

REACTOR PRESSURE VESSEL PRESERVICE ULTRASONIC EXAMINATION  
LIMITATIONS AT SEQUOYAH NUCLEAR PLANT, UNIT 2

Supplemental Report  
SwRI Project 17-6037

Prepared for

Tennessee Valley Authority  
1750 Chestnut Towers II  
Chattanooga, Tennessee 37401

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## 1. BASIS FOR REPORT

Southwest Research Institute (SwRI) performed an ultrasonic (UT) preservice examination (PSI) of Tennessee Valley Authority's (TVA) Sequoyah Nuclear Plant, Unit 2, reactor pressure vessel (RPV) during December 1980. Except for examination of the closure head and bolting and supplemental examinations of the lower head welds, the RPV UT examinations were performed from the vessel inside surfaces using mechanized positioning equipment (PaR Device and SwRI attachments) and an automated Data Acquisition System (DAS).

The RPV PSI results are reported in SwRI Final Report 17-6037: "Preservice Examination of Selected Class 1 Components of the Sequoyah Power Station, Unit 2," issued April 1981. The UT examinations revealed insignificant and geometric indications as well as indications which were evaluated by SwRI as being Code-acceptable. The examinations were conducted in accordance with the following documents:

- (1) Contract No. 64-148315 for "Baseline and Inservice Inspections of Reactor Vessels" issued by TVA to SwRI, dated June 1, 1978.
- (2) Section XI of the ASME Boiler and Pressure Vessel Code, "Rules for Inservice Inspection of Nuclear Power Plant Components," 1974 Edition with Addenda through Summer 1975.
- (3) Section V of the ASME Code, "Nondestructive Examination," 1974 Edition with Addenda through Summer 1975.
- (4) SwRI "Project Plan for the Preservice Examination of Selected Class 1 Components of Sequoyah Power Station, Unit 2," 80-TVA-SNP-2-1-0, dated July 1980.
- (5) SwRI "Plan for Mechanized Ultrasonic Examination of Selected Components at Sequoyah Power Station, Unit 2," dated September 1980.
- (6) U.S. Nuclear Regulatory Commission Regulatory Guide 1.65, "Materials and Inspection for Reactor Vessel Closure Studs," dated October 1973.
- (7) SwRI Nuclear Quality Assurance Program Manual, Revision 1.

Limitations to examination coverage were experienced during the PSI of the RPV and are generically identified in the SwRI Final Report previously referenced. In response to TVA's request for additional information concerning examination limitations and in anticipation of meeting the reporting requirements of the U.S. Nuclear Regulatory Commission Regulatory Guide 1.150 for future inservice RPV examinations, SwRI has performed a comprehensive review of the 1980 PSI data to further describe and quantify the examination limitations which were experienced. The results of that data review are summarized in this supplemental report. SwRI has continued to refine mechanized examination techniques and equipment such that many of the examination limitations experienced during the Sequoyah Unit 2 PSI will be minimized during future inservice examinations using currently applied techniques.

## 2. DESCRIPTION OF EXAMINATION LIMITATIONS

Two generic types of limitations were encountered most frequently during the PSI of the Sequoyah Unit 2 RPV welds and components:

- (1) Interference from search unit wedge-to-component near surface interface noise, and
- (2) Component geometric interference with the scanning equipment and/or geometric shadowing of examination areas.

Although current SwRI procedures require full vee-path and shallow angle search unit scans to compensate for the limitations encountered in the near surface, this general limitation was experienced throughout the Sequoyah Unit 2 PSI. However, it involved less than 2.5 percent of the weld examination volume for 45 degree techniques and 6.5 percent of the weld examination volume for 60-degree techniques. Generally, interface noise inhibited resolution capabilities at the near surface for about 1.0 inches or less of sound (metal) path for shear-wave examination and 1 inch to 2 inches of metal path for longitudinal-wave examinations. It should be noted that electronic gating did not result in any examination limitations since the entire instrument screen presentation was monitored during the examination, videotaped, and reviewed independently following the examinations.

Recent improvements in equipment design (such as multiple device pivot points and redesigned search unit modules) have greatly reduced limitations due to geometric shadowing and/or component geometric interference. However, this type of inherent interference presents the most significant examination limitation encountered during the Sequoyah Unit 2 RPV PSI.

The attached tables and figures detail the examination limitations experienced during the Sequoyah Unit 2 RPV PSI. Specifically, the tables quantify the limitations in terms of percent of Code-required examination volume which was not effectively covered. The accompanying figures graphically depict the location and extent of the limitations with respect to weld metal and associated base material.

### 2.1 RPV Lower Head Welds

Parallel and transverse scans of Bottom Head Cap-to-Spherical Ring Weld W01-02 were limited due to interference with in-core instrumentation tubes. Additional limitations to volumetric coverage were experienced due to noise encountered at the sound beam entrance point. Table 1 lists the percent of required examination volume not effectively examined for each lower head examination. Figure 1 depicts a layout of the lower head and shows the surface area not covered due to instrumentation tubes and core barrel support lugs. W01-02 was not examined from the inside surface of the bottom head cap due to instrumentation tubes. W01-02 was examined from the outside surface of the vessel using manual ultrasonic methods and obtained full coverage of the required weld volume.

Examination of the Lower Head Meridional Welds W2-A, B, C, D, E, and F were limited due to instrumentation tube interferences, core barrel support lug interferences and near surface interface noise. The percent of required examination volume not covered is provided in Table 1. Figure 1 is a rollout view of the lower head showing areas of module limitations for 360 degrees of vessel azimuth.

Examination of Bottom Head-to-Lower Shell Weld W02-03 was limited due to core support lugs and near surface noise to the extent listed in Table 1. Figure 1 is a rollout view of scan surface limitations due to the core support lug interferences.

## 2.2 RPV Shell Circumferential Welds

Table 2 lists the percent of Code-required weld volume not effectively scanned for each circumferential shell weld examination.

Except for near surface interface noise, there were no examination limitations for Lower Shell-to-Lower Middle Shell Weld W03-04 and Lower Middle Shell-to-Upper Middle Shell Weld W04-05.

Examination limitations of Upper Middle Shell-to-Upper Shell Weld W05-06 were due to interference from the reactor coolant nozzles and near surface interface noise. Figure 2 is a rollout view of the examination area showing azimuths of scan limitations due to the proximity of the recirculation nozzles.

Upper Shell-to-Flange Weld W06-07 was limited due to core barrel antirotation keyways at the top of the vessel and reactor coolant nozzles below the weld. Figure 2 is a rollout view of the upper shell which includes Weld W06-07.

## 2.3 Reactor Coolant Nozzle-to-Shell Welds

The reactor coolant inlet and outlet nozzles were examined from the nozzle bore as well as the vessel wall. Table 3 lists the volume of material not effectively examined from the bore or vessel wall. The limitations experienced were typical for each inlet or outlet nozzle, respectively. Interface noise did not significantly obscure examination coverage of the shell or bore near surface as the two examination approaches complemented one another.

Figures 3 and 4 are section views of the inlet and outlet nozzles, respectively. The most significant limitations to coverage of the Code-required examination volume (A, B, C, D, E) in the inlet and outlet nozzles were experienced during the transverse examinations from the vessel wall. Due to weld joint location and nozzle configuration, full transverse examination coverage of the volume of base metal on the nozzle side of the weld was not possible.

## 2.4 RPV Closure Head Welds

The RPV Closure Head welds were examined manually from the outside surface. Table 4 lists the volume of material not effectively examined.

Figure 5 depicts limitations in a section of the Closure Head Weld W08-09, Flange-to-Head weld. Examination of the Flange-to-Head weld could not be conducted from the flange side due to the flange configuration and was limited from the head side due to interference from the lifting lugs.

Figure 5 is a section view showing limitations to examination of Closure Head-to-Dollar Plate Weld W09-10. These examinations were limited as shown due to interference from the lifting lugs and the insulation support ring.

### 3. CONCLUSION

Limitations to complete coverage of ASME Code-required examination volumes were experienced during the Sequoyah Unit 2 RPV preservice examination due to both component configuration and system design restrictions. The extent of these examination limitations is identified in this report. Many of the areas not effectively examined during the RPV PSI were radiographed during fabrication. Due to refinements in equipment design and SwRI examination procedures, the extent of ultrasonic examination limitation will be greatly reduced during future inservice examinations of the Sequoyah Unit 2 RPV using currently applied examination techniques.

Table 1

## LOWER HEAD WELD LIMITATIONS

<u>Weld No.</u>	<u>Examination Angle</u>	<u>Percent of Volume Not Effectively Examined</u>	<u>Figure No.</u>
W01-02	0°	*54.18	1
	45°	*48.21	1
	60°	*51.12	1
	45°T	*61.36	1
	60°T	*60.48	1
W2-A	0°	53.90	1
	45°	24.42	1
	60°	17.32	1
	45°T	9.77	1
	60°T	4.79	1
W2-B	0°	44.86	1
	45°	11.41	1
	60°	9.42	1
	45°T	4.16	1
	60°T	0.68	1
W2-C	0°	60.20	1
	45°	19.05	1
	60°	12.80	1
	45°T	15.92	1
	60°T	4.79	1
W2-D	0°	45.70	1
	45°	9.13	1
	60°	9.11	1
	45°T	No Limitations	1
	60°T	No Limitations	1
W2-E	0°	46.39	1
	45°	11.05	1
	60°	9.90	1
	45°T	No Limitations	1
	60°T	No Limitations	1
W2-F	0°	45.19	1
	45°	12.16	1
	60°	13.44	1
	45°T	No Limitations	1
	60°T	No Limitations	1
W02-03	0°	42.56	1
	45°	30.35	1
	60°	18.98	1
	45°T	31.01	1
	60°T	30.55	1

\* Complete coverage was established by using manual UT method from vessel outside surface.

Table 2

## RPV CIRCUMFERENTIAL SHELL WELD LIMITATIONS

<u>Weld No.</u>	<u>Examination Angle</u>	<u>Percent of Volume Not Effectively Examined</u>	<u>Figure No.</u>
W03-04	0°	26.40	6
	45°	2.51	6
	60°	6.49	6
	45°T	2.51	6
	60°T	6.49	6
W04-05	0°	26.40	6
	45°	2.51	6
	60°	6.49	6
	45°T	2.51	6
	60°T	6.49	6
W05-06	0°	27.50	2
	45°	2.51	2
	60°	22.45	2
	45°T	2.51	2
	60°T	6.49	2
W06-07	0°	20.49	2
	45°	3.59	2
	60°	5.58	2
	45°T	1.75	2
	60°T	4.49	2



Table 3

## RPV NOZZLE WELD LIMITATIONS

<u>Examination Area</u>	<u>Examination Type</u>	<u>Percent of A-B-C-D-E Volume Not Effectively Examined</u>	<u>Figure No.</u>
Inlet Nozzles	Parallel Scans	45° - 7.34	3
		15° - 54.58	3
Inlet Nozzles	Transverse Scans	*45°T - 68.43	3
		*60°T - 68.43	3
Outlet Nozzles	Parallel Scans	45° - 10.38	4
		10° - 35.50	4
Outlet Nozzles	Transverse Scans	*45°T - 75.38	4
		*60°T - 75.38	4

\* Transverse examinations not performed from the nozzle forging side due to nozzle configuration. These percentages include the areas which were not examined.

Table 4

## RPV CLOSURE HEAD CIRCUMFERENTIAL WELD LIMITATIONS

<u>Weld No.</u>	<u>Examination Angle</u>	<u>Percent of Volume Not Effectively Examined</u>	<u>Figure No.</u>
W08-09	0°	52.09	5
	45°	18.92	5
	60°	12.09	5
	45°T	52.56	5
	60°T	52.39	5
W09-10	0°	5.29	5
	45°	5.31	5
	60°	5.31	5
	45°T	0.90	5
	60°T	0.54	5

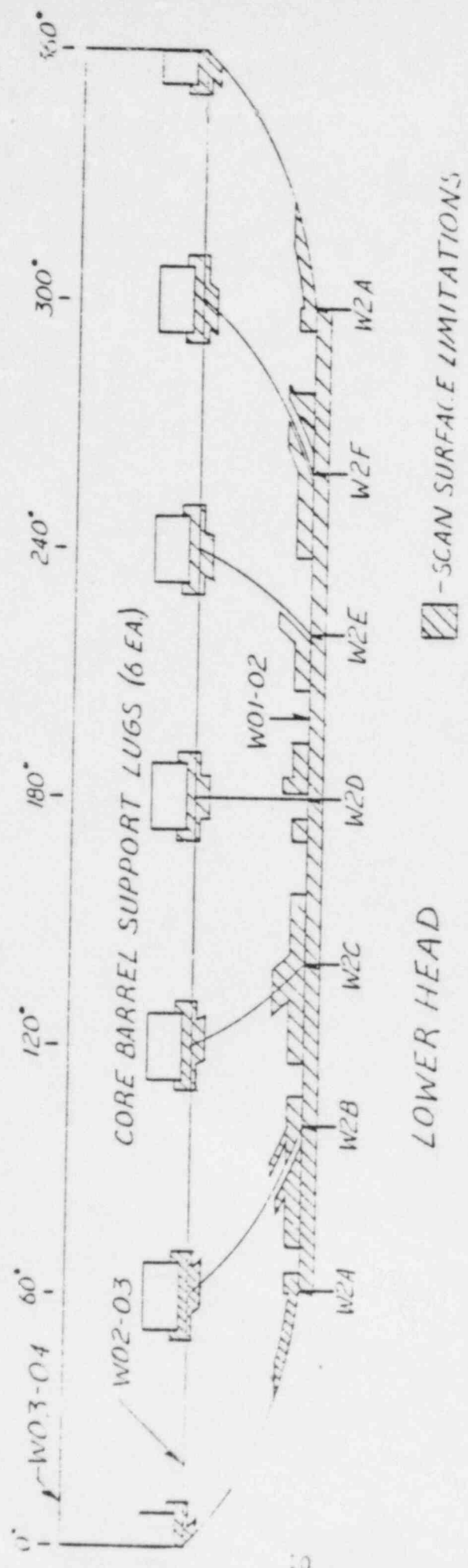


Figure 1

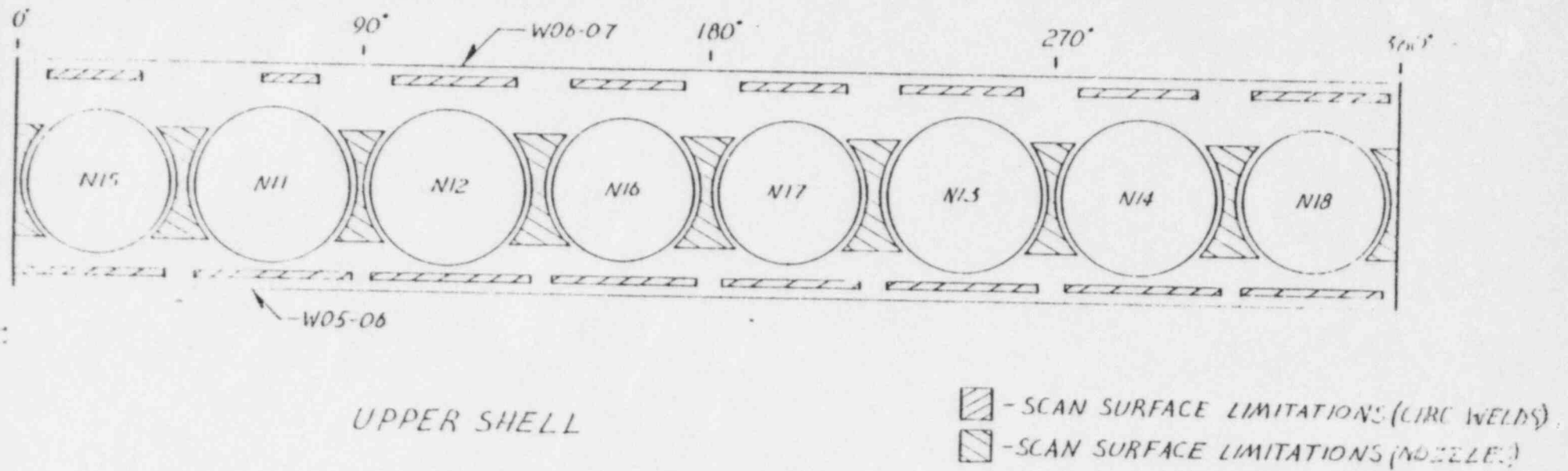


Figure 2

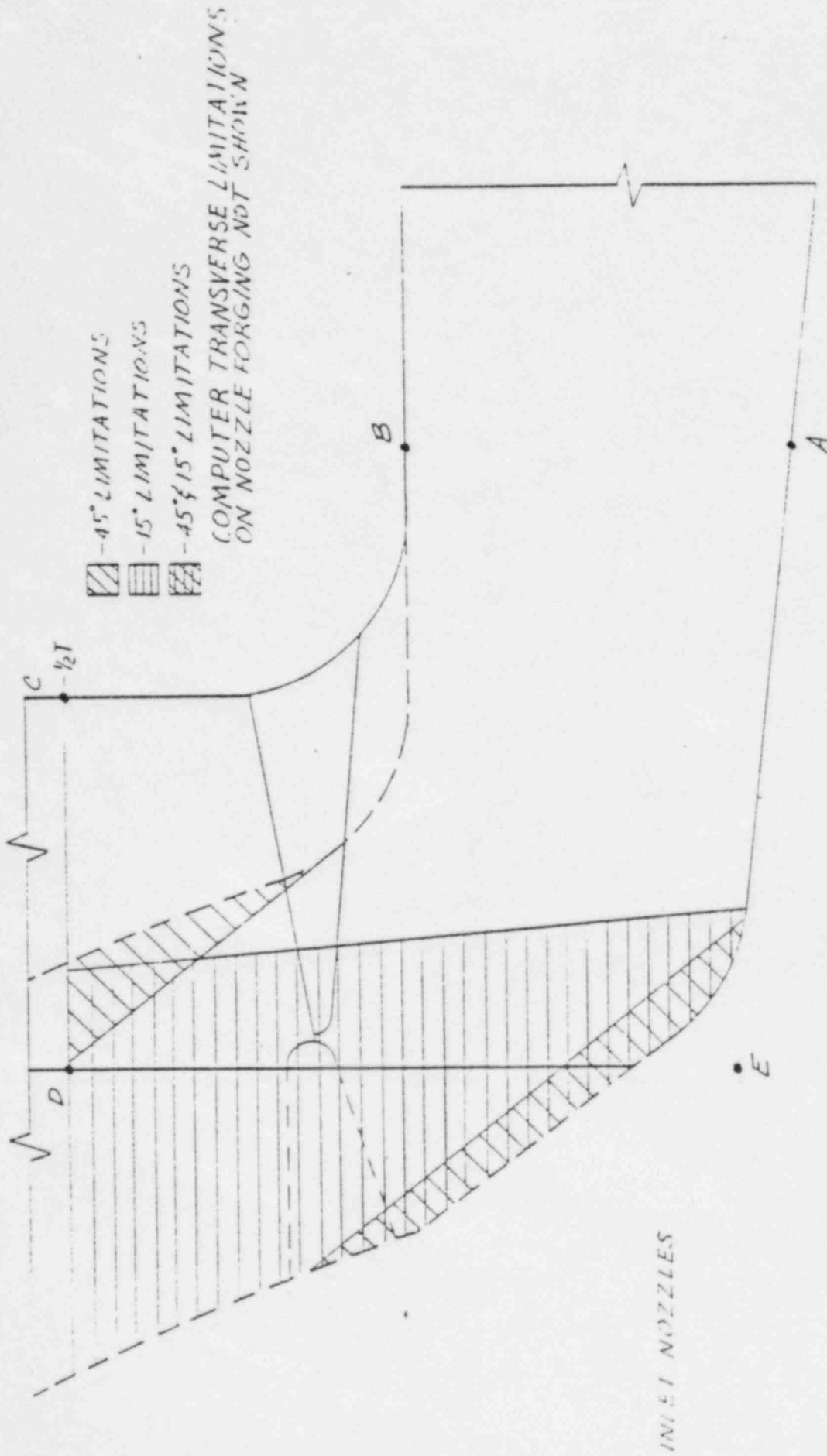
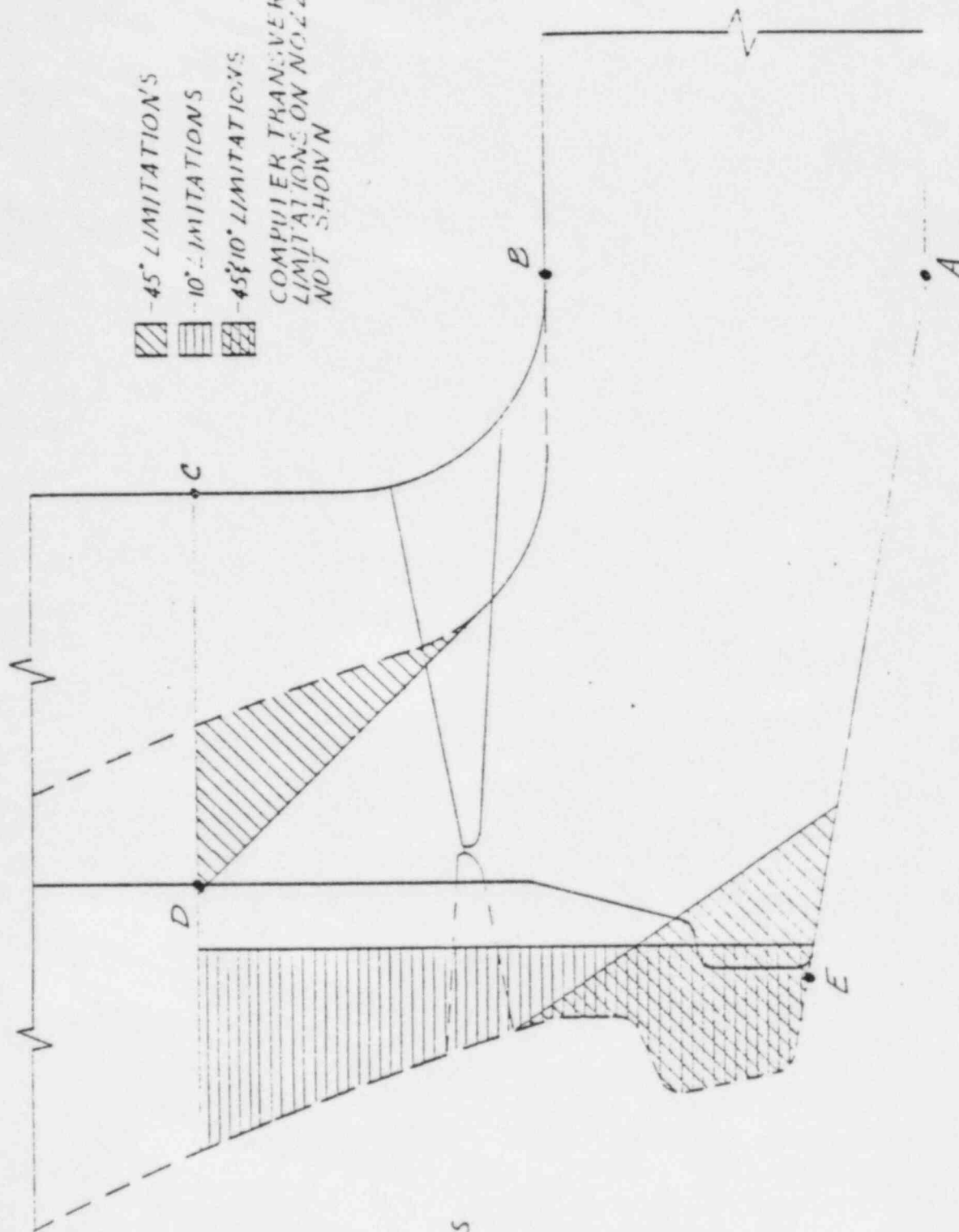


Figure 3



-45° LIMITATIONS  
 -10° LIMITATIONS  
 -45/10° LIMITATIONS  
 COMPUTER TRANSVERSE  
 LIMITATIONS ON NOZZLE FIELDS  
 NOT SHOWN

OUTLET NOZZLES

Figure 4

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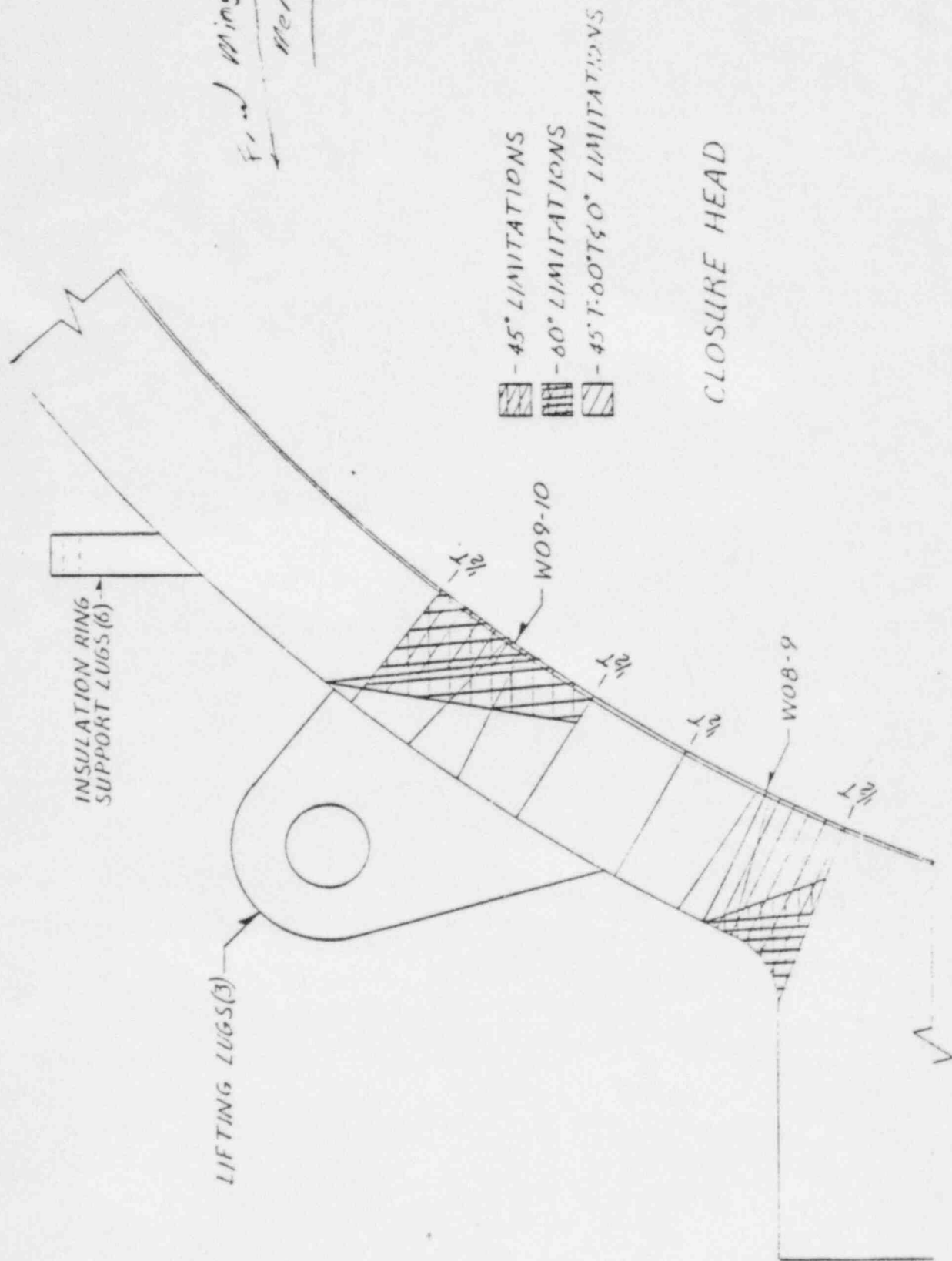


Figure 5

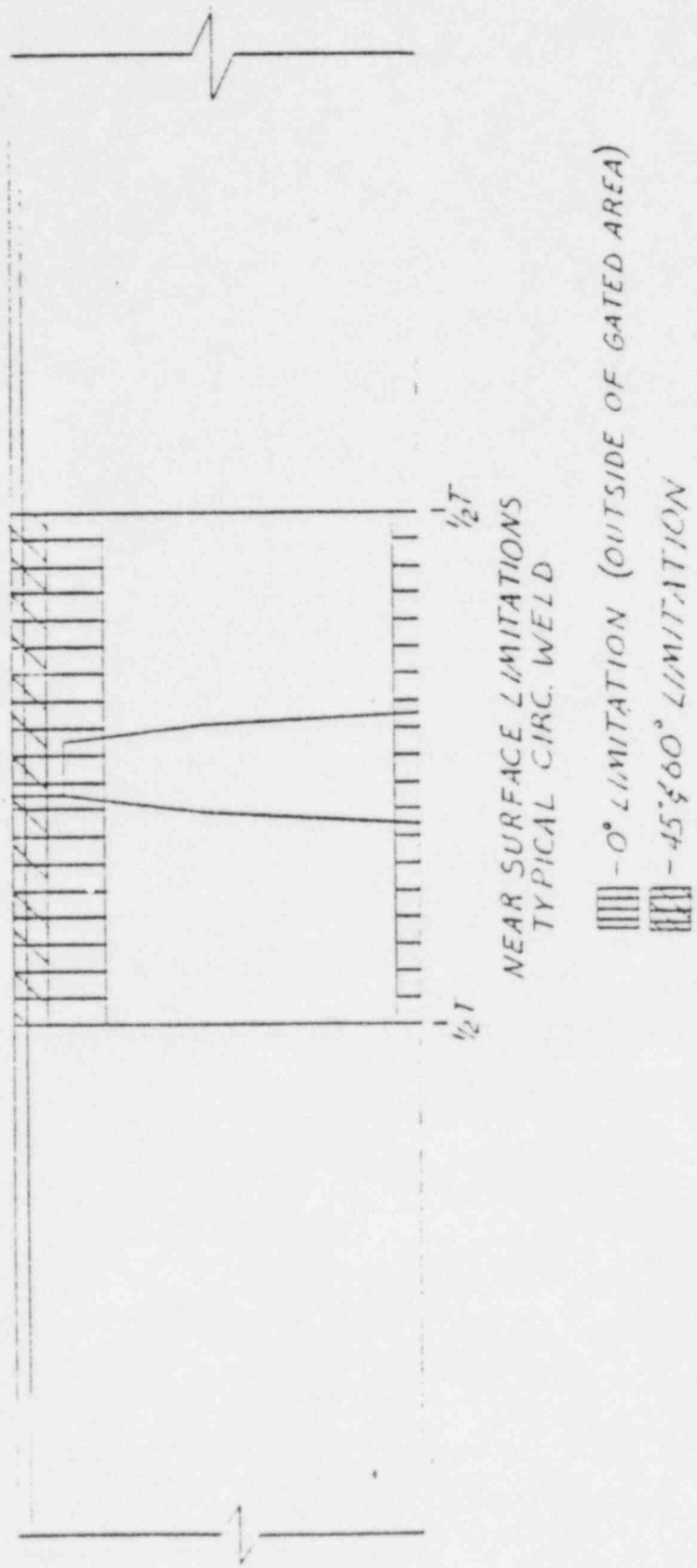
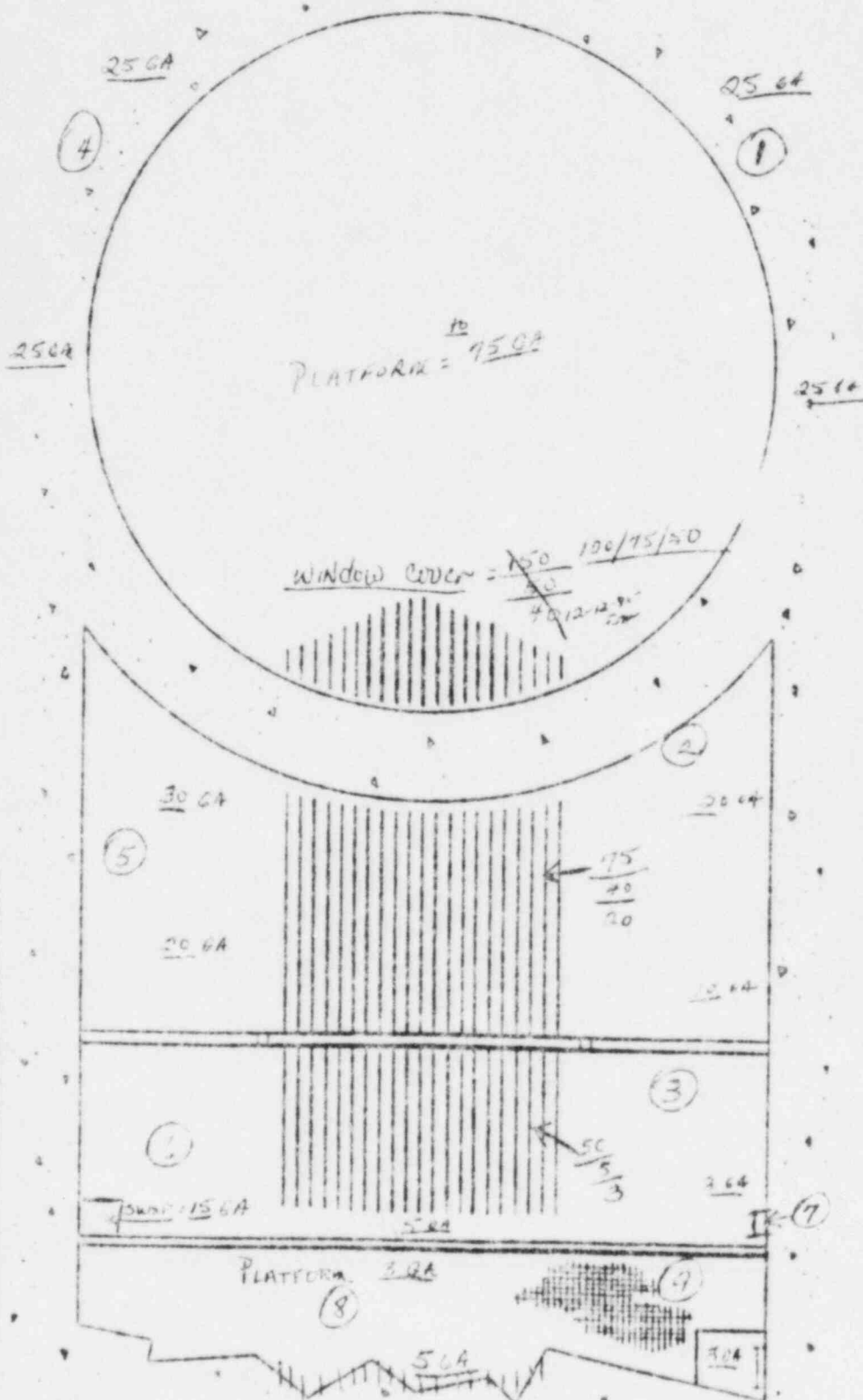


Figure 6



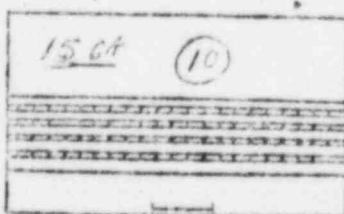
ATTACHMENT 3

UNIT I  
CONTAINMENT BLDG.  
KEYWAY  
ELEV. 651'  
30'64



Point	SEMI 100.00
①	100.000
②	50.000
③	40.000
④	30.000
⑤	20.000
⑥	40.000
⑦	5.000
⑧	6.000
⑨	7.000
⑩	8.000

Date 12-12-85  
Time 11:30  
Surveyed By JSH  
Survey No. 1-85-2351  
Instrument No. RM-14#500238  
T.C.# 515-153



REACTOR VESSEL LOWER HEAD DOLLAR WELD  
EXAMINATION ESTIMATED MAN-HOURS

<u>Item</u>	<u>Description</u>	<u>Hours</u>	<u>Men</u>
1	Build scaffolding	8.00	2
2	Safety inspection	0.25	1
3	Health physics surveys	1.00	1
4	Remove insulation	24.00	2
5	Perform examinations	9.00	3
6	Replace insulation	32.00	2
7	Remove scaffolding	4.00	2
	Total man-hours	164.25	

RME:JLR  
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