-30 percent of the magnetic particle inspections performed by the vendor. In addition, visual inspection of welds, during frequent shop surveillance inspections, was performed by a PQA resident inspector, and at times, two PQA inspectors. The defects discovered on-site (gib and gib gusset welds) could have been undetectable prior to post weld heat treatment (PWHT); and since weld inspection after PWHT was not feasible due to inaccessibility, the results preclude any concern that a breakdown in quality control was a possibility during shop fabrication.

3.0 DESCRIPTION OF DEFICIENCY

Based on extensive magnetic particle inspection, ultrasonic inspection, and exploratory grinding of selected gib gusset welds, it was concluded that a weld sample should be removed to gain some insight into the cause of the weld defects.

A weld sample (See Figure 2) was removed by drilling and cutting from the gib gusset that showed the most extensive ultrasonic indications. Material from the weld metal, gusset and top plate was taken from one of the sections for chemical analysis. The analysis showed no deviations from the specified chemistry or from normal trace elements.

Macroscopic examination of polished and etched sections revealed various degrees of cracking, predominantly in the vicinity of the fusion zone of the top plate and along the weld-prep bevels of the gusset, the most severe as represented in Figure 3. The cracks in the top plate apparently initiated in the weld heat-affected zone, near the root of the weld, and propogated outward,

toward the weld surface, close to the fusion boundary, partially along the heat affected zone and partially through weld metal. It is now believed these cracks propogated during stress relief. The smaller cracks in the gusset and gib plates were located near the fusion boundary, close to the root of the weld, and have the appearance of delayed, cold, hydrogen-initiated cracks.

High temperature oxide on the fracture surface of both types of cracks indicates exposure to air above 800°F; clearly the cracks existed prior to, and/or developed during, stress relief. The cause of cracking is still being investigated. It is postulated at this time that the most probable cause of the defects was hydrogen delayed cracking aggravated by post weld heat treatment. There is no evidence of lamellar tearing in the top plate, which is fabricated from an electroslag remelted steel.

4.0 ANALYSIS OF SAFETY IMPLICATIONS

The removal of all weld defects and the restoration of the gibs and gib gussets with an upgraded level of quality assurance will clearly establish the structural integrity of this support to satisfy all safety considerations for all conditions of design.

5.0 CORRECTIVE ACTION

Based on the reinspection performed to date, all the gibs (12 total) and all the gib gussets (48 total) will be removed and replaced, using a weld fabrication procedure/sequence (see Appendix I) that should eliminate the weld deficiencies that exist in this area of the support structure. An upgraded NDE program for the reworked gib and gib gusset welds has been established and is equivalent to the program for all the other welds on the structure, that were ultrasonically inspected by the vendor, and to acceptance criteria that would satisfy present code standards.

As shown in Table 1, the upgraded NDE program for the entire RVSS closely conforms to ASME III, Subsection NF. In many cases, the NDE requirements for the RVSS exceed those specified in Subsection NF, i.e., the secondary welds have been exposed to both in-process and final weld pass magnetic particle inspection (NF requires only visual examination). All volumetrically inspected welds were also in-process and final welds pass inspected by magnetic particle (NF does not require both examinations to be performed). In summary, by (1) rewelding the gibs and gib gusset plates, (2) reinspecting the skirt-to-base flange weld to more stringent acceptance criteria, and (3) verifying the volumetric and magnetic particle examination performed by the vendor, the resultant weld fabricated RVSS will readily satisfy present-day criteria and in many cases exceed those criteria.

6.0 ADDITIONAL REPORT

A final report will be issued when the weld rework effort on the gib/gib gussets is completed. Presently, this effort is scheduled for completion by July 15, 1981.

APPENDIX I

SEQUENCE AND OPERATIONS FOR REPAIR OF GIB GUSSETS AND GIBS

A. Removal of gib gussets and gibs

1. All gibs, gib gussets, weld metal and 1/4 in. of the top surface of the 7 in. thick top plate is to be removed. Removal may be either the entire top 1/4 in. of the plate or the rectangular areas approximating the 12 locations of the gussets and gibs.

B. Replacement of gib gussets and gibs

1. The excavation is to be ground in preparation for buttering.
2. Perform prod, dry powder, MT of the ground surface(s) in accordance with TEST section.
3. Perform straight beam UT of ground surfaces in accordance with TEST section, where gussets and gibs are to be welded.
4. Preheat and soak 1 hr. minimum at 250-350°F prior to welding. The welding procedure specification is to be qualified with this preheat. Maintain preheat until completion of welding of gibs and two inner gib gussets at the 12 locations. Preheat shall be achieved by the use of resistance strip heaters, not torch heat.
5. Butter surface(s) where gib and gib gussets are to be welded.
6. Grind buttered layer(s) to prepare for MT and MT inspect each layer using the dry powder, prod technique. Submerged arc welding is recommended for this buttering. The thickness of the finished butter layers is to be 1/4 in minimum.
7. Prepare weld preps on gibs and gib gusset. MT weld prep using dry powder, prod technique.
8. Record fit-up dimensions on each gib prior to welding. Weld gibs, use peening, minimize distortion, MT each layer using prod technique. The size of the reinforcing fillet is not to exceed the size of the specified fillet by more than 1/8 in.
9. Grind welded surfaces smooth for UT and contour grind toes of reinforcing fillet welds to eliminate undercut, overlap, etc. A 1/4 in. radius burring tool shall be used for contour grinding.
10. MT gib welds using prod technique.
11. Weld two inner gussets using 3/8 in. thick backing bars.

12. Bake welds in gibs and inner gussets at 350°F-450°F - hold 8 hr. and then cool to below 100°F.

13. During or after cooling to 100°F, repeat Step No. B-9.

14. Perform MT on inner gusset and gib welds four days after reaching 100°F level.

15. Perform UT on gib and gusset welds.

16. Reapply welding preheat and soak for the 1 hour minimum prior to welding.

17. Weld two outer gussets same as No. B-11.

18. Bake two outer gussets welds same as No. B-12.

19. Repeat Step No. 13.

20. Perform MT on outer gusset welds four days after reaching 100°F level.

21. Perform UT on outer gusset welds.

C. General precautions

1. Control electrode storage, handling and issue so as to avoid moisture pick up in electrode coating.

2. Maintain weld joints in clean, dry condition during all welding. Do not contaminate with scale, oxides, oils, etc.

3. Apply techniques to minimize residual stresses throughout all welding:

   a. Good fit-up

   b. Peening

   c. Use of "buttering technique" when welding, i.e., the side walls of the bevel shall be welded before the throat of the weld.

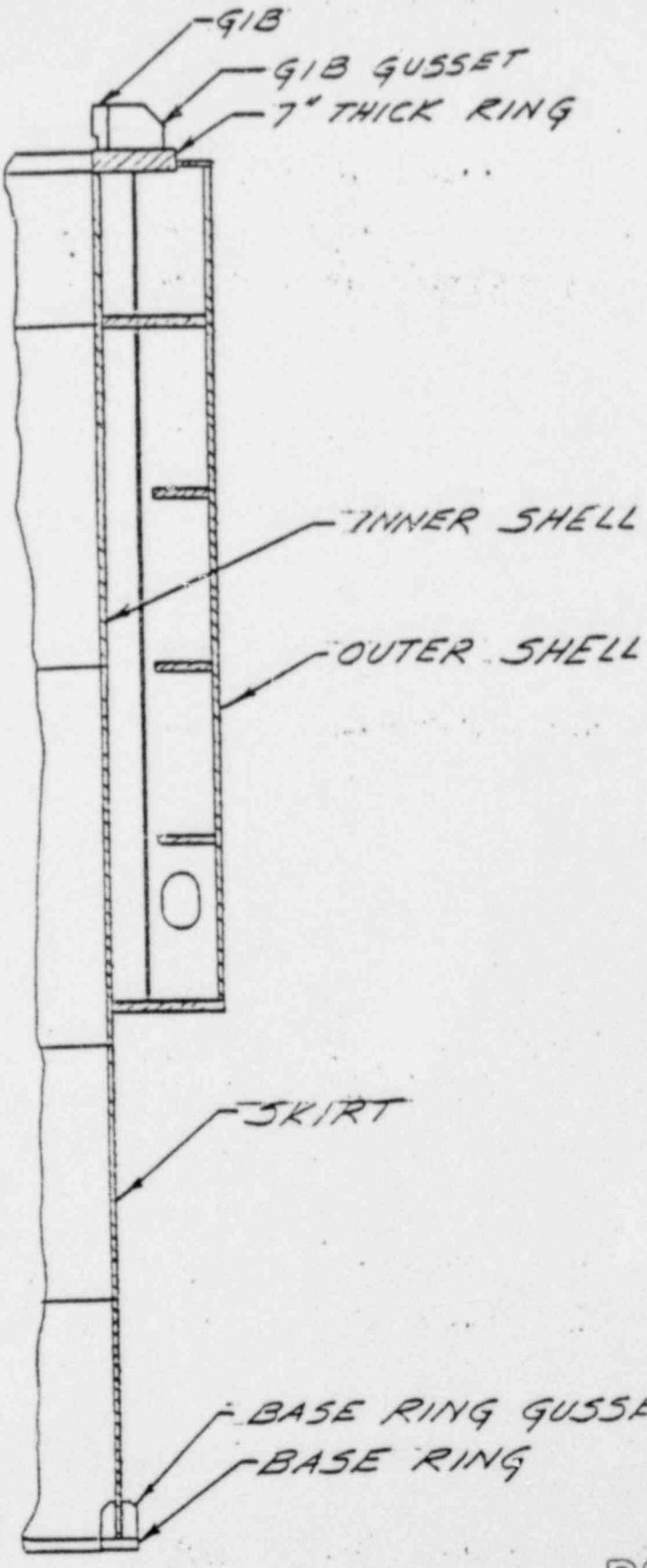

FIGURE -1

DATE												TITLE: NEUTRON SHIELD TANK SECTIONAL VIEW	REF:
PREP.		RHF											
CHECK	5		4		3		2		1				SKETCH
APPR.													

▲ 5215.9

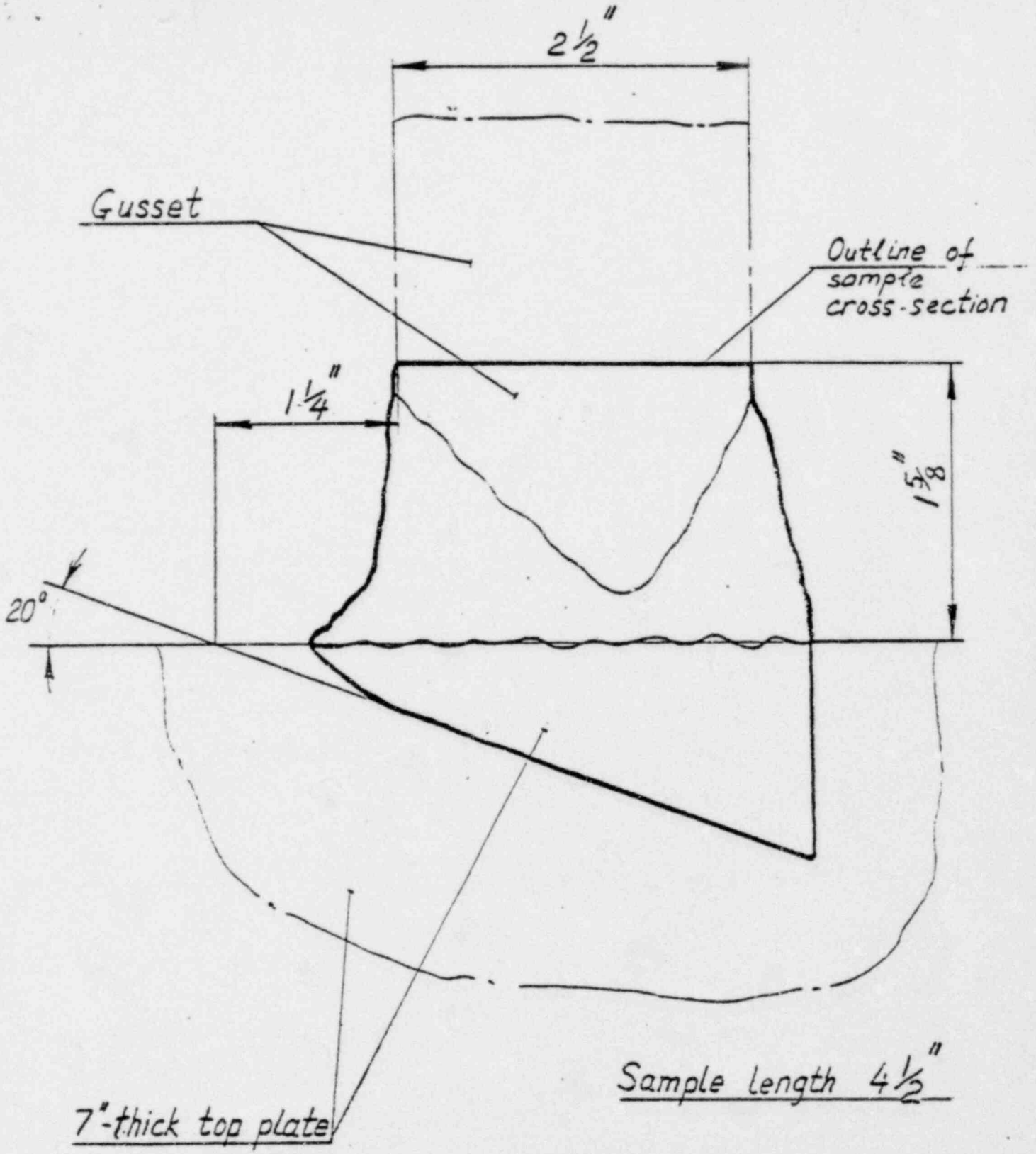

FIGURE 2

POWER INDUSTRY GROUP	TITLE	Sample for metallurgical examination	SCALE:
CHECKED			DATE:
CORRECT			SKETCH NUMBER
APPROVED			
REVISIONS	② ③ ④ ⑤		

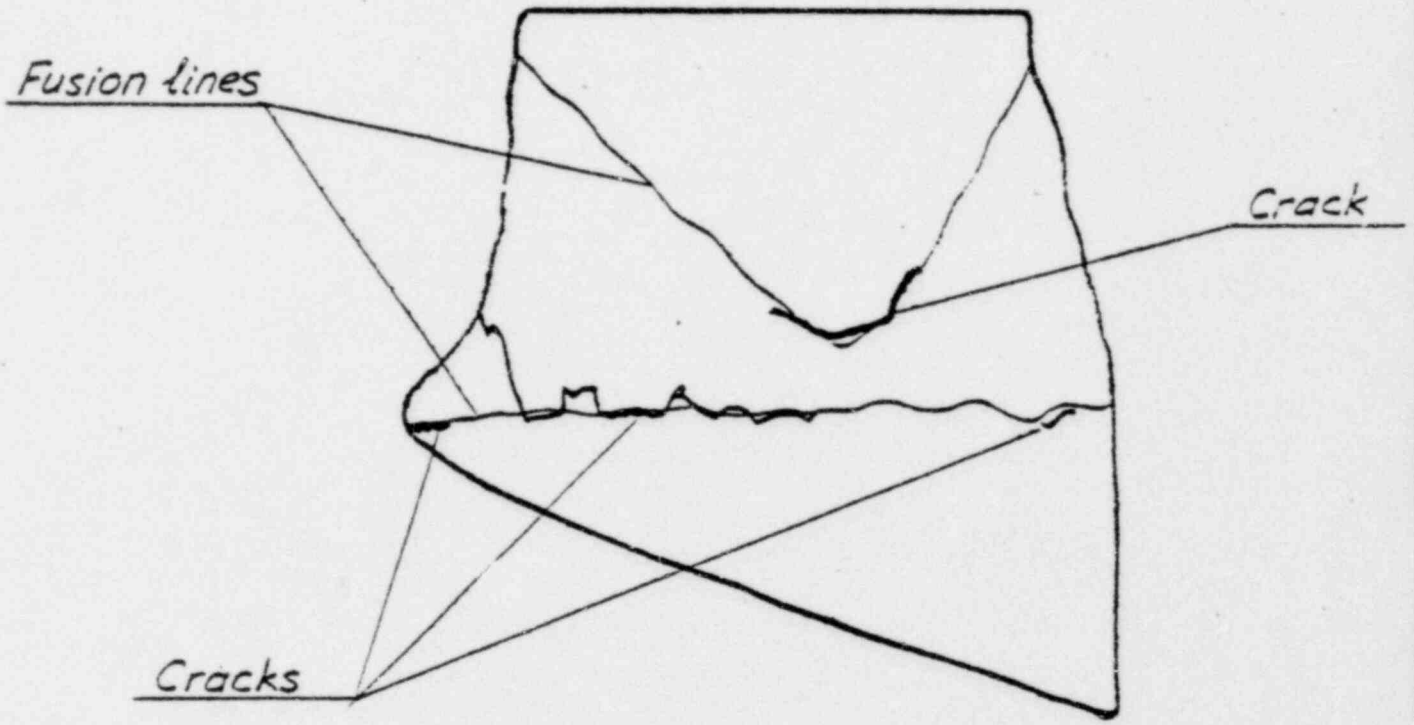

FIGURE 3

POWER INDUSTRY GROUP		TITLE Representative cracks	SCALE:
CHECKED			DATE:
CORRECT			
APPROVED			SKETCH NUMBER
REVISIONS	② ③ ④ ⑤		

TABLE I- NDE COMPARISON TO ASME III, NF REQUIREMENTS
(See Figure 1 for Major RVSS Section Identification)

	Vendor Inspection Type/Accept. Criteria	On-Site Inspection Type/Accept. Crit.	ASME III, NF Requirements
I. PRIMARY WELDS			
A. Top Plate			
1. Gibs	MT/ASME III, NF	UT/Exploratory) See	RT/UT
2. Gib Gussets	MT/ASME III, NF	UT/Exploratory) Note 1	RT/UT
3. Top Plate			
3.1 Butt Joints on 7" Plate)	UT/ASME VIII*+	5%, random UT	RT/UT
3.2 Butt Joints on 2" Plate)		Sample/ASME VIII*	
3.3 7" Plt. to 2" Plate)			
B. Tank Annular Section			
1. Inner and Outer Shell to Top Plt.	UT/ASME VIII*+	5% UT/ASME VIII*	RT/UT
2. Inner Shell Joints	RT/ASME VIII (Top Sect. UT)*+	Review Film*	RT/UT
3. Outer Shell (top section only)	UT/ASME VIII*+	5%, UT/ASME VIII*	RT/UT
C. Inner Shell (skirt section)			
1. Circum. and Long Butt Joints	RT/ASME VIII*	Review Film*	RT/UT
D. Skirt to Base Flange (excluding gussets)	MT/ASME III, NF	UT/Exploratory*	RT/UT
E. Base Flange Butt Joints	MT/ASME III, NF	UT/Exploratory*	RT/UT
II. SECONDARY WELDS			
A. Tank Annular Section			
1. Outer Shell (lower section)	MT/ASME III, NF	MT/ASME III, NF	Visual examination
2. Bulkhead Plates (interior)	MT/ASME III, NF	MT/ASME III, NF	Visual examination
3. Manway (top plate)	MT/ASME III, NF+	MT/ASME III, NF	Visual examination
4. Bottom Plate Segments	MT/ASME III, NF+	MT/ASME III, NF	Visual examination
B. Skirt Section			
1. Instr. Access Flange	MT/ASME III, NF	MT/ASME III, NF	Visual examination
2. Manway	MT/ASME III, NF	MT/ASME III, NF	Visual examination
C. Skirt to Base Flange			
1. Gusset Plates	MT/ASME III, NF	MT/ASME III, NF	Visual examination

+MT (outside surface only) after hydro
*Plus MT per ASME III, NF

Note 1 - Reworked welds will be UT inspected per ASME VIII plus MT per ASME III, NF