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Thiokol Corporation

Flight Motor Set 360L001 (STS-26R) Final Report

Volume V (Nozzle Component)

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Final Report
Nozzle Component

July 1989

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1.0 INTRODUCTION

A review of the performance and post-flight condition of the STS-26 Redesigned Solid Rocket Motor (RSRM) nozzles is presented in this document. Applicable Discrepancy Reports (DRs) and Process Departures (PDs) are presented in Section 5.0. The Nozzle Component Program Team (NCPT) performance evaluation and the Redesign Program Review Board (RPRB) assessment is included in Section 6.0.

The STS-26 nozzle assemblies were flown on the RSRM First Flight (Space Shuttle Discovery) on 29 September 1988. The nozzles were a partially submerged convergent/divergent movable design with an aft pivot point flexible bearing. The nozzle assembly (Figure 1) incorporated the following features:

a. RSRM forward exit cone with snubbers
b. RSRM fixed housing
c. Structural backup Outer Boot Ring (OBR)
d. RSRM cowl ring
e. RSRM nose inlet assembly
f. RSRM throat assembly
g. RSRM forward nose and aft inlet ring
h. RSRM aft exit cone assembly with Linear-Shaped Charge (LSC)
i. RTV backfill in joints 1, 3, and 4
j. Use of EA913 NA adhesive in place of EA913 adhesive

k. Redesigned nozzle plug

l. Carbon Cloth Phenolic (CCP) with 750 ppm sodium content

Figures 2a and 2b show the CCP material usage for the STS-26 forward nozzle assemblies and aft exit cone assemblies.

2.0 OBJECTIVES

The RSRM First Flight test objectives, as outlined in TWR-17535 (MTI Engineering Requirements Document for RSRM First Flight), are as follows (CPW1-3600 paragraph numbers are in parentheses):

K. Demonstrate flex bearing system reusability (3.2.1.9.c).

Y. Post-flight inspection of flex bearing to determine sealing performance in the flight environment (3.2.1.2.3.b).

Z. Post-flight inspection to verify no gas leaks occurred between the flex bearing internal components (3.2.1.2.3.d).

AD. Post-flight inspection for flex bearing damage due to water impact (3.2.1.4.6.a).

AE. Post-flight inspection to verify nozzle liner performance (3.2.1.4.13).

AV. Post-flight inspection to verify remaining nozzle ablative thicknesses (3.3.6.1.2.7).

Post-flight inspection to verify nozzle safety factors (3.3.6.1.2.8).

3.0 SUMMARY/CONCLUSIONS

Compliance to the objectives is discussed below.

K. Evaluation indicates no condition which would adversely affect the reusability of the flex bearing system. Both flex bearings have met all of the refurbishment requirements and are acceptable for reuse.

Y. Preliminary inspection shows the flex bearings remained sealed throughout all motor induced environments. Tensile leak tests done during the refurbishment cycle indicated no leakage.

Z. Preliminary inspection shows the flex bearings maintained a positive seal within the internal components. Tensile leak tests done during the refurbishment cycle also indicated no leakage.

AD. Both flex bearings have met all of the refurbishment requirements indicating there was no damage due to water impact.

AE. Evaluation of both nozzle liners revealed erosion profiles similar to what has been observed on RSRM static test nozzles. Wedgeouts in the aft ends of the RH cowl (120 to 137 degrees) and nose cap (5 to 20 degrees) contained small amounts of slag. Sectioning of the liners showed that the wedgeouts occurred post-burn.

AV. Measurements of the nozzle remaining ablative liner thicknesses show that the design safety factors have been met.

Sectioning and measurement of the liners show that the performance margins of safety are all positive.

4.0 RESULTS/DISCUSSION

All STS-26 post-flight nozzle observations are discussed in detail below. CCP liner Performance Margins of Safety (PMS) are presented using measured erosion, and corresponding measured char values adjusted to the end of action time.

4.1 STS-26A (LH) Nozzle/Flex Bearing

Overall erosion of the STS-26A forward nozzle assembly CCP ablative liner was smooth and uniform. All CCP delaminations, wedgeouts, and pop-ups were determined to be post-burn occurrences resulting from cooldown of the liners. Blowpaths were observed in joints 1, 2, and 4, but there was no blowby, erosion, or heat effect to the primary O-rings. Small amounts of corrosion were found on the metal surfaces of joints 1, 3, 4, and 5, but no pitting was observed. Heavy corrosion and pitting was found on the nose inlet housing bonding surfaces when the phenolics were washed off.

Post-flight subassembly flow surface gaps are shown in Figure 3. Overall views of the nozzle are shown in Figures 4 through 9.

4.1.1 STS-26A Nozzle Components

STS-26A Aft Exit Cone Assembly

Overall views of the STS-26A aft exit cone fragment are shown in Figures 10 and 11.

The aft exit cone was severed aft of the compliance ring by the LSC. The nozzle severance system performance was nominal. The exit cone cut was clean, with no unusual tearing or breaking. The remaining aft exit cone fragment showed missing CCP liner 360 degrees circumferentially. This is a typical post-flight observation and occurs at LSC firing and at splashdown. Glass Cloth Phenolic (GCP) plies exposed by the missing liner showed no signs of heat effect.

The polysulfide groove fill on the forward end of the aft exit cone showed no separations. Post-flight measurements of the polysulfide groove radial width (Table 1) show that the GCP insulator did not pull away from the aluminum shell during cooldown. The polysulfide shrank axially aft up to 0.12 in.

There were no separations observed within the GCP insulator on the forward end.

STS-26A Forward Exit Cone Assembly

Overall views of the STS-26A forward exit cone are shown in Figures 8 and 9.

The forward exit cone showed missing CCP liner over the center portion of the cone 360 degrees circumferentially. This is a typical post-flight observation and occurs at splashdown and during Diver Operated Plug (DOP) insertion. The GCP insulator exposed by the missing liner showed no signs of heat effect. The CCP liner remained bonded on the forward 11 inches and on the aft 8 inches of the cone. These portions showed nominal erosion with no major washing or pocketing. The aft 8 inches of the liner showed the typical dimpled erosion pattern that has occurred on all flight and static test forward exit cones (see Figure 12). The maximum radial depth of the dimpled erosion was 0.15 inch.

The aft end of the forward exit cone showed bondline separations between the EA946 adhesive and the steel housing from 30 to 60 degrees and from 124 to 148 degrees. The maximum radial width of the separations was 0.025 inch. The forward end of the forward exit cone showed bondline separations between the GCP and CCP (0.04 inch maximum radial width), and cohesive separations within the GCP (0.04 inch maximum radial width) intermittently around the circumference. Figure 13 lists the location and radial width measurements of all separations on the forward exit cone. These separations are typical observations which have been seen on previous static test and flight nozzles, and have been shown to occur post-burn.

Photographs of the sectioned forward exit cone liner are presented in Figures 14 through 17. Char and erosion analysis of the sections is presented in Table 2. Figure 18 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.01 occurring at station 28 (180 degrees).

STS-26A Throat Assembly

Overall views of the STS-26A throat assembly (throat ring and throat inlet ring) are shown in Figures 8 and 9.

The post-fired mean diameter of the throat was 55.922 inches (erosion rate of 8.42 mils/second based on an action time of 122.4 seconds). Nozzle post-burn throat diameters have ranged from 55.787 to 56.38 inches. The flow surface bondline gap between the throat and throat inlet rings was 0.08 inch and is typical of past static test and flight nozzles.

Erosion of the throat and throat inlet rings was smooth and uniform with no wedgeouts observed. Popped-up charred CCP material was observed on the forward 1.5 inches of the throat ring at 10, 70, 210, 285, and 345 degrees. Sharp edges indicate the popped-up material occurred after motor operation. Impact marks were noted on the throat inlet ring and on the aft end of the throat ring intermittently around the circumference. The largest was located on the throat inlet ring at 130 degrees and measured 1 inch circumferentially by 0.5 inch axially by 0.25 inch radially (Figure 19). These marks most likely resulted from the loose aft and forward exit cone CCP material inside the motor at splashdown.

Bondline separations between the EA913 NA adhesive and the steel throat support housing were observed on the aft end circumferentially except from

0 to 25 degrees and at 335 degrees. The maximum radial width of these separations was 0.10 inch. Metal-to-adhesive bondline separations measuring 0.03 inch wide radially were observed on the forward end of the throat assembly circumferentially except at 180 degrees. Separations between the adhesive and GCP and within the adhesive were observed at 110, and 180 degrees, respectively. These also measured 0.03 inch wide radially. Figure 20 lists the location and radial width measurements of all separations on the throat assembly. These separations are typical observations which have been seen on previous static test and flight nozzles, and have been shown to occur post-burn.

Photographs of the sectioned throat assembly liner are presented in Figures 21 through 24. Char and erosion analysis of the sections is presented in Table 3. Figure 25 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.06 occurring at station 8 (0 degrees).

STS-26A Nose Inlet Assembly

Overall views of the STS-26A nose inlet asssembly (forward nose ring, aft inlet ring, and nose cap) are shown in Figures 4 and 5.

The ply angle of the forward nose (-503) ring was checked and found to be of the RSRM design. The flow surface bondline gap between the -503 ring and the aft inlet (-504) ring was 0.15 inch. The flow surface bondline gap between the -503 ring and the nose cap was 0.05 inch. These post-fired measurements are typical of past static test and flight nozzles.

The -503 and -504 rings showed smooth erosion with no pockets, wash areas, or wedgeouts. Impact marks occurring after motor operation were observed on both rings intermittently around the circumference (Figures 26 and 27). These marks most likely resulted from the loose aft and forward exit cone CCP material inside the motor at splashdown.

The nose cap showed smooth erosion with no pockets or major washes observed. The aft 2 to 3 inches showed popped-up charred CCP material at 137, 280, 310, and 332 degrees. Typical post-burn wedgeouts on the aft 2 to 3 inches (Figure 28) were noted from 14 to 26, 40 to 93, 110 to 122, 156 to 172, and 248 to 265 degrees. The maximum radial depth was 0.5 inch at the cowl interface. Sharp edges indicate the popped-up material and the wedgeouts occurred after motor operation. No wedgeouts were observed on the forward end of the nose cap.

The aft end of the nose inlet assembly (-504 ring aft end) showed metal to adhesive bondline separations (0.01 inch maximum radial width) occurring intermittently around the circumference. Bondline separations between the EA946 adhesive and the GCP (0.01 inch maximum radial width) were also observed. Bondline separations were observed on the aft end of the nose cap between the metal and EA946 adhesive, and the adhesive and GCP intermittently around the circumference. The maximum radial width of these separations was 0.005 inch. One separation, 0.003 inch wide radially, was noted within the adhesive from 26 to 28 degrees. Figure 29 lists the location and radial width measurements of all separations on the nose inlet assembly. These separations are typical observations seen on previous static test and flight nozzles and have been shown to occur post-burn.

Photographs of the sectioned nose inlet assembly rings are presented in Figures 30 through 37. Char and erosion analysis of the sections is presented in Tables 4 and 5. Figure 38 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.05 occurring at station 39.5 (180 degrees) for the -503/-504 rings, and 0.04 occurring at station 24 (90 degrees) for the nose cap.

Following the washout of the phenolics, it was found that the aluminum nose inlet housing had extensive corrosion and pitting on all bonding surfaces 360 degrees circumferentially (Figures 39 through 46). This was also found on the STS-26B (RH) nose inlet housing. The cause of this corrosion has been attributed to seawater which enters bondline separations during splashdown and retrieval (Ref. Memo L231-FY89-M130). The metal bonding surfaces were not accessible until phenolic washout at Clearfield Operations. Therefore, corrosion protection was not applied to these surfaces until approximately 4 months after flight. This hardware will be inspected during refurbishment for compliance to STW7-3434 (Refurbishment Of And Acceptance Criteria For Space Shuttle SRM Nozzle Metal Hardware).

STS-26A Cowl Ring

Overall views of the STS-26A cowl ring are shown in Figures 6 and 7. Close-up views are shown in Figures 47 through 50. All cowl vent holes appeared plugged with slag on the Outer Diameter (OD) of the ring (see Figure 48).

Typical ridged erosion was observed intermittently around the cowl circumference. The forward portion of the ring eroded a maximum of 0.15 inch greater than on the aft portion of the ring (Figure 47). This is a result of the low ply angle of the cowl ring and has been observed on the majority of flight and static test nozzles. There were no wedgeouts observed on the cowl ring.

There were no bondline separations on the forward end of the cowl ring.

Photographs of the sectioned cowl ring are presented in Figures 51 through 54. Typical subsurface ply lifting was observed intermittently around the circumference along the forward 2 inches of the cowl. The largest ply lift separation was 0.10 inch at 0 degrees (Figure 51). There was no evidence of flow or erosion within the delaminations.

Char and erosion analysis of the sections is presented in Table 6 (Stations 0 through 7). Figure 55 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.19 occurring at station 2 (90 degrees).

STS-26A Outer Boot Ring/Flex boot

Overall views of the STS-26A OBR and flex boot are shown in Figures 6 and 7. Close-up views of the OBR are shown in Figures 47 through 50. The bondline between the OBR and cowl ring remained intact with no indications of flow. The flow surface bondline gap was 0.18 inch and is typical of past static test and flight nozzles.

The structural backup OBR was intact. The flow surfaces showed smooth erosion with no pockets, major washes, or wedgeouts. Delaminations in the charred CCP of the aft tip were observed 360 degrees circumferentially (Figure 56). Charred CCP material on the aft tip adjacent to the flex boot fractured and popped up over a majority of the circumference (Figure 57). A large impact mark was located on the aft end of the OBR at 190 degrees and measured 6 inches circumferentially (Figure 49). This may have been due to the loose CCP material in the motor after splashdown. Sharp edges on the surfaces indicate this occurred after motor operation.

Photographs of the sectioned OBR are presented in Figures 58 through 61. Char and erosion analysis of the sections is presented in Table 6 (Stations 8 through 12). Figure 55 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.58 occurring at station 9 (90 degrees).

The flex boot remained attached to the outer boot ring 360 degrees circumferentially, and showed no bonline separations. The cavity side of the flex boot was evenly sooted and showed no evidence of flow or erosion (Figures 62 through 64). It appeared typical of previous flight and static test motor flex boots. A minimum of 3 NBR plies remained around the circumference after motor burn. Table 7 presents the flex boot material affected depths and performance margins of safety (PMS). The worst case PMS was 0.19 at 280 degrees.

STS-26A Fixed Housing

Overall views of the STS-26A fixed housing assembly are shown in Figures 6 and 7.

The fixed housing insulation erosion was smooth and uniform. Post-burn wedgeouts of charred CCP material were observed on the forward 2 inches intermittently around the circumference (Figure 65). The maximum radial depth of these wedgeouts was 0.5 inch. There was no heat effect to the GCP.

There were no bondline separations observed on the forward or aft end.

Photographs of the sectioned fixed housing assembly liner are presented in Figures 66 through 69. Char and erosion analysis of the sections is presented in Table 8. Figure 70 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.56 occurring at station 11 (0 degrees).

STS-26A Bearing Protector

The bearing protector was sooted along the entire length and circumference (Figures 71 through 73). Slightly heavier soot and erosion was observed in line with the cowl ring vent holes at the thickened portion, but there was no bearing protector burn-through. There was no evidence of heat effect on the Inner Diameter (ID) surface of the bearing protector.

STS-26A Flex Bearing

Examination of the flex bearing revealed no damage, soot, heat effect, or flow indications (see Figures 74 and 75). All rubber pads, metal shims, and end rings appeared to be in nominal condition. Subsequent refurbishment and testing has verified that the flex bearing is acceptable for reuse.

4.1.2 STS-26A Nozzle Internal Joints

Descriptions of the STS-26A nozzle internal joints follows.

STS-26A Aft Exit Cone-to-Forward Exit Cone (Joint No. 1)

A cross-sectioned view of the STS-26A aft exit cone/forward exit cone field joint is presented in Figure 76. Photographs of the post-flight joint are shown in Figures 77 through 82.

The backfilled RTV extended below the joint char line circumferentially except at the 266.2-degree location. RTV filled the radial ID portion of the joint except at 236.2, 266.2, 292.8, and 296.6 degrees where unfilled void areas were located. The backfill also reached the high pressure side of the primary O-ring from 38 to 185, and 314.4 to 356.2 degrees. One blowpath 0.10 inch wide circumferentially was observed at the 266.2 degrees unfilled void area. The primary O-ring saw pressure, but showed no signs of blowby, erosion, or heat effect.

Examination of the joint showed a black residue and aluminum oxide corrosion appearing on both metal surfaces of the joint between the primary and secondary O-rings, and outboard of the secondary O-ring intermittently around the circumference. The black residue was heaviest from 131 to 270 to 0 degrees (Figure 83). The aluminum oxide corrosion was heaviest from 0 to 90 to 131 degrees (Figure 84). There was no pitting observed. It has been determined that the black residue is the beginning stage of the aluminum oxide corrosion.

The aft flange of the forward exit cone was scratched at the 90-degree location by a guide pin during aft exit cone demate (Figure 85). The scratch was approximately 0.002 inch deep axially, 3.5 inches long circumferentially and 0.375 inch wide radially.

STS-26A Throat-to-Forward Exit Cone (Joint No. 4)

A cross-sectioned view of the STS-26A throat/forward exit cone joint is presented in Figure 86. Photographs of the post-flight joint are shown in Figures 87 through 92.

The RTV backfill extended below the joint char line and filled the axial portion of the joint 360 degrees circumferentially. RTV reached the high pressure side of the primary O-ring from 65 to 125, 195 to 210, and 312 to 350 degrees. One blow path measuring 1.0 inch circumferentially was found at 310 degrees on the radial OD portion of the joint (Figure 93). The GCP was sooted at this location, but not heat affected. The primary O-ring saw pressure, but there was no evidence of blowby, erosion, or heat effect. Soot was not evident on the radial ID or the axial portions of the joint.

It is believed that the blow path extended cohesively through the RTV at this location. White deposits, possibly salt, were found on the phenolic radial ID portion of the joint intermittently around the circumference.

Corrosion was evident on both metal surfaces of the joint, extending from 25 to 125, and 190 to 330 degrees on the throat and 360 degrees circumferentially on the forward exit cone. There was no pitting observed on the metal surfaces.

STS-26A Nose Inlet-to-Throat (Joint No. 3)

A cross-sectioned view of the STS-26A nose inlet/throat joint is presented in Figure 94. Photographs of the post-flight joint are shown in Figures 95 through 100.

The RTV backfill extended below the joint char line 360 degrees circumferentially. RTV completely filled the radial ID portion of the joint circumferentially except from 309 to 313 degrees. RTV also extended onto the radial OD from 52 to 70, 146 to 149, 163 to 171, 174 to 190, 195 to 197, and 210 to 220 degrees, but did not reach the primary O-ring. One blow path measuring 0.9 inch wide circumferentially and 1.2 inches deep radially was observed at 136 degrees (Figures 101 and 102). The blow path terminated within the RTV. The primary O-ring did not see pressure.

Aluminum oxide corrosion was observed on both metal surfaces of the joint inboard of the primary O-ring, but no pitting was observed. Rust was found within the metal/adhesive separations on the forward end of the throat support housing intermittently around the circumference.

Minor surface scratches were observed on the aft end of the nose inlet housing (-504 ring aft end) where jacking screws were used to disassemble the joint.

STS-26A Nose Inlet-to-Bearing Forward End Ring-to-Cowl (Joint No. 2)

A cross-sectioned view of the STS-26A nose inlet/forward end ring/cowl joint is presented in Figure 103. Photographs of the post-flight joint are shown in Figures 104 through 112.

The RTV extended below the joint char line and filled the axial portion of the joint 360 degrees circumferentially. The radial bondline between the nose cap and cowl showed RTV mixed with the EA913 NA adhesive 360 degrees circumferentially. The adhesive was typically sandwiched between two layers of RTV. There was no RTV extending to the primary O-ring. One blow path was observed at 216 degrees. On the aft end of the nose cap, the blow path measured 0.60 inch wide circumferentially and charred the GCP approximately 0.005 inch deep axially. On the forward end of the cowl ring, the blow path measured 0.40 inch wide circumferentially and charred the silica cloth phenolic (SCP) approximately 0.01 inch deep axially (Figure 113). The EA913 NA adhesive on the cowl eroded approximately 0.1 inch deep axially (maximum) by 0.7 inch wide circumferentially at the blow path location. Soot was observed on the nose cap/forward end ring interface surfaces, reaching the primary O-ring from 156 to 162, and 180 to 240 degrees (Figure 112). There was no blowby, erosion, or heat effect to the primary O-ring. Soot also extended to midway between the bolt holes around the remainder of the circumference.

Both the nose inlet housing and the cowl housing metal surfaces were heavily sooted at the blow path location. Electrical conductivity tests run on these parts showed that there was no heat damage. The bearing forward end ring was also sooted, and the paint was chipped off in various spots, but neither the end ring or the paint were heat affected.

Water was found on the nose housing aft face and in the bolt holes from 12 to 198 degrees. Aluminum oxide corrosion was observed on the forward face of the cowl housing from 214 to 224 degrees and extended approximately 0.5 inch radially inward. Corrosion and salt deposits were also found on the ID surface of the cowl housing forward flange 360 degrees circumferentially. This indicates water leaked between the cowl housing and bearing protector during splashdown.

STS-26A Fixed Housing-to-Bearing Aft End Ring (Joint No. 5)

A cross-sectioned view of the STS-26A aft end ring/fixed housing joint is presented in Figure 114. Photographs of the post-flight joint are shown in Figures 115 through 121.

RTV filled approximately 80 percent of the axial portion of the joint and reached the high pressure side of the primary O-ring at 25 to 30, 35 to 43, 55, 65 to 78, 240, and 308 to 313 degrees. Voids isolated within the RTV were observed on the radial portion of the joint intermittently around the circumference (Figure 121). The largest measured 0.9 inch deep radially by 1.7 inches wide circumferentially. None of the voids extended to the flex boot cavity. There were no blow paths observed in the joint.

Water was found on the aft face of the aft end ring and in the bolt holes intermittently around the circumference. Rust corrosion was observed on both metal surfaces of the joint between the O-rings at 15 degrees (Figure 122), but there was no pitting. Rust corrosion was found on the aft end ring inboard of the secondary O-ring intermittently around the circumference. Again, no pitting was observed. A white corrosion spot (0.10 inch in diameter) located at 260 degrees was also noted (Figure 123).

4.2 STS-26B Nozzle/Flex Bearing

Overall erosion of the STS-26B forward nozzle assembly CCP ablative liner was smooth and uniform. All CCP delaminations, wedgeouts, and pop-ups were determined to be post-burn occurrences resulting from cooldown of the liners. Blowpaths were observed in joints 2 and 4, but there was no blowby, erosion, or heat effect to the primary O-rings. Small amounts of corrosion were found on the metal surfaces of joints 1, 2, 3, and 4, but no pitting was observed. Heavy corrosion and pitting was found on the nose inlet housing bonding surfaces when the phenolics were washed off. The forward exit cone also showed corrosion on the ID bonding surface.

Post-flight subassembly flow surface gaps are shown in Figure 124. Overall views of the nozzle are shown in Figures 125 through 130.

4.2.1 STS-26B Nozzle Components

STS-26B Aft Exit Cone Assembly

An overall view of the STS-26B aft exit cone fragment is shown in Figure 131.

The aft exit cone was severed aft of the compliance ring by the LSC. The nozzle severance system performance was nominal. The exit cone cut was clean, with no unusual tearing or breaking. The remaining aft exit cone fragment showed missing CCP liner 360 degrees circumferentially. This is a typical post-flight observation and occurs at LSC firing and during splashdown. GCP plies exposed by the missing liner showed no signs of heat effect.

The polysulfide groove fill on the forward end of the aft exit cone showed one separation between the polysulfide and the GCP insulator. The separation was located at 211 degrees and measured 0.02 inch wide radially, 0.04 inch deep axially and 1.3 inches long circumferentially. Post-flight measurements of the polysulfide groove radial width (Table 9) show that the GCP insulator did not pull away from the aluminum shell during cooldown. The polysulfide shrank axially aft up to 0.10 inch.

There were no separations observed within the GCP insulator on the forward end.

STS-26B Forward Exit Cone Assembly

Overall views of the STS-26B forward exit cone are shown in Figures 129 and 130.

The forward exit cone showed missing CCP liner over the center 14 inches of the cone 360 degrees circumferentially. This is a typical post-flight observation and occurs at splashdown and during Diver Operated Plug (DOP) insertion. The GCP insulator exposed by the missing liner showed no signs of heat effect. The CCP liner remained bonded on the forward 11 inches and on the aft 9 inches of the cone. These portions showed nominal erosion with no major washing or pocketing. The aft 9 inches of the liner showed the typical dimpled erosion pattern that has occurred on all flight and static test forward exit cones (Figure 132). The maximum radial depth of the dimpled erosion was 0.15 inch.

The aft end of the forward exit cone showed no bondline or cohesive separations. Bondline separations on the forward end of the forward exit cone were noted between the steel shell and the EA946 adhesive circumferentially except at 105 degrees. Separations were also found between the GCP and CCP, within the GCP, and within the adhesive. Figure 133 lists the location and radial width measurements of all separations on the forward exit cone. These separations are typical observations seen on previous static test and flight nozzles and have been shown to occur post-burn.

Photographs of the sectioned forward exit cone liner are presented in Figures 134 through 137. Char and erosion analysis of the sections is presented in Table 10. Figure 18 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.05 occurring at station 1 (0 and 180 degrees), and station 8 (270 degrees).

Following washout of the phenolics, large areas of corrosion were noted along the forward 5 to 12 inches of the ID bonding surface (Figures 138 and 139). This "band" of corrosion appeared aft of the forward shear pins. Light and dark colored areas of corrosion as well as rust spots and pitting were observed. Corroded areas were also found on the aft 7 inches of the ID bonding surface centered around the aft shear pin holes (Figures 140 through 144). The largest area was at 120 degrees (Figure 142). Visual inspections of these indicate that sea water may have leaked through the shear pin holes where the lightning cables were attached (every 30 degrees). Light and dark areas of corrosion, rust spots, and pitting were observed. Small rust spots were also noted intermittently around the rest of the ID surface (Figure 142). These were typically 0.050 to 0.10 inches in diameter. This hardware will be inspected during refurbishment for compliance to STW7-3434 (Refurbishment Of And Acceptance Criteria For Space Shuttle SRM Nozzle Metal Hardware).

STS-26B Throat Assembly

Overall views of the STS-26B throat assembly (throat ring and throat inlet ring) are shown in Figures 125 and 126.

The throat post-flight mean diameter was 55.876 inches (erosion rate of 8.18 mils/second based on an action time of 123.2 seconds). Nozzle post-burn throat diameters have ranged from 55.787 to 56.38 inches. The flow surface bondline gap between the throat and throat inlet rings was 0.10 inch and is typical of past static test and flight nozzles.

The throat and throat inlet rings eroded smoothly with no pockets or major washes observed. The forward end of the throat inlet ring showed post-burn wedgeouts of charred CCP material from 28 to 40, 95 to 105 and 355 to 0 to 5 degrees (Figure 145). The maximum axial width of the wedgeouts was 0.75 inch at the 28-to-40-degree location. Post-burn wedgeouts of the throat inlet ring forward end have been observed on previous post-flight nozzles. The forward 1.5 inches of the throat ring showed popped-up charred CCP material intermittently around the circumference. Sharp edges indicate the popped-up material occurred after motor operation. Marks resulting from DOP insertion were observed on the throat ring intermittently around the circumference.

Bondline separations on the aft end of the throat ring between the EA913 NA adhesive and the steel throat support housing were observed around the majority of the circumference. Separations were also found between the adhesive and GCP, within the GCP, and within the adhesive. There were no separations between the GCP and CCP on the aft end. The forward end of the throat inlet ring showed metal to adhesive bondline separations circumferentially except from 255 to 0 degrees. Separations were also observed between the GCP and CCP. Figure 146 lists the location and radial width measurements of all separations on the throat assembly. These separations are typical observations seen on previous static test and flight nozzles and have been shown to occur post-burn.

Photographs of the sectioned throat assembly liner are presented in Figures 147 through 149. Char and erosion analysis of the sections is presented in Table 11. Figure 25 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.07 occurring at station 8 (180 degrees).

STS-26B Nose Inlet Assembly

Overall views of the STS-26B nose inlet assembly (forward nose ring, aft inlet ring, and nose cap) are shown in Figures 125 through 128.

The ply angle of the forward nose ring was checked and found to be of the RSRM design. The flow surface bondline gap between the forward nose (-503) ring and the aft inlet (-504) ring was 0.18 inch. The flow surface bondline gap between the -503 ring and nose cap was 0.05 inch. These post-fired measurements are typical of past static test and flight nozzles.

The -503 and -504 rings showed smooth erosion with no pockets or major washes observed. The -503 ring showed popped-up charred CCP material at the nose cap interface from 155 to 165 degrees. The popped-up material was 0.08 inch wide axially and occurred after motor operation. Impact marks occurring after motor operation were observed on both rings intermittently around the circumference (Figures 150 and 151). The marks most likely resulted from the loose aft and forward exit cone CCP material in the motor at splashdown.

The nose cap showed smooth erosion with no pockets or major washes observed. The aft 2.0 to 3.5 inches of the nose cap showed typical post-burn wedgeouts intermittently around the circumference (Figure 152). These measured approximately 0.5 in. deep radially at the cowl interface. One wedgeout location from 5 to 20 degrees showed slag covering exposed CCP material. Sectioning of the liner determined that this wedgeout occurred post-burn.

The aft end of the nose inlet assembly (-504 ring aft end) showed metal to adhesive bondline separations measuring 0.02 inch wide radially from 238 to 245 degrees, and at 250 degrees. There were no cohesive separations or separations at the adhesive/GCP and GCP/CCP interfaces. Bondline separations were observed on the aft end of the nose cap between the metal and EA946 adhesive at 105, 135 to 255, 285 to 315, and 345 degrees. These separations were typically 0.005 inch wide radially. There were no cohesive separations or separations at the adhesive/GCP and GCP/CCP interfaces. Figure 153 lists the location and radial width measurements of all separations on the nose inlet assembly. These separations are typical observations seen on previous static test and flight nozzles, and have been shown to occur post-burn.

Photographs of the sectioned nose inlet assembly rings are presented in Figures 154 through 161. Char and erosion analysis of the sections is presented in Tables 12 and 13. Figure 38 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.01 occurring at station 32 (180 degrees) for the -503/-504 rings, and 0.01 occurring at station 24 (225 degrees) for the nose cap.

Following the washout of the phenolics, it was found that the aluminum nose inlet housing had extensive corrosion and pitting on all bonding surfaces 360 degrees circumferentially (Figures 162 through 167). Most of the corrosion on the nose cap bonding surface was found on the aft 5 inches 360 degrees circumferentially. The forward edge of this corrosion was shaped in a "saw tooth" pattern (Figure 166). The leading edge of the nose inlet housing showed areas of pitting approximately 0.04 to 0.05 inch deep (Figure 168). The entire -503 ring bonding surface was heavily corroded and pitted 360 degrees circumferentially, and approximately 90 percent of the -504 ring bonding surface showed various stages of corrosion and pitting. This corrosion has been attributed to seawater which enters bondline separations during splashdown and retrieval (Ref. Memo L231-FY89-M130). The metal bonding surfaces were not accessible until phenolic washout at Clearfield Operations. Therefore, corrosion protection was not applied to these surfaces until approximately 4 months after flight. This hardware will be inspected during refurbishment for compliance to STW7-3434 (Refurbishment Of And Acceptance Criteria For Space Shuttle SRM Nozzle Metal Hardware).

STS-26B Cowl Ring

Overall views of the STS-26B cowl ring are shown in Figures 127 and 128. Close-up views are shown in Figures 169 through 171. All cowl vent holes appeared plugged with slag on the OD of the ring (Figure 172).

The cowl ring showed typical ridged erosion intermittently around the part circumference. The forward portion of the ring eroded a maximum of 0.15 inch greater than the aft portion (Figure 169). This is a result of the low ply angle of the cowl ring and has been observed on the majority of flight and static test nozzles. One wedgeout was observed on the aft 3.5 inches of the cowl ring from 120 to 137 degrees (Figure 173). The maximum radial depth of the wedgeout was 0.6 inch at the outer boot ring interface. Slag coated the exposed CCP material at the wedgeout location. Sectioning of the liner determined that this wedgeout occurred post-burn.

There were no bondline separations on the forward end of the cowl ring.

Photographs of the sectioned cowl ring are presented in Figures 174 through 177. Typical subsurface ply lifting was observed intermittently around the circumference along the length of the cowl. The largest ply lift separation was 0.20 inch at 270 degrees (Figure 177). There was no evidence of flow or erosion within the delaminations. Char and erosion analysis of the sections is presented in Table 14 (Stations 0 through 7).

Figure 55 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.04 occurring at station 0 (45 degrees).

STS-26B Outer Boot Ring/Flex Boot

Overall views of the STS-26B outer boot ring are shown in Figures 127 and 128. Close-up views are shown in Figures 169 through 171. The bondline between the outer boot ring and cowl ring remained intact with no indications of flow. The flow surface bondline gap was 0.20 inch and is typical of past static test and flight nozzles.

The structural backup outer boot ring was intact. The flow surfaces showed smooth erosion with no pockets, wedgeouts, or major washes. Minor wash areas extended from the cowl to the forward 1.5 inches of the OBR from 120 to 150, and 151 to 158 degrees, and measured a maximum of 0.2 inch radially deep. These have occurred on the majority of flight and static test nozzles. Popped-up charred CCP material was observed on the forward 1.8 inches of the OBR intermittently around the circumference. The popped-up material is a common observation and occurs after motor operation. Delaminations in the charred CCP of the aft tip were observed 360 degrees circumferentially (Figure 178). Charred CCP material on the aft tip adjacent to the flex boot fractured and popped up over a majority of the circumference.

Photographs of the sectioned outer boot ring are presented in Figures 179 through 182. Char and erosion analysis of the sections is presented in Table 14 (Stations 8 through 11.3). Figure 55 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.59 occurring at station 10 (0 degrees).

The cavity side of the flex boot was evenly sooted and showed no evidence of flow or erosion (Figures 183 through 185). It appeared typical of previous flight and static test motor flex boots. A minimum of 3.0 NBR plies remained around the circumference after motor burn. Table 15 presents the flex boot material affected depths and Performance Margins of Safety. The worst case PMS was 0.19 at 280 degrees.

STS-26B Fixed Housing Assembly

Overall views of the STS-26B fixed housing assembly are shown in Figures 127 and 128.

The fixed housing insulation showed smooth erosion with no pockets or major washing observed. Post-burn wedgeouts of charred CCP material were observed on the forward 2.0 inches of the fixed housing insulation from 30 to 65, 135 to 145, and 165 to 180 degrees. The wedgeouts were a maximum of 0.5 inch deep radially. There was no heat effect to the GCP.

There were no bondline separations observed on the forward or aft end.

Photographs of the sectioned fixed housing assembly liner are presented in Figures 186 through 189. Char and erosion analysis of the sections is presented in Table 16. Figure 70 shows the location of the measurement stations. All margins of safety were positive, with a minimum of 0.54 occurring at station 3 (270 degrees).

STS-26B Bearing Protector

The bearing protector was sooted along the entire length and circumference (Figures 190 through 192). Heavier soot and erosion were observed in line with the cowl ring vent holes at the thickened portion of the bearing protector. Erosion depths at the vent hole locations are presented in Table 17. There was no evidence of heat effect on the ID surface of the bearing protector.

STS-26B Flex Bearing

Examination of the flex bearing revealed no damage, soot, heat effect, or flow indications (Figure 193). All rubber pads, metal shims, and end rings appeared to be in nominal condition. Subsequent rerfurbishment and testing has verified that the flex bearing is acceptable for reuse.

4.2.2 STS-26B Nozzle Internal Joints

Descriptions of the STS-26B nozzle internal joints follows.

STS-26B Aft Exit Cone-to-Forward Exit Cone (Joint No. 1)

A cross-sectioned view of the STS-26B aft exit cone-to-forward exit cone field joint is presented in Figure 194. Photographs of the post-flight joint are shown in Figures 195 through 200.

The backfilled RTV extended below the joint char line 360 degrees circumferentially. RTV filled the radial ID portion of the joint except at 103 degrees where an unfilled void area approximately 1.0 inch wide circumferentially was located. The backfill also extended to the high pressure side of the primary O-ring from 0 to 81, 82 to 101, 103 to 123, 154 to 178, 182 to 237, 243 to 251, 258 to 265, and 268 to 0 degrees. There were no blowpaths observed in the joint and the primary O-ring saw no pressure. Char was observed on the RTV in the axial portion of the joint at 237 degrees. The RTV was not eroded or heat affected at the charred location. It is believed that the char penetrated the joint at splashdown.

Examination of the joint showed a black residue and aluminum oxide corrosion appearing on both metal surfaces between the primary and secondary O-rings, and outboard of the secondary O-ring intermittently around the circumference (Figure 201). The aluminum oxide corrosion was heaviest from 112.6 to 143.2 degrees. There was no pitting observed. It was determined that the black residue is the beginning stage of the aluminum oxide corrosion.

One through hole on the forward exit cone housing aft flange was dinged by a guide pin during the aft exit cone demate. The ding was approximately 0.02 inch deep and was located at 95.6 degrees (Figure 202).

STS-26B Throat-to-Forward Exit Cone (Joint No. 4)

A cross-sectioned view of the STS-26B throat-to-forward exit cone joint is presented in Figure 203. Photographs of the post-flight joint are shown in Figures 204 through 209.

The RTV backfill extended below the joint char line and filled the radial ID portion of the joint circumferentially, except at 185 degrees. RTV filled the axial portion of the bondline from 40 to 165 degrees, and 240 to 345 degrees. RTV did not reach the high-pressure side of the primary O-ring. One blow path measuring 0.25 inch circumferentially was found at 185 deg. Excess grease at this location inhibited the RTV backfill, resulting in an unfilled void area. The primary O-ring saw pressure, but ther was no evidence of blowby, erosion, or heat effect. The GCP also showed no signs of heat effect.

Rust corrosion was observed on both surfaces of the joint within the metal housing/adhesive bondline separations intermittently around the circumference. Black corrosion was observed near the primary sealing surface of the throat housing aft end from 80 to 85 degrees, and 345 to 0 to 4 degrees. There was no pitting on the metal surfaces.

STS-26B Nose Inlet-to-Throat (Joint No. 3)

A cross-sectioned view of the STS-26B nose inlet-to-throat joint is presented in Figure 210. Photographs of the post-flight joint are shown in Figures 211 through 216.

The RTV backfill extended below the joint char line 360 degrees circumferentially. RTV filled the radial ID portion of the joint circumferentially except at 50 degrees. RTV also extended onto the radial OD up to the GCP/CCP interface at 35, 275, and 325 degrees. An unfilled void area, 1.0 inch circumferentially, was located at 50 degrees. There was no blow path to the void area. The primary O-ring did not see pressure. Grease was observed on both sides of the joint 360 degrees circumferentially extending 0.1 to 1.0 inch inboard of the primary O-ring.

Minor surface corrosion was observed on the aft end of the nose inlet housing inboard of the primary O-ring, but no pitting was observed. This aluminum oxide corrosion extended approximately half way down the ID side of the primary O-ring groove at 325 degrees. There was no corrosion on the forward end of the throat housing.

STS-26B Nose Inlet-to-Bearing Forward End Ring-to-Cowl (Joint No. 2)

A cross-sectioned view of the STS-26B nose inlet-to-bearing forward end ring-to-cowl joint is presented in Figure 217. Photographs of the post-flight joint are shown in Figures 218 through 226.

The RTV extended below the joint char line and filled the axial portion of the joint 360 degrees circumferentially. The radial bondline between the nose cap and cowl showed RTV mixed with the EA913 NA adhesive intermittently around the circumference. The adhesive was typically sandwiched between two layers of RTV. RTV filled approximately 80 percent of the axial bondline between the nose cap and bearing forward end ring. No RTV extended to the primary O-ring. One blow path was observed at 266 degrees and measured 0.5 inch wide circumferentially (Figure 227). The cowl SCP and nose cap GCP insulators showed no heat effect. The primary O-ring saw pressure, but there was no evidence of blowby, erosion, or heat effect. Soot was observed on the radial OD of the joint 360 degrees circumferentially. Soot reached up to the axial bolt holes on the nose inlet housing intermittently around the circumference, but did not reach the primary O-ring. Salt deposits were also noted on the radial OD surfaces.

Both the aft face of the forward end ring flange and the forward face of the cowl housing were sooted at 130 to 153, 165, 255, and 303 to 310 degrees, but were not heat effected. The paint on the forward end ring OD flange surface was chipped off in various spots, but was not heat affected. Minor rust spots were noted in areas where the paint was chipped off. Aluminum oxide corrosion was observed on the forward end ring/nose inlet housing interface surfaces, and on the cowl housing/forward end ring interface surfaces intermittently around the circumference. Aluminum oxide corrosion was also found intermittently on the forward flange ID surface of the cowl housing (Figure 228).

STS-26B Fixed Housing-to-Bearing Aft End Ring (Joint No. 5)

A cross-sectioned view of the STS-26B aft exit cone/forward exit cone field joint is presented in Figure 229. Photographs of the post-flight joint are shown in Figures 230 through 235.

RTV filled approximately 75 percent of the axial portion of the joint and reached the high pressure side of the primary O-ring from 75 to 110, 123 to 128, 135 to 148, and 195 to 218 degrees. Voids isolated within the RTV were observed on the radial portion of the joint intermittently around the circumference. The largest measured 0.45 inch deep radially by 0.30 inch wide circumferentially. A void at 171 degrees extended onto the axial portion of the joint, but terminated within the RTV. There were no blow paths observed in the joint, and the primary O-ring did not see pressure.

Rust corrosion was found on the aft end ring inboard of the secondary O-ring intermittently around the circumference. No pitting was observed.

4.3 Instrumentation

There was no instrumentation installed on the STS-26 nozzles.

5.0 DISCREPANCY REPORTS AND PROCESS DEPARTURES

The STS-26 Nozzle DRs and PDs reviewed by the Morton Thiokol senior material review board are included in Appendix A. These were presented in the STS-26 RSRM Acceptance Review Level III (TWR-18117A). Brief descriptions of the DRs and PDs, and correlations to post-flight observations are discussed below.

5.1 STS-26A DRs and PDs

Aft Exit Cone

DR 123524-01 (Waiver No. RWW 404)

LDIs within the GCP were found at 240 degrees, 54 inches aft of the forward end. This portion of the aft exit cone was severed by the LSC during reentry and was not recovered. Post-flight inspection of this part was not possible.

DR 162635-01, -02 (Waiver No. RWW 405)

LDIs within the GCP were found at 222 degrees (39.5 inches aft of the compliance ring), and 240 and 243 degrees (4 inches aft of the compliance ring). This portion of the aft exit cone was severed by the LSC during reentry and was not recovered. Post-flight inspection of this part was not possible.

Forward Exit Cone

DR 151717-01 (Waiver No. RWW 387)

Eight LDIs within the GCP were found running 360 degrees circumferentially along a full ply length. Post-flight inspection of the exposed GCP did not reveal any delaminations extending to the surface.

PD 150663-01

The white stripe (90-degree mark) on the phenolic liner was 1.75 inches from the 90-degree reference pin (0.75 inch over maximum). The liner was bonded at the same radial location as the dry fit. Orientation to correlate post-flight performance with any pre-flight anomalies was not affected.

Throat Assembly

DR 128578-01

Intermittent pitting, a maximum of 0.002 inch deep, was found on the aft sealing surface. After being repaired, the joint was succesfully leak tested. Post-flight inspection did not reveal any indications of blow-by.

Nose Inlet Assembly

DR 152142-01

Phosphoric Acid Anodization (PAA) and EA9228 Primer applied to the bonding surfaces was not uniform (dark streaks and spots). The PAA and primer system was deleted from the engineering design change. This part was grit blasted and the phenolics bonded using 51-L surface preparation techniques. All of the phenolics were intact and remained bonded to the housing.

PD 150024-01

The EA946 adhesive for the nose cap bond was not applied within 6 hours from the grit blast requirement. This was reworked to blueprint requirements. No post-flight anomamlies were noted.

PD 150024-02

The EA946 adhesive for the nose cap bond was not applied within 1 hour from methylchloroform wipe. This was reworked to blueprint requirements. No post-flight anomamlies were noted.

Cowl Assembly

DR 126842-01

Intermittent pitting was found on the cowl housing (worst-case condition was 0.180 inch in diameter by 0.039 inch deep on the ID flange. The pits were honed out to remove sharp edges. No post-flight anomalies were noted.

Flex Bearing

DR 123208-01

One threaded hole (0.190-32 UNF) on the aft end ring accepted the no-go threaded plug gage for 6.5 turns. Proper bolt torque was verified and showed no damage. Post-flight inspection showed damage to the bolt hole.

DR 123439-01

The unbond area on pad 11 exceeded the maximum allowable of 9 in^2. The flex bearing passed all of the acceptance tests and post-flight refurbishment requirements.

5.2 STS-26B DRs and PDs

Nozzle/Aft Segment Assembly

DR 153960-01

A broken girth gage wire was found between the aft dome boss and nozzle assembly. This did not affect O-ring gap openings. The joint successfully passed leak check. Post-flight inspection showed no anomalies as a result of this condition.

Aft Exit Cone

DR 123533-01, (Waiver No. RWW 406)

An LDI measuring 2.35 inches circumferentially, 1.2 inches axially, and 0.031 inch radially was found in the GCP 0.393 inch from the forward end at 45 degrees. Post-flight inspection of the GCP after sectioning (Figure 236) did not reveal any delaminations.

Throat/Nose Inlet Joint Assembly

DR 150682-01, -02

The primary to secondary seal cavity was pressurized to 1040 psig during high pressure leak check (the requirement is 740 ± 15 psig), and 40 psig during low pressure leak check (the requirement is 30 ± 3 psig). The joint passed leak check, and no anomalies were observed during post-flight inspection.

Nose Inlet Assembly

PD 149145-01

This involved the forward first wrap of the nose ring during the carbon hydroclave cure. While decreasing pressure, the pressure dropped to 168 psig for 4 minutes, then remained in tolerance during the remainder of the cure. The CCP liner met all acceptance criteria. There were no anomalies observed during post-flight inspection.

Cowl Assembly

DR 128474-01

Pitting was observed on the OD and ID surfaces of the cowl housing. Maximum depths were 0.049 inch on the ID side, and 0.041 inch on the OD side. These were blended out to remove sharp edges. Post-flight inspection has not revealed any anomalies.

Flex Bearing

DR 123437-01

One threaded hole (0.750-16 UNF) on the aft end ring accepted the no-go threaded plug gage for eight turns. A helical coil insert was used as a standard repair. There was no damage noted during post-flight inspection. The repair did not affect the flex bearing performance.

Bearing Protector

PD 127767-01

This involved the GCP autoclave cure for the bearing protector inner ring. The autoclave vacuum dropped below the minimum of 15 in. Hg for a total of 177 minutes. The inner ring met all acceptance tests, and the bearing protector assembly using this ring passed strength tests. There were no anomalies observed during post-flight inspection.

6.0 NOZZLE COMPONENT PROGRAM TEAM (NCPT) RECOMMENDATIONS AND REDESIGN PROGRAM REVIEW BOARD (RPRB) ASSESSMENT

The NCPT reviewed all observations documented in this report. The team classified five Problem Reports (written at KSC) as minor anomalies. After internal nozzle joint inspections at Clearfield, the team initially classified five observations as potential anomalies. Three of these were further classified as minor anomalies, and the other two remained observations. These were presented to the RPRB on 9 and 11 November, 1988. The RPRB agreed with all the classifications. These minor anomalies were recorded on Post-Fire Anomaly Record (PFAR) forms and are included in Appendix B. The PFARs contain detailed descriptions and corrective actions as accepted and/or modified by the RPRB. A listing of the PFARs is listed below.

6.1 STS-26A Nozzle

PFAR NUMBER	DESCRIPTION
360L001A-11	Corrosion on aft exit cone metal between primary and secondary O-rings.

360L001A-12	Corrosion on forward exit cone metal between primary and secondary aft exit cone O-rings.
360L001A-43	RTV and EA913 NA adhesive mixing in joint 2.

6.2 STS-26B Nozzle

PFAR NUMBER	DESCRIPTION
360L001B-10	Corrosion on aft exit cone metal between primary and secondary O-rings.
360L001B-38	Ding on forward exit cone aft flange.
360L001B-42	Corrosion on forward exit cone metal between primary and secondary aft exit cone O-rings.
360L001B-44	RTV backfill in joint 4 inhibited by excessive grease.
360L001B-45	RTV and EA913 NA adhesive mixing in joint 2.

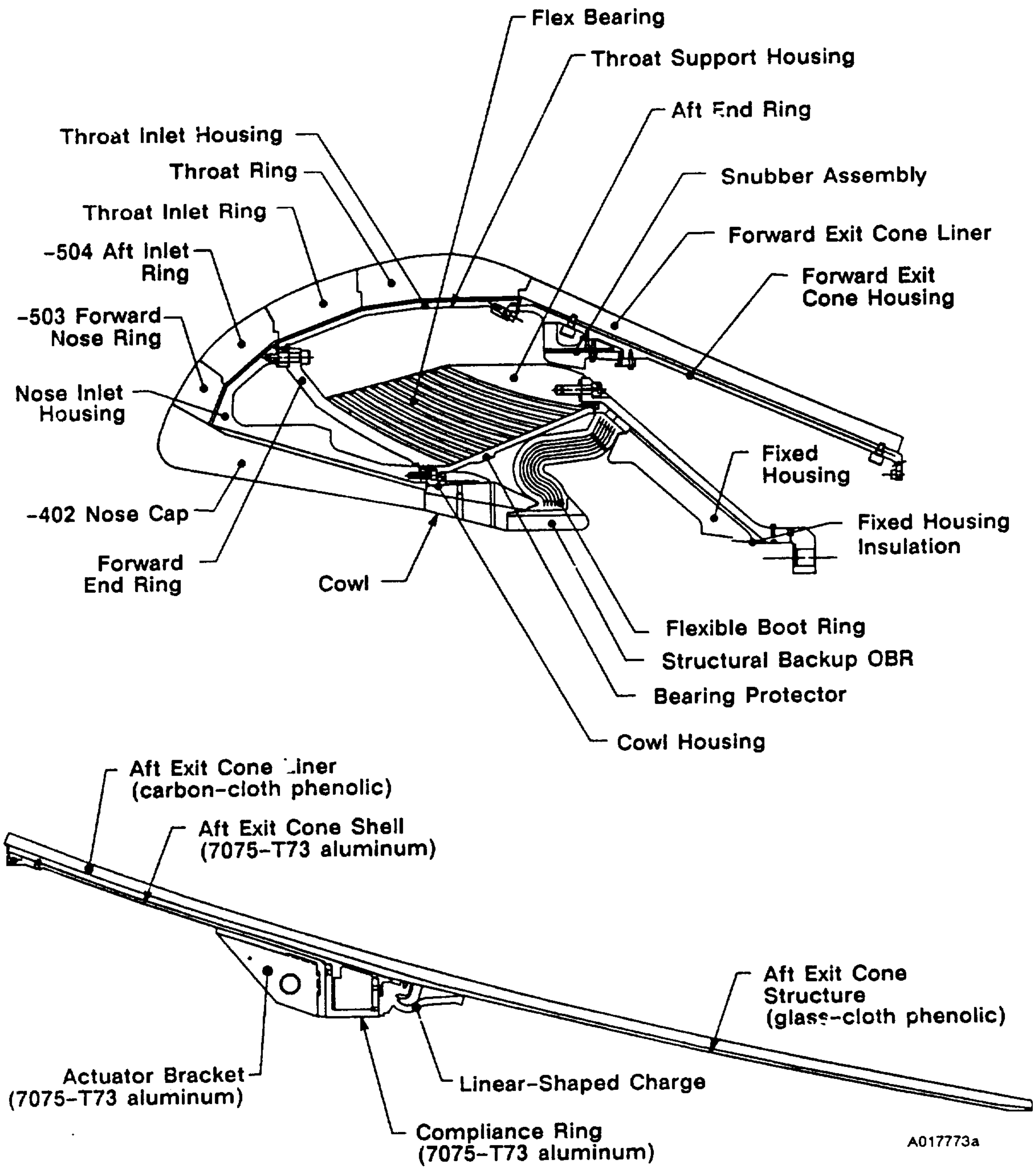
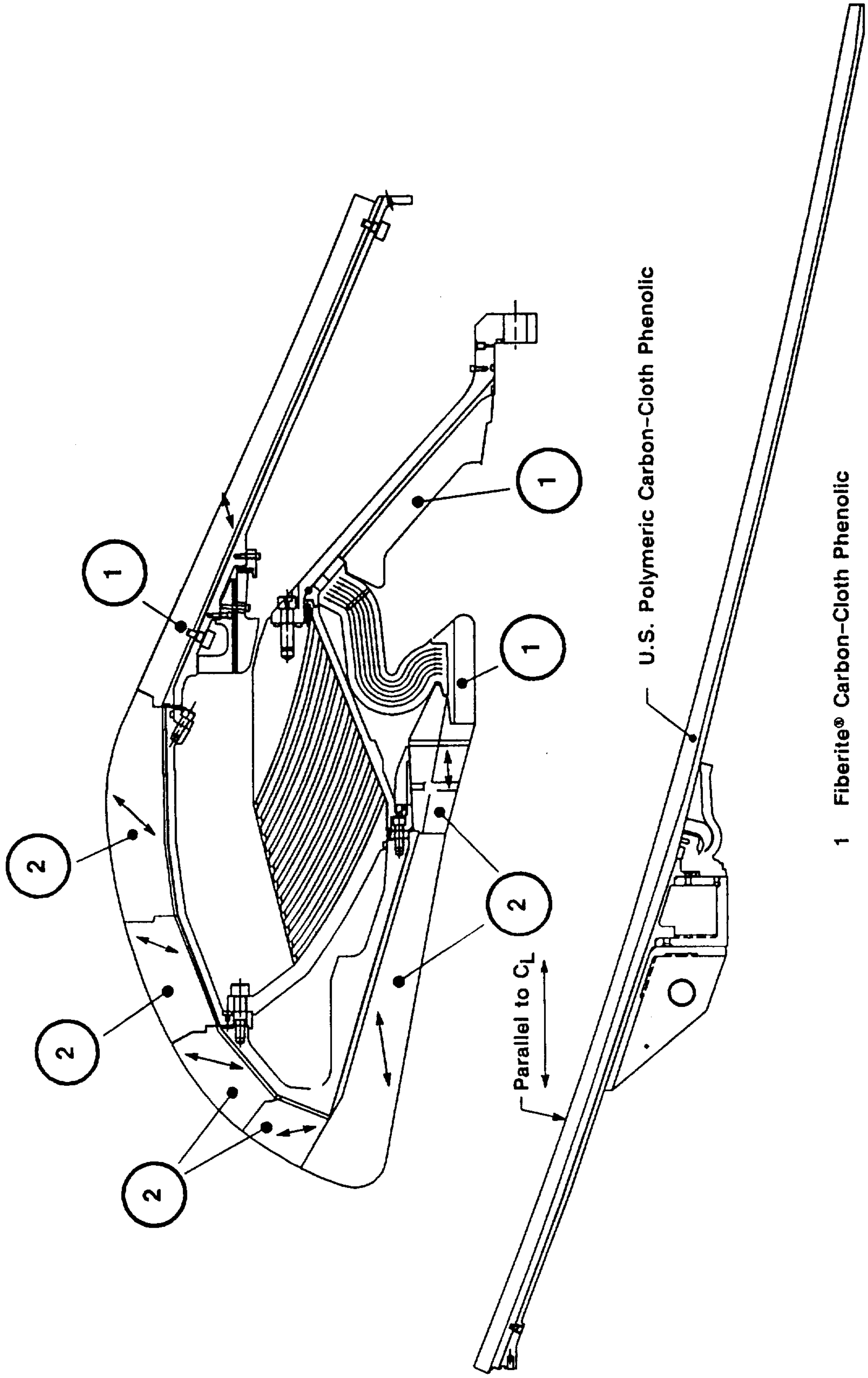
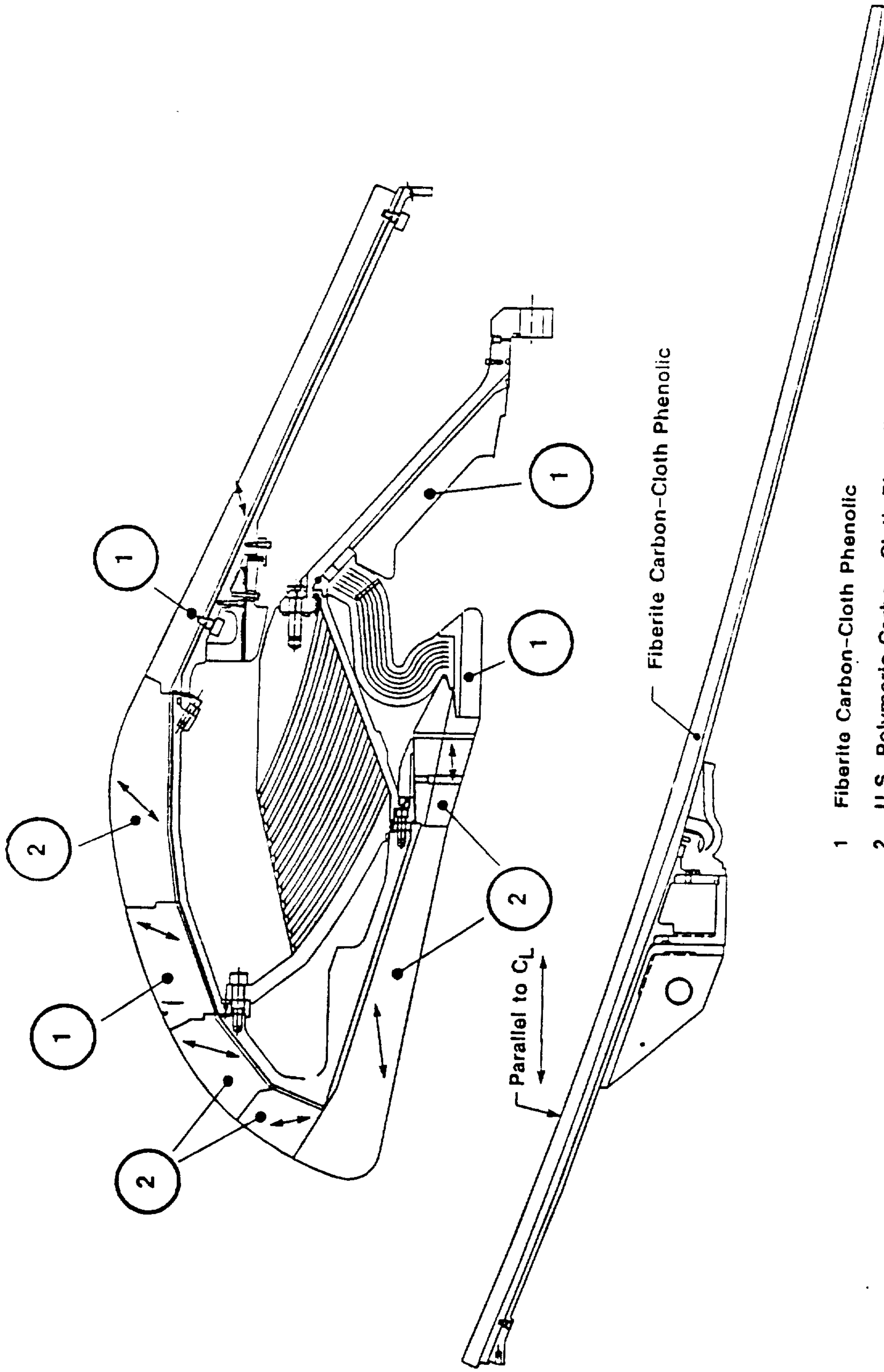


Figure 1 STS-26 Nozzle Components



1 Fiberite® Carbon-Cloth Phenolic
2 U.S. Polymeric Carbon-Cloth Phenolic

Figure 2a STS-26A Nozzle Material



1 Fiberite Carbon-Cloth Phenolic
2 U.S. Polymeric Carbon-Cloth Phenolic

Figure 2B STS-26B Nozzle Material

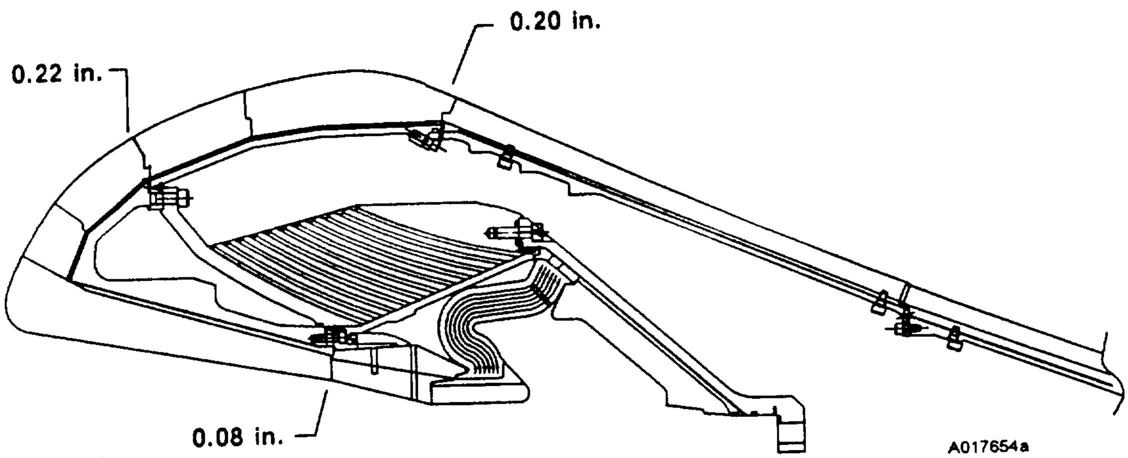


Figure 3 STS-26A Joint Flow Surface Gap Openings

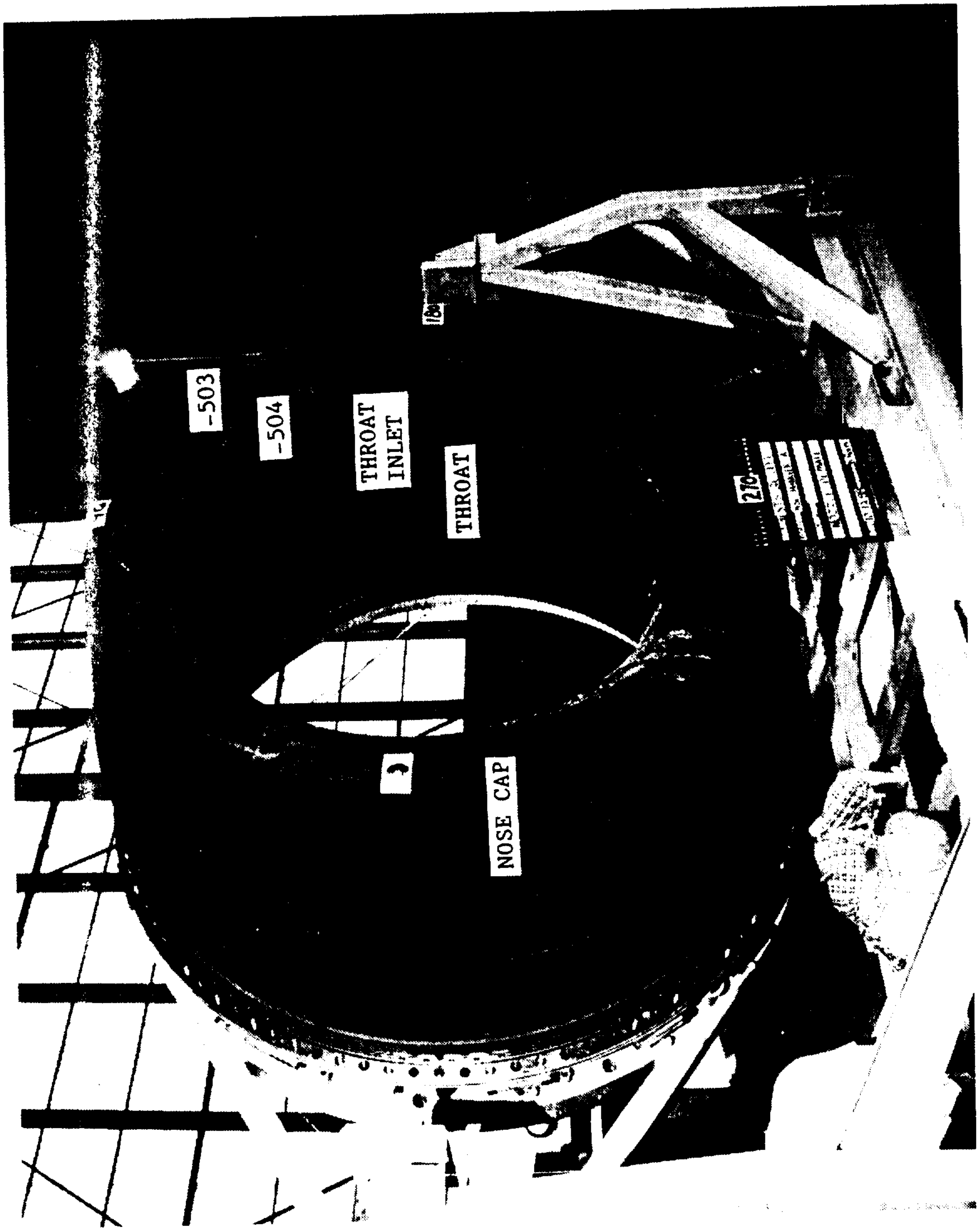


Figure 4 STS-26A Forward Nozzle Assembly

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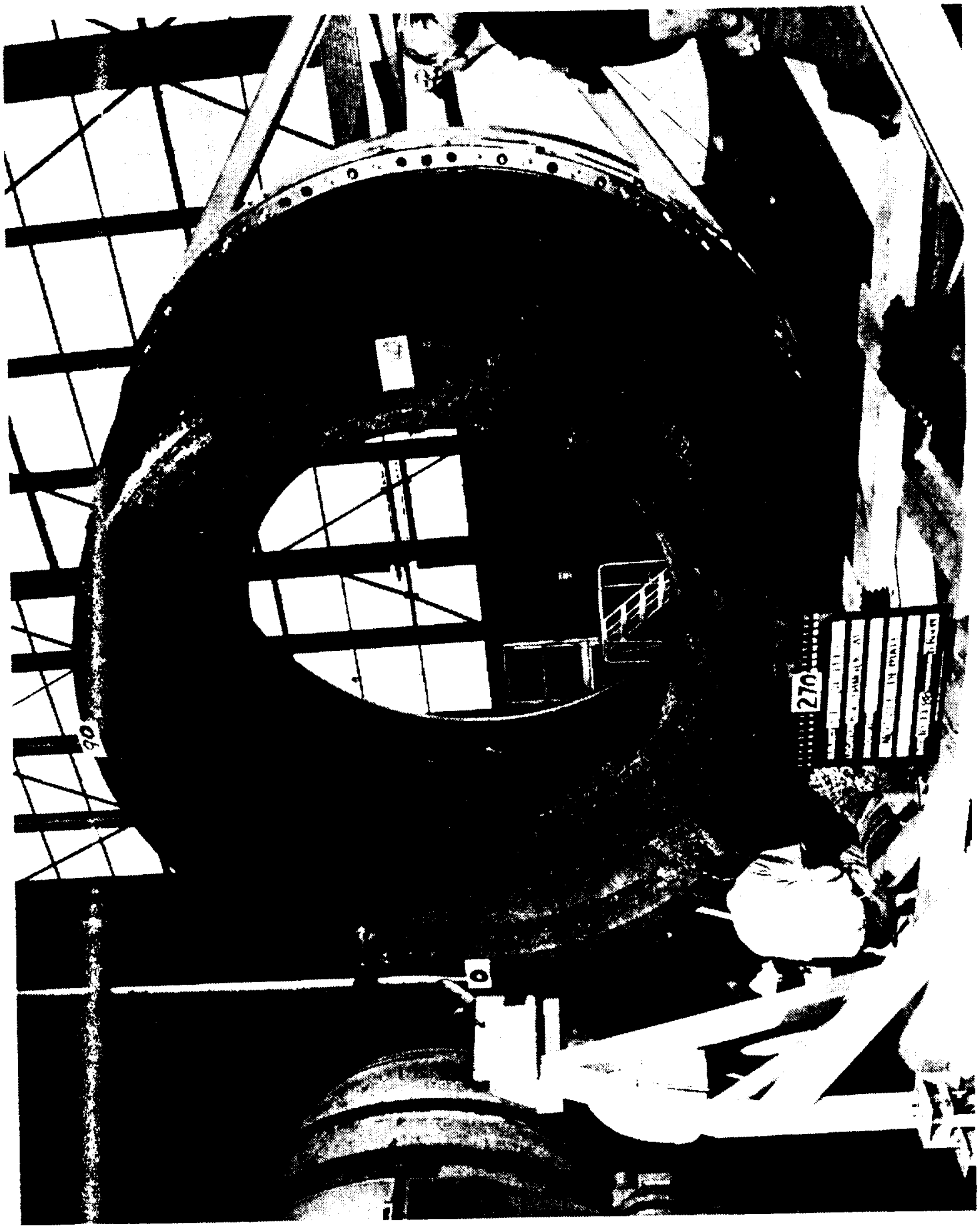

Figure 5 STS-26A Forward Nozzle Assembly

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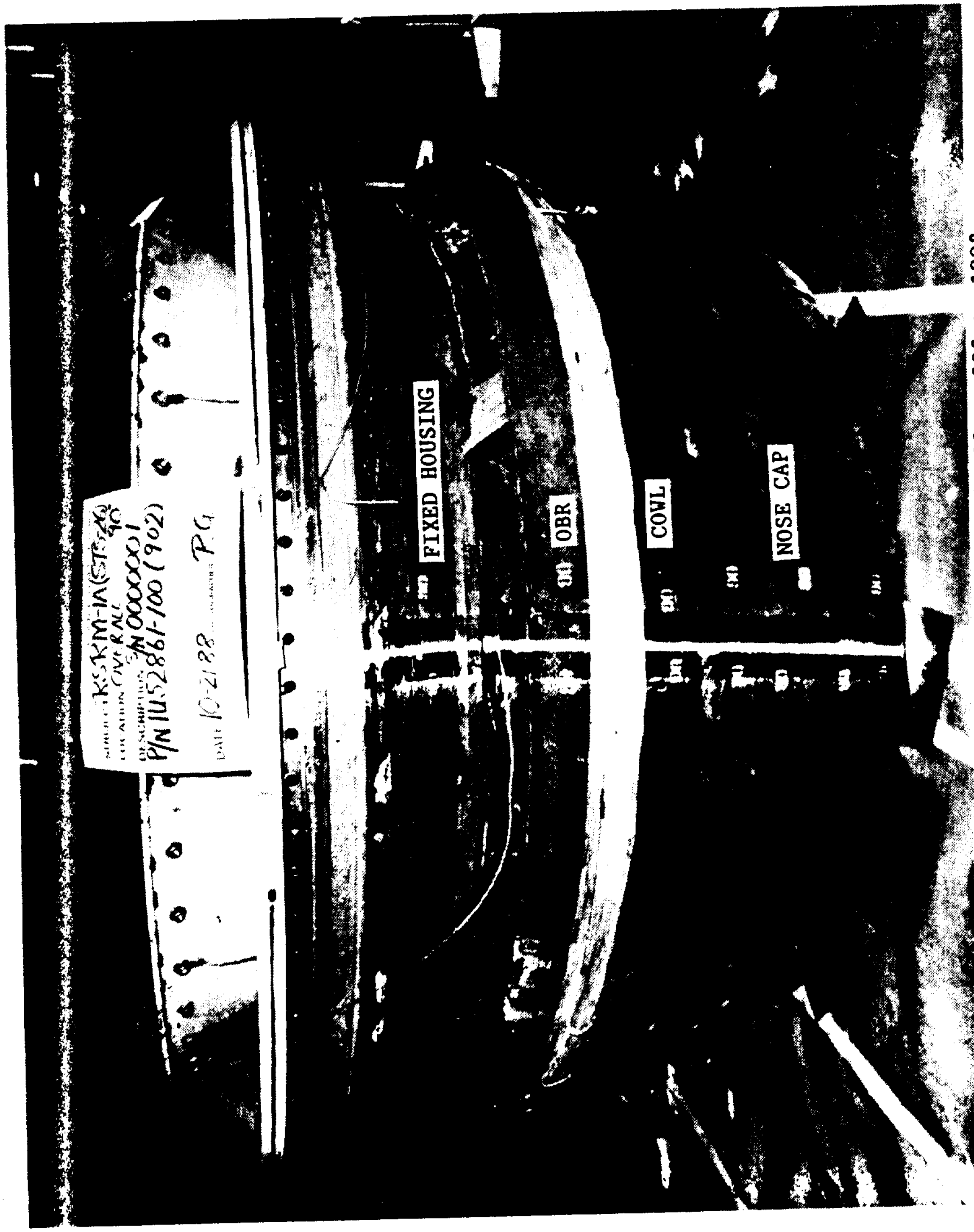

Figure 6 STS-26A Forward Nozzle Assy (External) 0° to 90° to 180°

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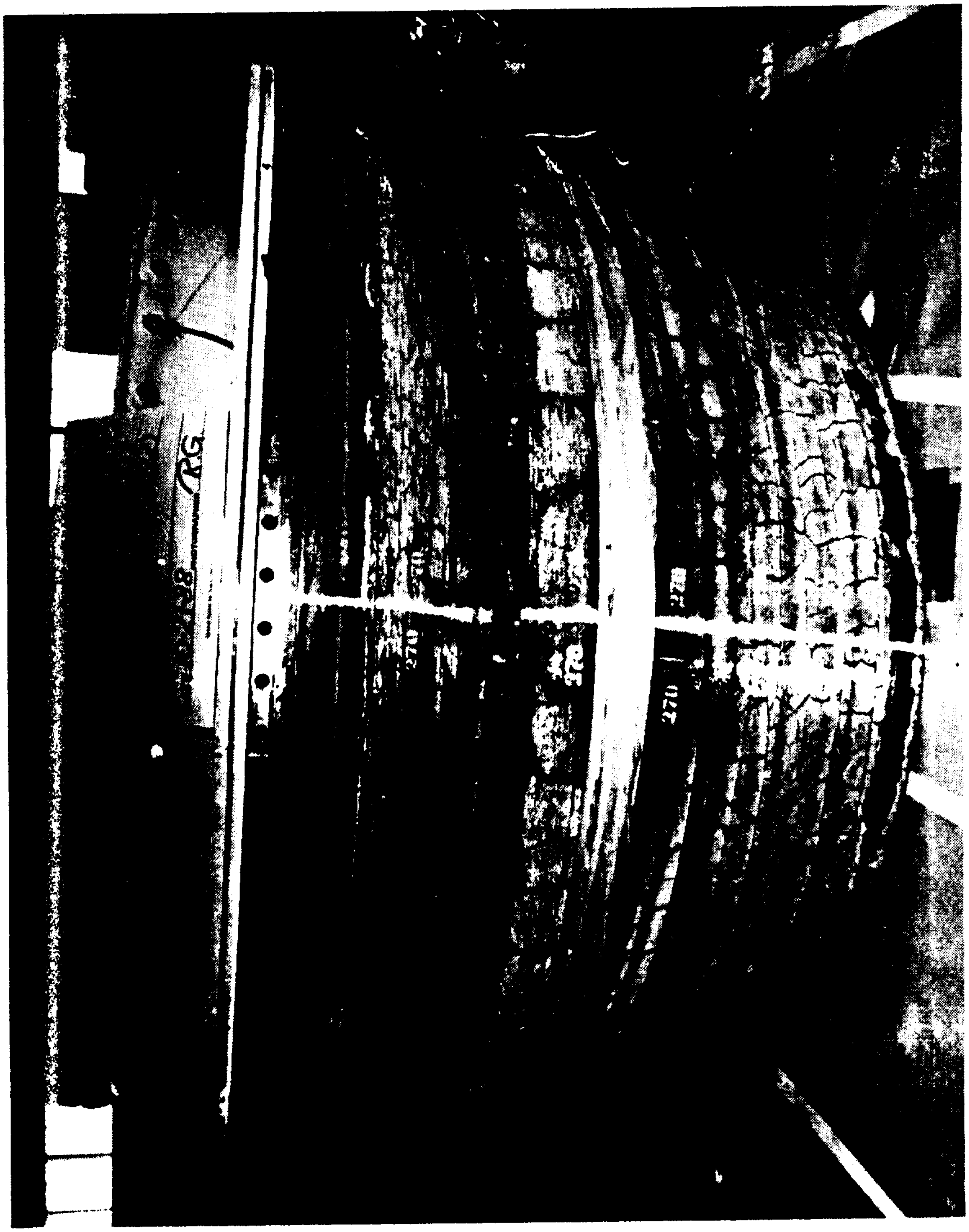

Figure 7 STS-26A Forward Nozzle Assy (External) 180° to 270° to 0°

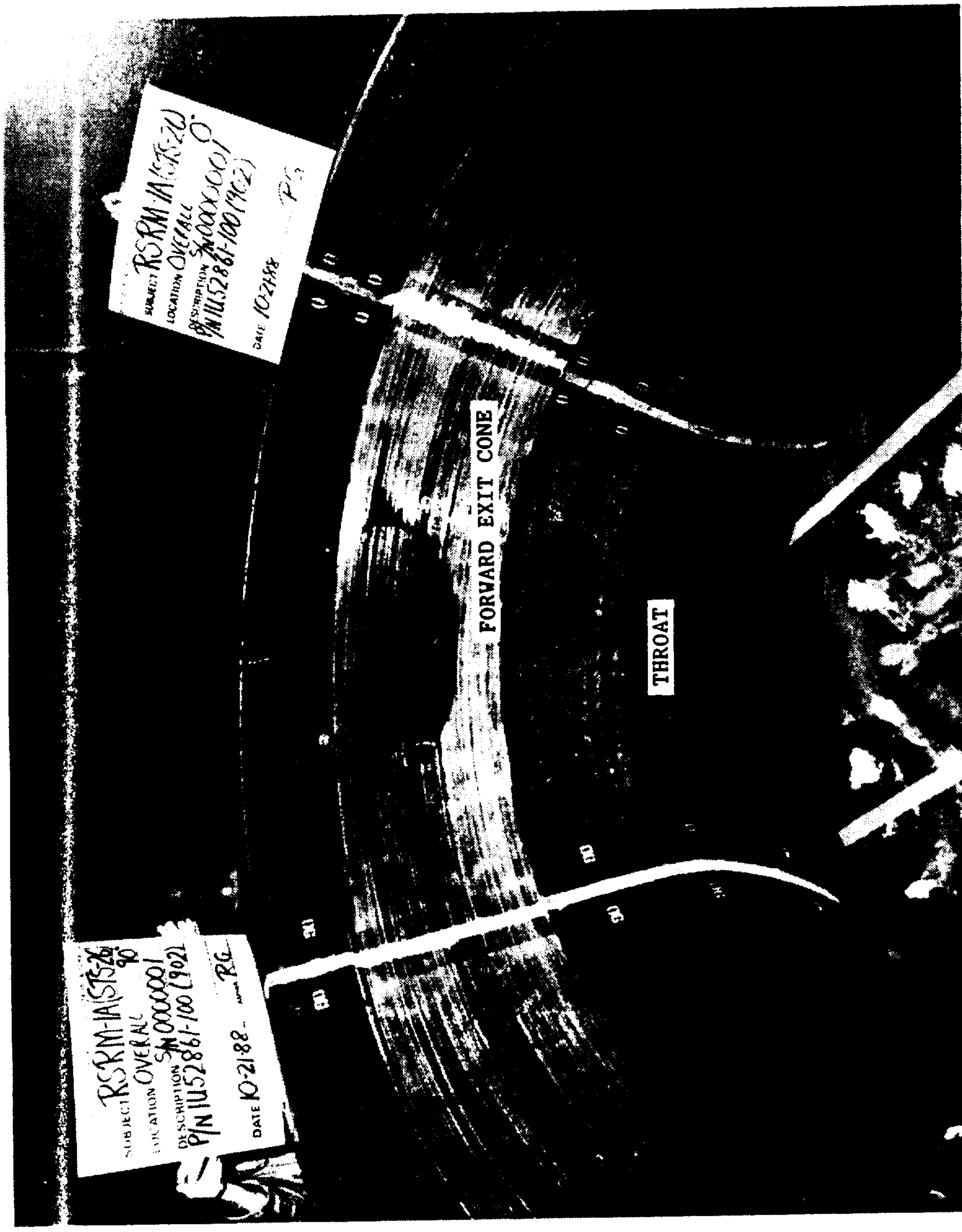

Figure 8 STS-26A Forward Nozzle Assy (Internal) 0° - 90°

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Figure 9 STS-26A Forward Nozzle Assy (Internal) 180° - 270°

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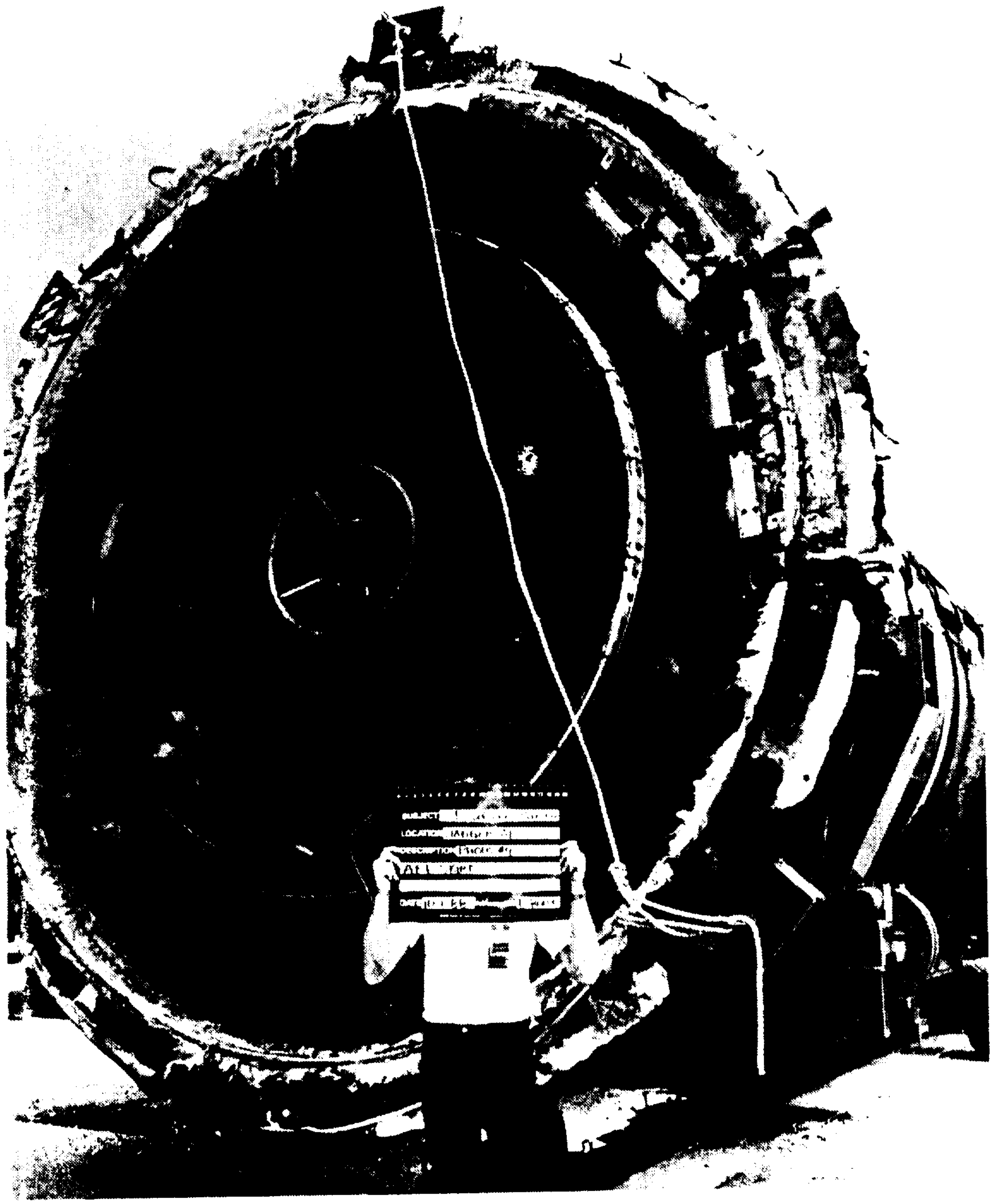

Figure 10 STS-26A Aft Exit Cone Fragment

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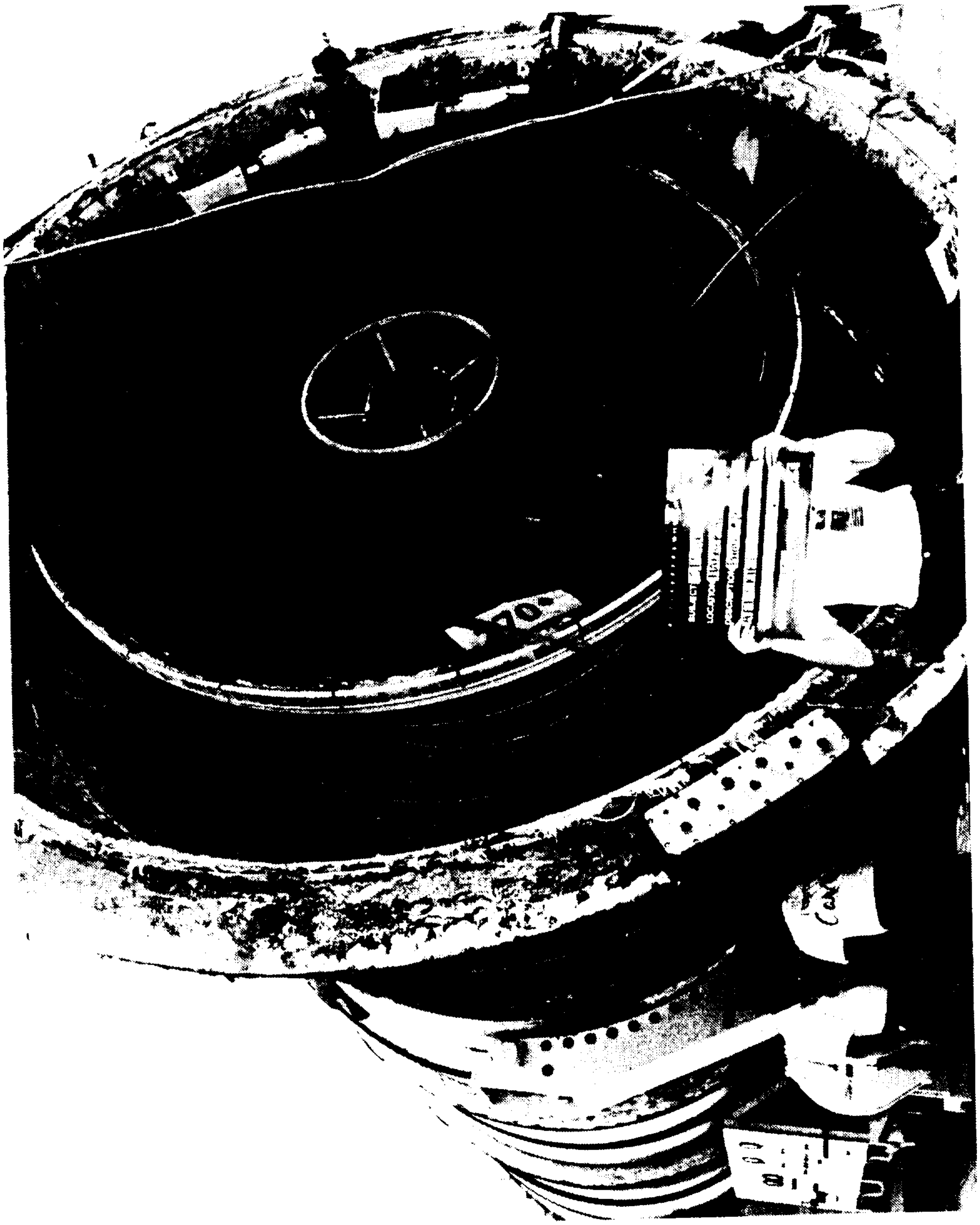
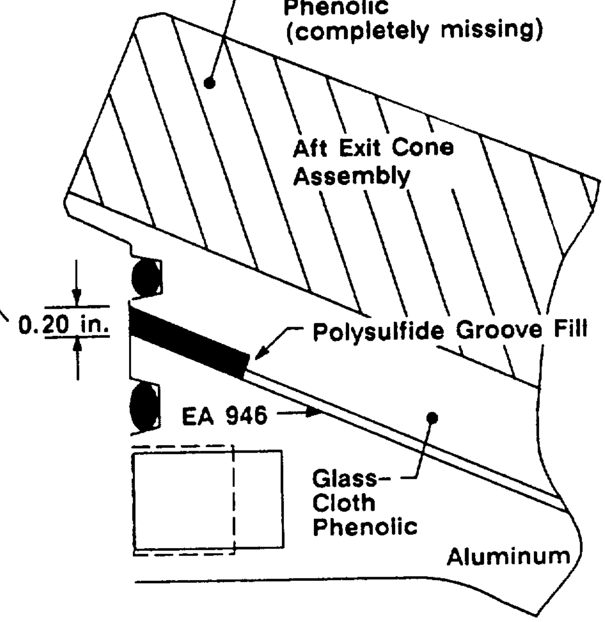


Figure 11 STS-26A Aft Exit Cone Fragment



Angular Location (deg)	Width (in.)
0	0.18
15	0.19
30	0.19
45	0.18
60	0.19
75	0.18
90	0.18
105	0.19
120	0.18
135	0.18
150	0.17
165	0.17
180	0.17
195	0.16
210	0.16
225	0.17
240	0.16
255	0.17
270	0.14
285	0.18
300	0.17
315	0.19
330	0.16
345	0.17

Table 1 STS-26A Aft Exit Cone Post-Flight Polysulfide Groove Radial Widths

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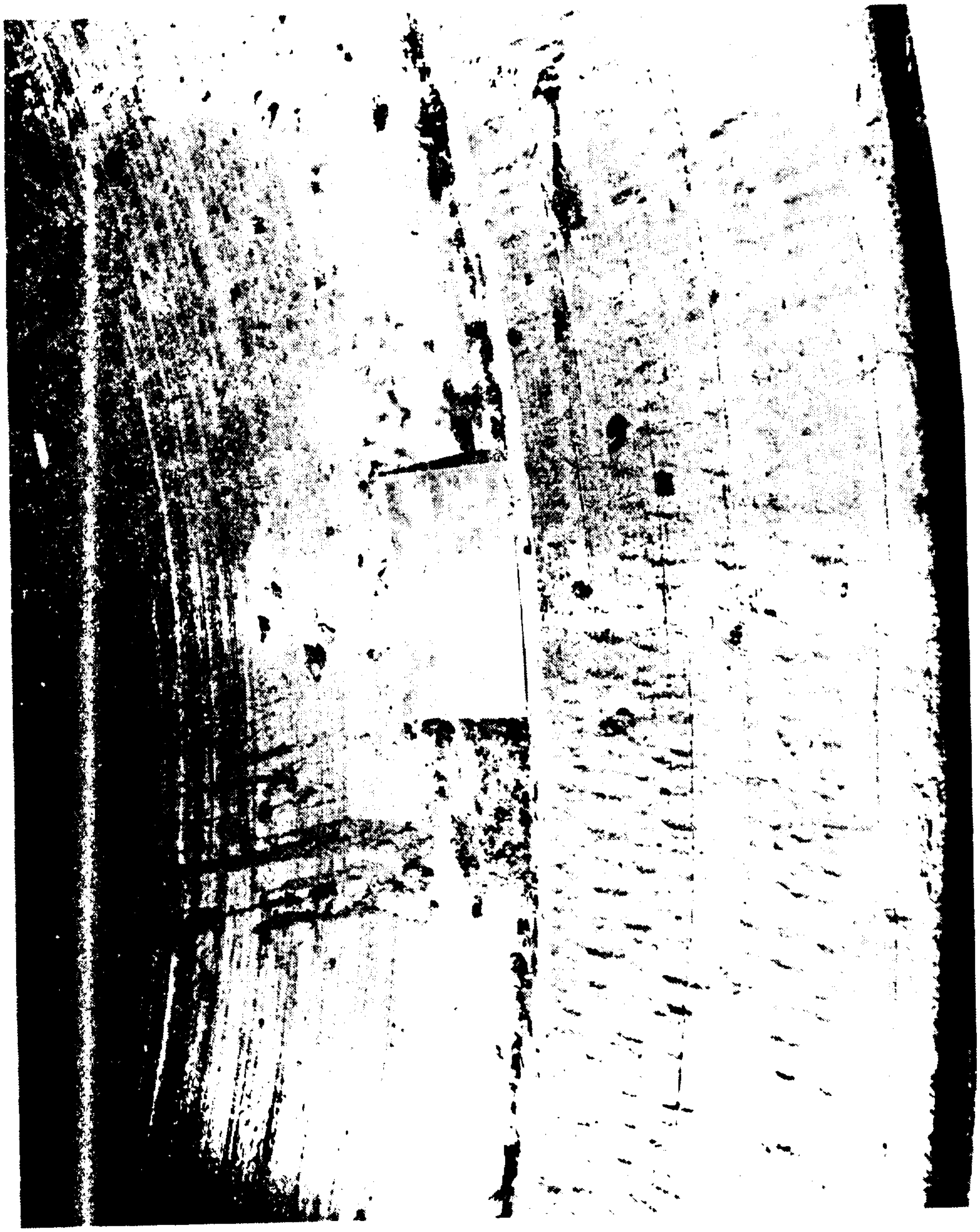
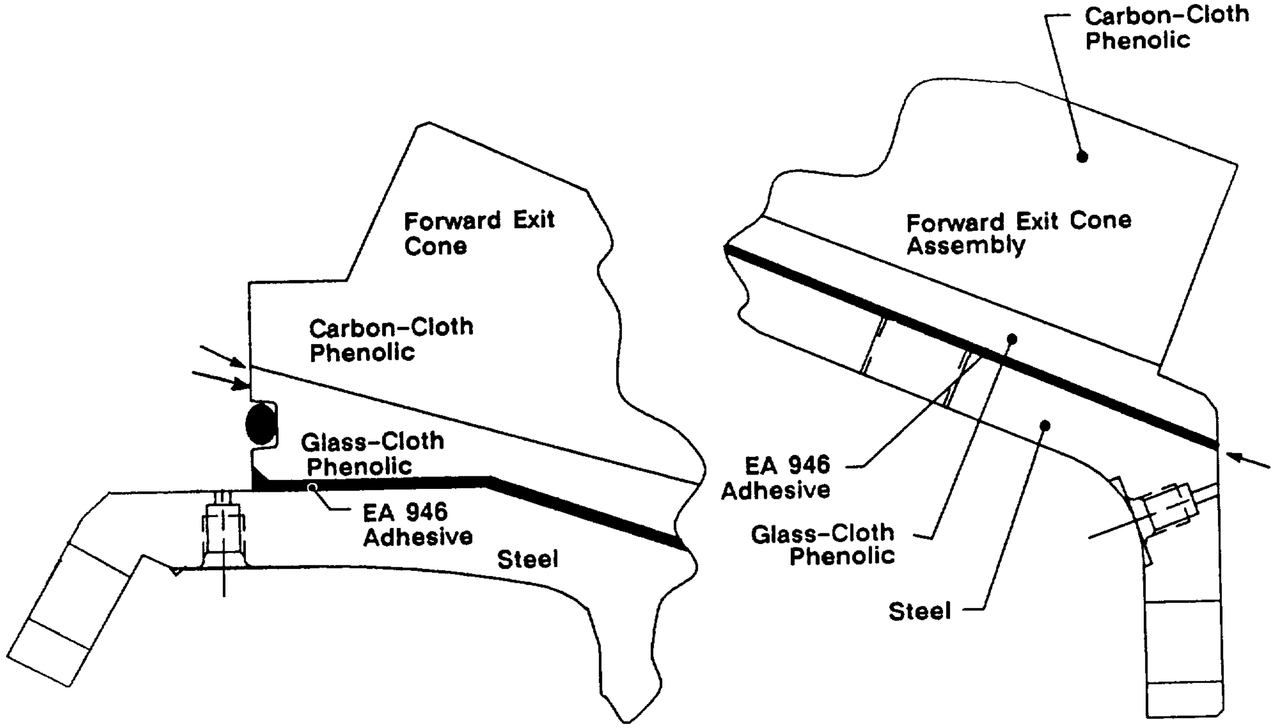


Figure 12 STS-26A Forward Exit Cone Dimpled Erosion (270 Degrees)



Forward End

Location (deg)	Radial Separation (in.)	Separation Type
310	0.005	GCP/CCP
325	0.040	GCP/CCP
332	0.040	GCP/CCP
182-192	0.015	Within GCP
230-252	0.030	Within GCP
285-307	0.030	Within GCP
318-325	0.030	Within GCP
332-0	0.040	Within GCP

Aft End

Location (deg)	Radial Separation (in.)	Separation Type
30	0.015	Metal/Adhesive
45	0.015	Metal/Adhesive
60	0.002	Metal/Adhesive
124	0.025	Metal/Adhesive
135	0.025	Metal/Adhesive
148	0.025	Metal/Adhesive

Figure 13 STS-26A Forward Exit Cone Bondline Separations

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Figure 14 STS-26A Forward Exit Cone Liner Section (0 Degrees)

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Figure 15 STS-26A Forward Exit Cone Liner Section (90 Degrees)

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Figure 16 STS-26A Forward Exit Cone Liner Section (180 Degrees)

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Figure 17 STS-26A Forward Exit Cone Liner Section (270 Degrees)

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Table 2 STS-26A Forward Exit Cone Erosion and Char Data

Angular Location	Stations 1	4	8	12	16	20	24	28	32	34
0 degrees										
Measured Erosion	NA	0.35	0.34	NA	NA	NA	NA	0.25	0.25	0.15
Measured Char	NA	0.68	0.74	NA	NA	NA	NA	0.69	0.74	0.75
Adjusted Char*	NA	0.54	0.59	NA	NA	NA	NA	0.55	0.59	0.60
2E + 1.25AC	NA	1.38	1.42	NA	NA	NA	NA	1.19	1.24	1.05
RSRM Min Liner Thickness	1.789	1.714	1.614	1.510	1.414	1.345	1.314	1.321	1.366	1.404
Margin of Safety	NA	0.24	0.14	NA	NA	NA	NA	0.11	0.10	0.34
90 degrees										
Measured Erosion	0.45	0.37	0.32	NA	NA	NA	NA	0.24	0.23	0.21
Measured Char	0.84	0.72	0.71	NA	NA	NA	NA	0.71	0.76	0.70
Adjusted Char*	0.67	0.58	0.57	NA	NA	NA	NA	0.57	0.61	0.56
2E + 1.25AC	1.74	1.46	1.35	NA	NA	NA	NA	1.19	1.22	1.12
RSRM Min Liner Thickness	1.789	1.714	1.614	1.510	1.414	1.345	1.314	1.321	1.366	1.404
Margin of Safety	0.03	0.17	0.20	NA	NA	NA	NA	0.11	0.12	0.25
180 degrees										
Measured Erosion	0.41	0.35	0.36	NA	NA	NA	NA	0.29	0.19	0.13
Measured Char	0.82	0.76	0.73	NA	NA	NA	NA	0.73	0.77	0.73
Adjusted Char*	0.66	0.61	0.58	NA	NA	NA	NA	0.58	0.62	0.58
2E + 1.25AC	1.64	1.46	1.45	NA	NA	NA	NA	1.31	1.15	0.99
RSRM Min Liner Thickness	1.789	1.714	1.614	1.510	1.414	1.345	1.314	1.321	1.366	1.404
Margin of Safety	0.09	0.17	0.11	NA	NA	NA	NA	0.01	0.19	0.42
270 degrees										
Measured Erosion	0.44	0.37	0.41	NA	NA	NA	NA	NA	NA	NA
Measured Char	0.76	0.82	0.67	NA	NA	NA	NA	NA	NA	NA
Adjusted Char*	0.61	0.66	0.54	NA	NA	NA	NA	NA	NA	NA
2E + 1.25AC	1.64	1.56	1.49	NA	NA	NA	NA	NA	NA	NA
RSRM Min Liner Thickness	1.789	1.714	1.614	1.510	1.414	1.345	1.314	1.321	1.366	1.404
Margin of Safety	0.09	0.10	0.08	NA	NA	NA	NA	NA	NA	NA

* Measured Char Adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

Refer to Figure 18 for station locations

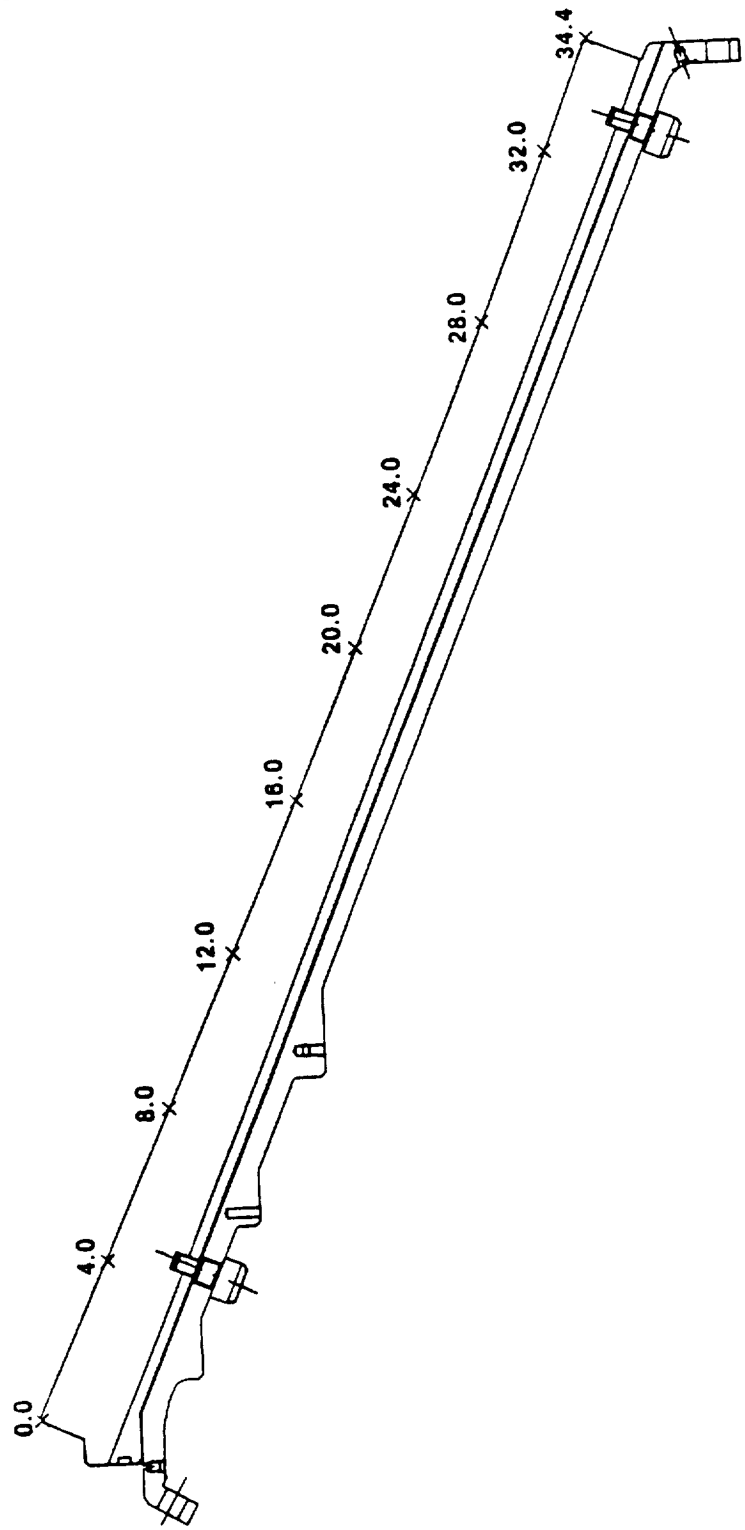

Figure 18 Forward Exit Cone Assembly Nozzle Stations

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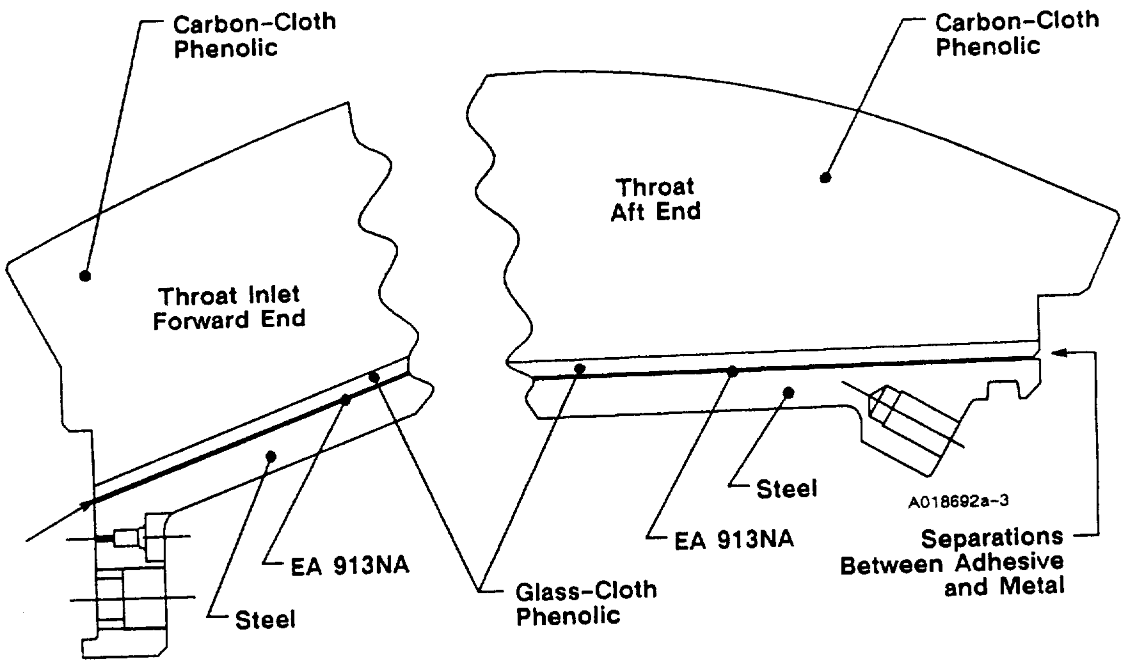
Figure 19 STS-26A Throat Ring Impact Marks (130 Degrees)



Fwd End Bondline Separations

Location (deg)	Radial Separation (in.)	Separation Type
0	0.030	Metal/Adhesive
15	0.030	Metal/Adhesive
30	0.030	Metal/Adhesive
45	0.030	Metal/Adhesive
60	0.030	Metal/Adhesive
75	0.030	Metal/Adhesive
90	0.030	Metal/Adhesive
105	0.030	Metal/Adhesive
110	0.030	GCP/Adhesive
120	0.030	Metal/Adhesive
135	0.030	Metal/Adhesive
150	0.030	Metal/Adhesive
165	0.030	Metal/Adhesive
180	0.030	Within Adhesive
180	0.030	Metal/Adhesive
195	0.030	Metal/Adhesive
210	0.030	Metal/Adhesive
225	0.030	Metal/Adhesive
270	0.030	Metal/Adhesive
285	0.030	Metal/Adhesive
300	0.030	Metal/Adhesive
315	0.030	Metal/Adhesive
330	0.030	Metal/Adhesive
345	0.030	Metal/Adhesive

Aft End Metal-to-Adhesive Bondline Separations

Location (deg)	Radial Separation (in.)
30	0.100
45	0.005
60	0.100
75	0.100
90	0.100
105	0.100
120	0.100
135	0.005
150	0.005
165	0.005
180	0.005
195	0.003
210	0.100
225	0.100
270	0.100
285	0.100
300	0.100
315	0.100
330	0.100
345	0.100

Figure 20 STS-26A Throat Assembly Bondline Separations

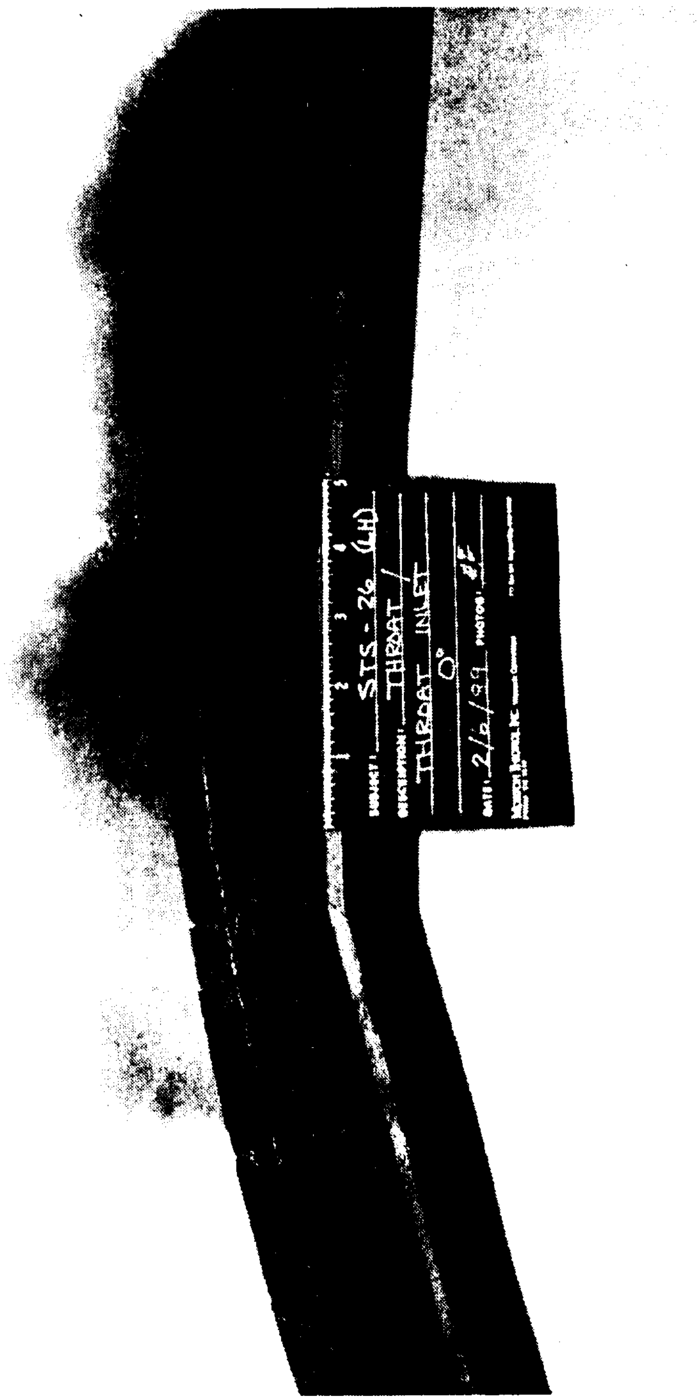


Figure 21 STS-26A Throat/Throat Inlet Section (0 Degrees)

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Figure 22 STS-26A Throat/Throat Inlet Section (90 Degrees)

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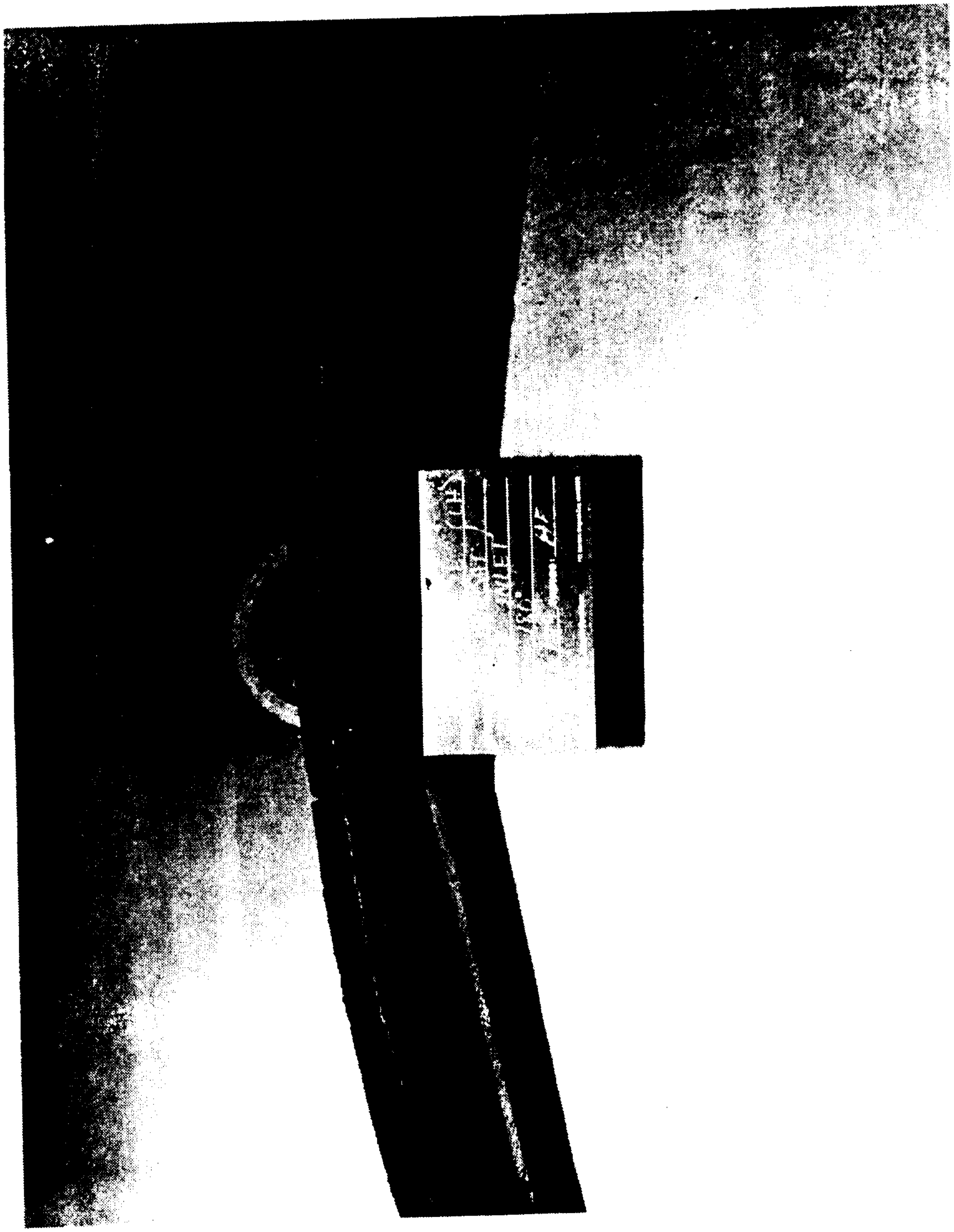

Figure 23 STS-26A Throat/Throat Inlet Section (180 Degrees)

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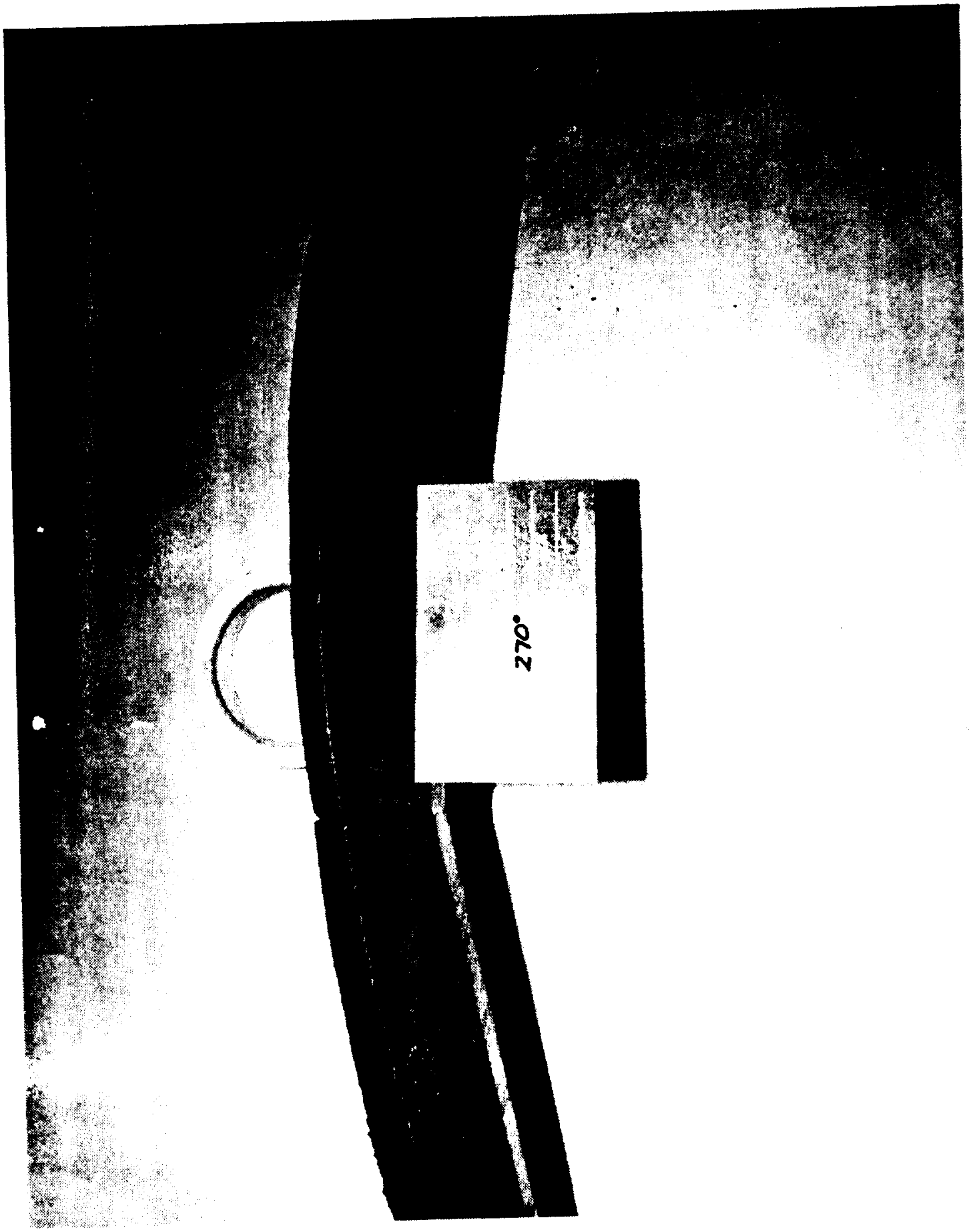

Figure 24 STS-26A Throat/Throat Inlet Section (270 Degrees)

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Table 3 STS-26A Throat Assembly Erosion and Char Data

Stations

Angular Location	1	2	4	6	8	10	12	14	16	18	20	22	23
0 degrees													
Measured Erosion	1.06	1.12	1.20	1.25	1.28	1.25	1.21	1.18	1.14	1.00	0.80	0.52	0.45
Measured Char	0.61	0.58	0.58	0.52	0.48	0.50	0.51	0.53	0.58	0.60	0.70	0.78	0.79
Adjusted Char *	0.46	0.44	0.44	0.39	0.36	0.38	0.38	0.40	0.44	0.45	0.53	0.59	0.59
2E + 1.25AC	2.69	2.78	2.94	2.99	3.01	2.97	2.90	2.86	2.82	2.56	2.26	1.77	1.64
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.189	3.397	3.517	3.626	3.710	3.586	3.232	2.583	2.110
Margin of Safety	0.18	0.17	0.13	0.10	0.06	0.14	0.21	0.27	0.31	0.40	0.43	0.46	0.29
90 degrees													
Measured Erosion	1.05	1.08	1.18	1.18	1.23	1.19	1.18	1.18	1.10	0.71	0.74	0.44	0.38
Measured Char	0.61	0.54	0.55	0.55	0.53	0.47	0.48	0.45	0.53	0.59	0.66	0.78	0.64
Adjusted Char *	0.46	0.41	0.41	0.41	0.40	0.35	0.36	0.34	0.40	0.44	0.50	0.59	0.48
2E + 1.25AC	2.67	2.67	2.88	2.88	2.96	2.82	2.81	2.78	2.70	1.97	2.10	1.61	1.36
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.189	3.397	3.517	3.626	3.710	3.586	3.232	2.583	2.110
Margin of Safety	0.19	0.22	0.15	0.14	0.08	0.20	0.25	0.30	0.38	0.82	0.54	0.60	0.55
180 degrees													
Measured Erosion	1.00	1.06	1.12	1.15	1.22	1.16	1.15	1.10	1.06	0.92	0.73	0.45	0.35
Measured Char	0.62	0.59	0.58	0.60	0.56	0.55	0.52	0.55	0.56	0.57	0.67	0.78	0.86
Adjusted Char *	0.47	0.44	0.44	0.45	0.42	0.41	0.39	0.41	0.42	0.43	0.50	0.59	0.65
2E + 1.25AC	2.58	2.67	2.78	2.86	2.97	2.84	2.79	2.72	2.65	2.37	2.09	1.63	1.51
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.189	3.397	3.517	3.626	3.710	3.586	3.232	2.583	2.110
Margin of Safety	0.23	0.21	0.19	0.15	0.08	0.20	0.26	0.34	0.40	0.51	0.55	0.58	0.43
270 degrees													
Measured Erosion	1.09	1.11	1.18	1.20	1.26	1.21	1.21	1.20	1.12	0.98	0.76	0.50	0.38
Measured Char	0.66	0.67	0.61	0.57	0.48	0.45	0.46	0.49	0.64	0.68	0.69	0.70	0.80
Adjusted Char *	0.50	0.50	0.46	0.43	0.36	0.34	0.35	0.37	0.48	0.51	0.52	0.53	0.60
2E + 1.25AC	2.80	2.85	2.93	2.93	2.97	2.84	2.85	2.86	2.84	2.60	2.17	1.66	1.51
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.189	3.397	3.517	3.626	3.710	3.586	3.232	2.583	2.110
Margin of Safety	0.13	0.14	0.13	0.12	0.07	0.20	0.23	0.27	0.31	0.38	0.49	0.56	0.40
130 degrees													
Measured Erosion	1.09	1.12	1.20	1.18	1.24	1.21	1.20	1.15	1.09	1.00	0.70	0.45	0.45
Measured Char	0.69	0.72	0.67	0.52	0.53	0.50	0.45	0.57	0.47	0.58	0.56	0.55	0.57
Adjusted Char *	0.52	0.54	0.50	0.39	0.40	0.38	0.34	0.43	0.35	0.44	0.42	0.41	0.43
2E + 1.25AC	2.83	2.92	3.03	2.85	2.98	2.89	2.82	2.83	2.62	2.54	1.93	1.42	1.43
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.189	3.397	3.517	3.626	3.710	3.586	3.232	2.583	2.110
Margin of Safety	0.12	0.11	0.09	0.15	0.07	0.18	0.25	0.28	0.42	0.41	0.68	0.82	0.47

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

Refer to Figure 25 for Station Locations

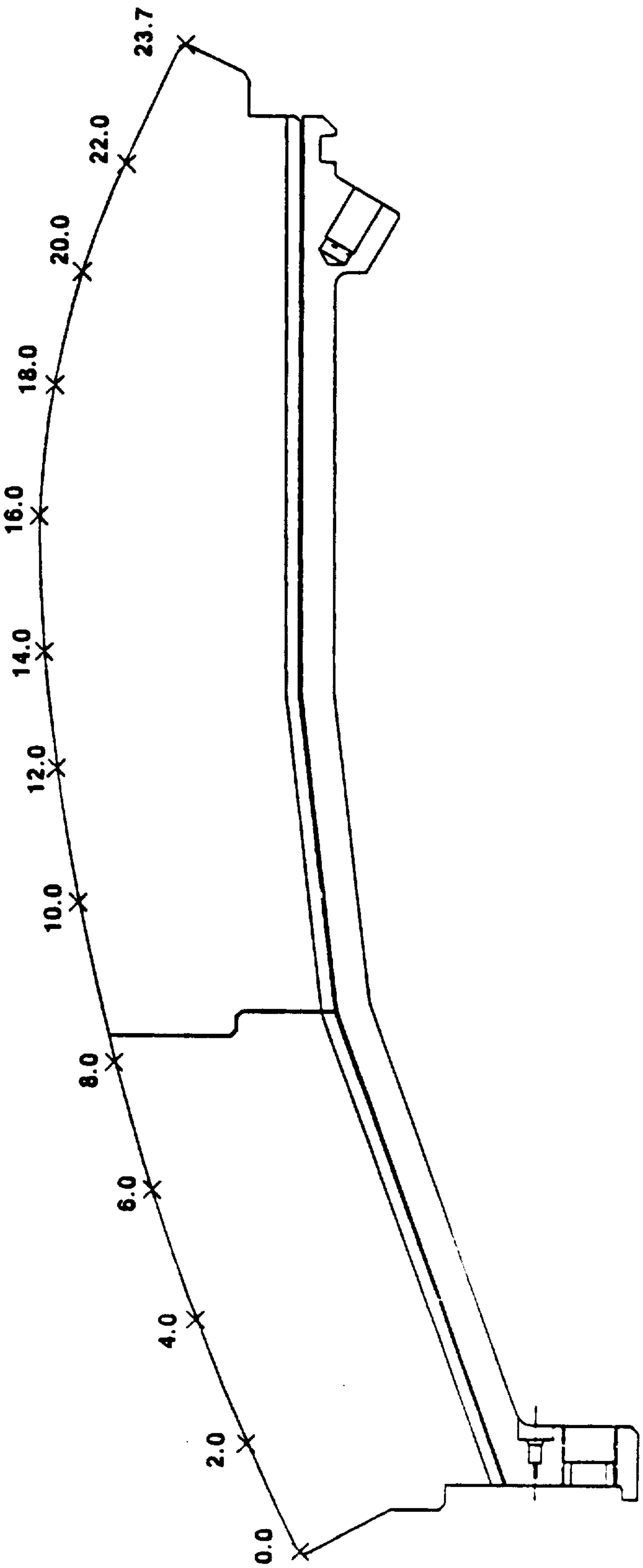

Figure 25 Throat Inlet Assembly Erosion Measurement Stations

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Figure 26 STS-26A -503 Ring Impact Marks (3 Degrees)

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Figure 27 STS-26A -504 Ring Impact Mark (85 Degrees)

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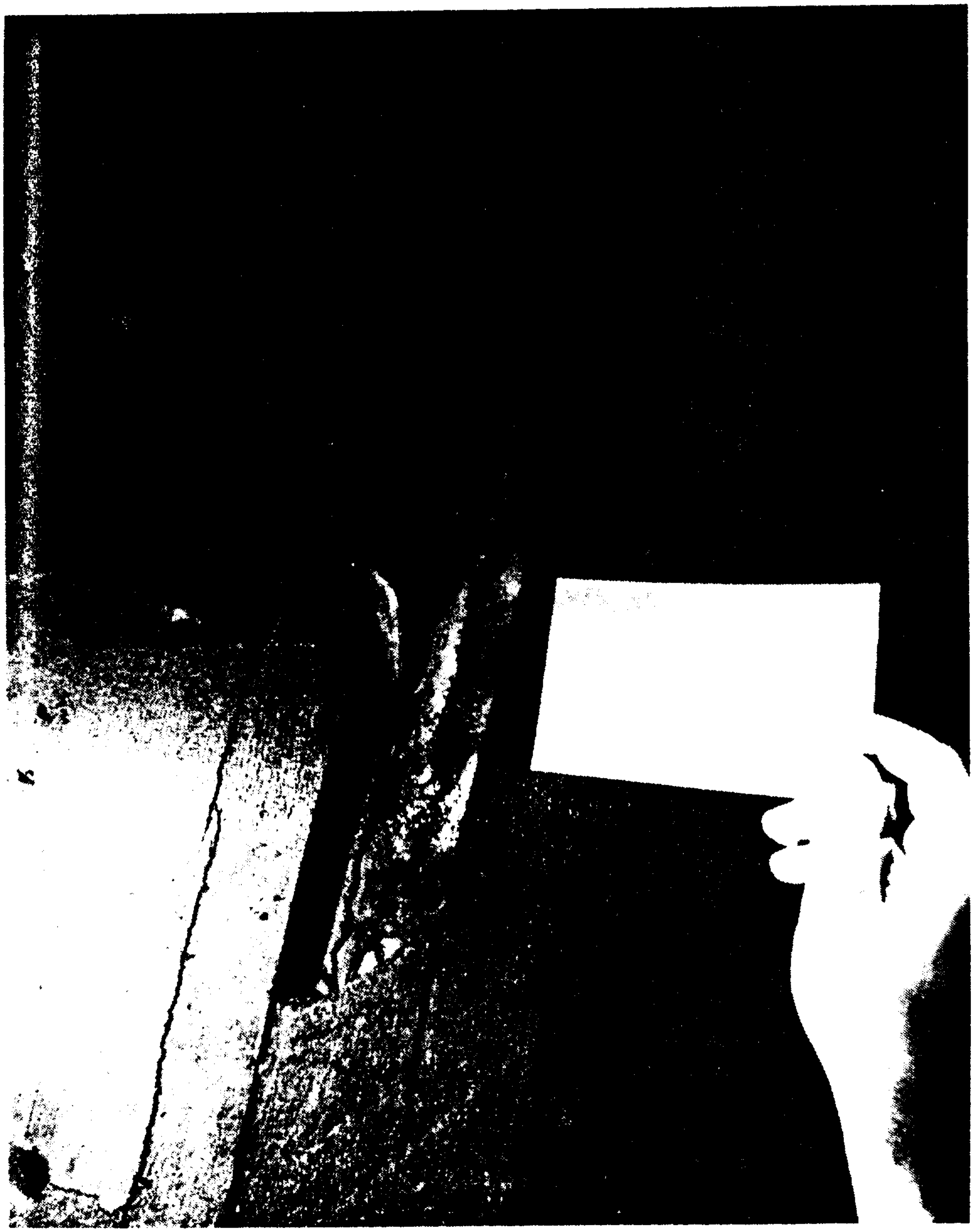
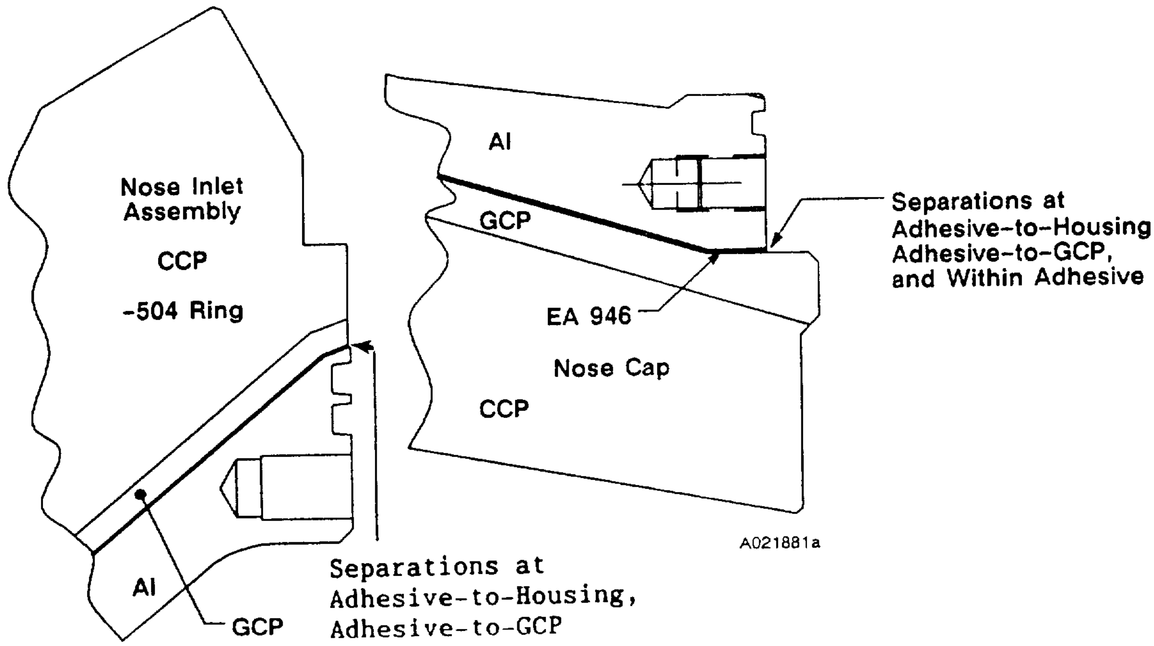


Figure 28 STS-26A Nose Cap Wedgeout (20 Degrees)



Location (deg)	Radial Separation (in.)	Separation Type*
0	0.005	1
15	0.005	1
30	0.005	1
45	0.005	1
75	0.005	1
165	0.005	1
180	0.010	1
195	0.010	2
210	0.005	1
240	0.005	1
255	0.005	1
270	0.005	1
330	0.005	2
345	0.005	2

Location (deg)	Radial Separation (in.)	Separation Type*
0	0.005	1
0-6	0.005	2
15	0.005	2
24	0.005	1
26-28	0.003	3
28-36	0.003	2
75	0.003	2
114	0.003	1
150	0.003	1
165	0.003	2
180	0.003	2
228	0.003	1
240	0.003	2
250-256	0.005	2
258-267	0.003	2
277-282	0.005	1
282-285	0.003	2
300	0.003	1, 2
309-319	0.003	2
330	0.003	2
336-342	0.003	1
345	0.003	2

*Type 1 = Metal/Adhesive
Type 2 = Adhesive/GCP
Type 3 = Within Adhesive

Figure 29 STS-26A Nose Inlet Assembly Bondline Separations

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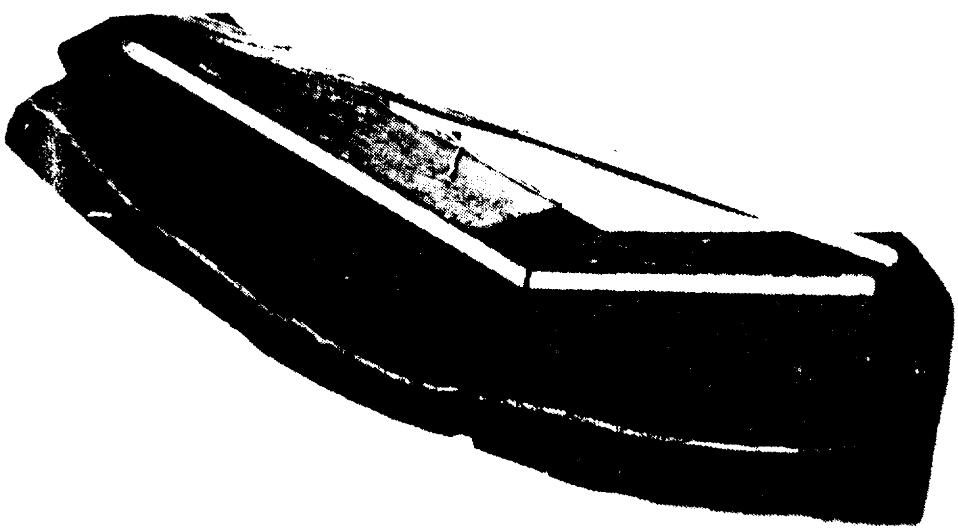

Figure 30 STS-26A Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section - 0 Degrees

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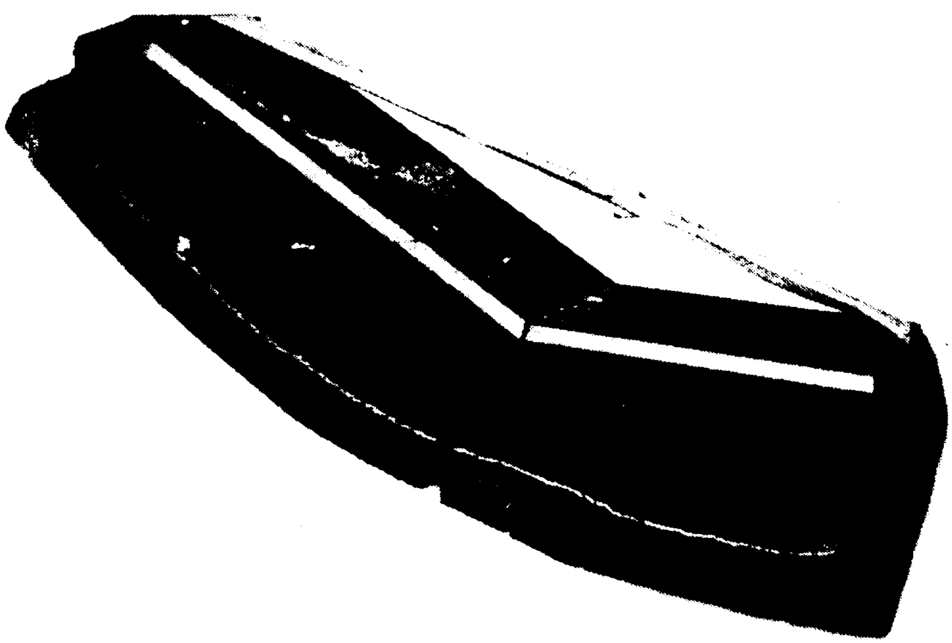

Figure 31 STS-26A Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section - 90 Degrees

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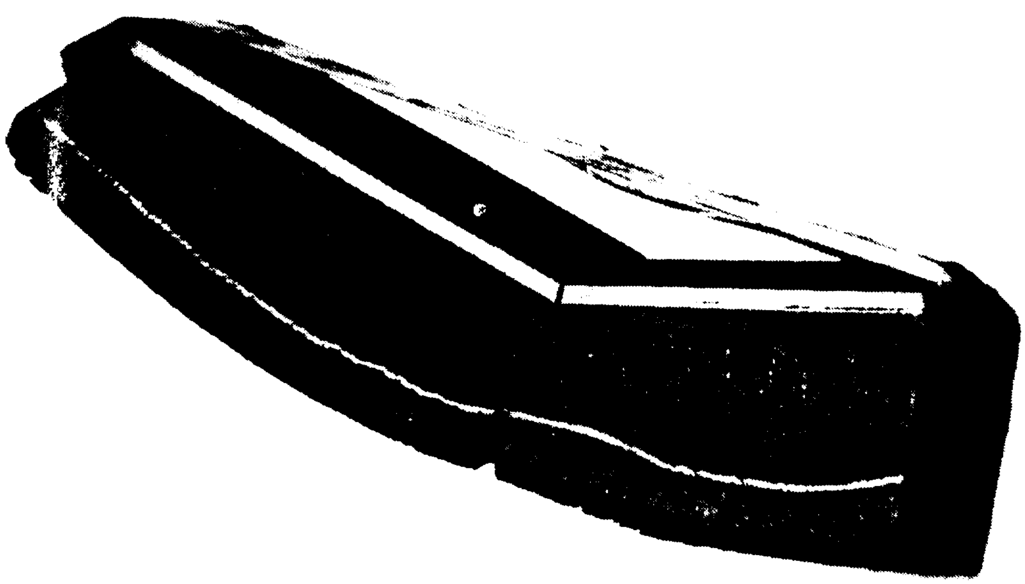

Figure 32 STS-26A Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section - 180 Degrees

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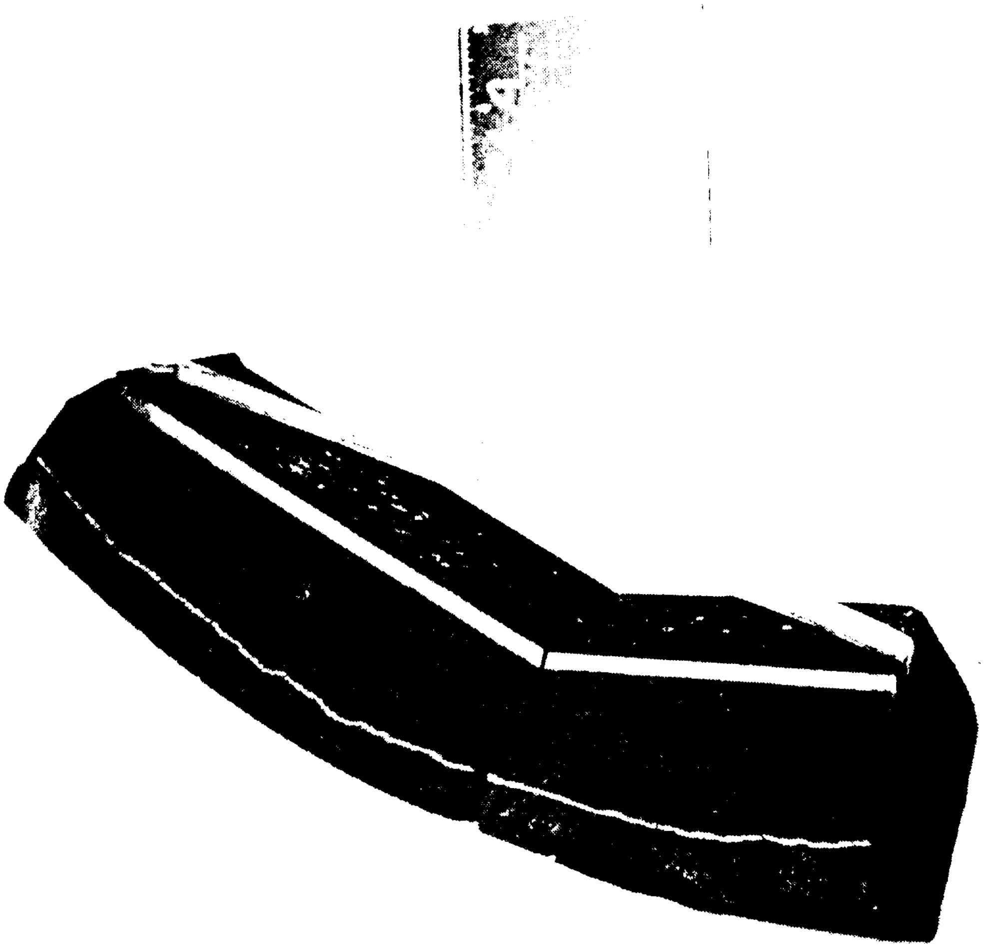

Figure 33 STS-26A Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section - 270 Degrees

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Figure 34 STS-26A Nose Cap Section (0 Degrees)

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Figure 35 STS-26A Nose Cap Section (90 Degrees)

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Figure 36 STS-26A Nose Cap Section (180 Degrees)

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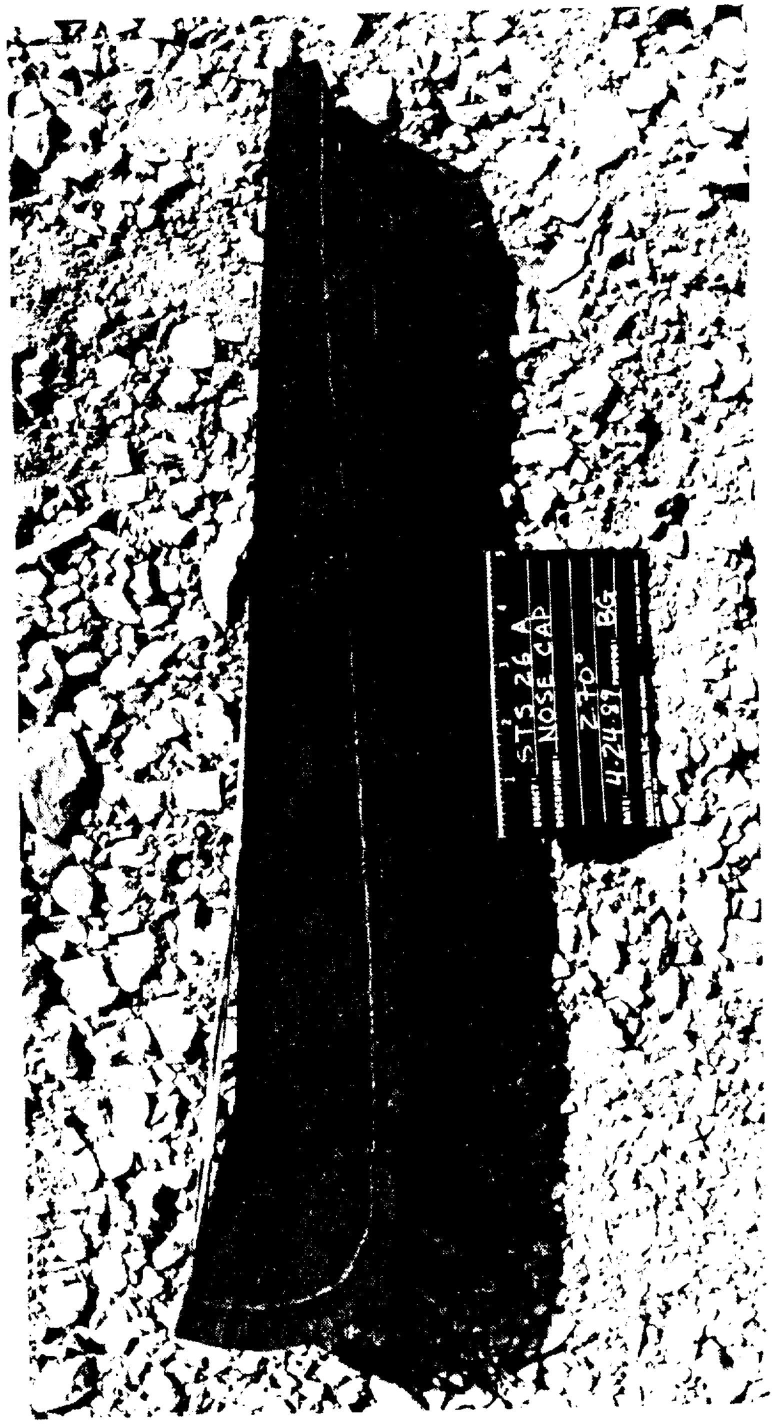

Figure 37 STS-26A Nose Cap (270 Degrees)

Table 4 STS-26A Nose Inlet Rings (-503, -504) Erosion and Char Data

Angular Location	Stations 28	30	32	34	36	38	39.5
0 degrees							
Measured Erosion	1.19	0.94	0.91	0.87	0.90	0.96	1.20
Measured Char	0.70	0.71	0.66	0.55	0.60	0.60	0.45
Adjusted Char*	0.53	0.53	0.50	0.41	0.45	0.45	0.34
2E + 1.25AC	3.04	2.55	2.44	2.26	2.36	2.48	2.82
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	2.981
Margin of Safety	0.16	0.28	0.21	0.41	0.35	0.22	0.06
90 degrees							
Measured Erosion	1.09	0.83	0.86	0.83	0.85	0.94	1.15
Measured Char	0.70	0.70	0.64	0.63	0.61	0.62	0.44
Adjusted Char*	0.53	0.53	0.48	0.47	0.46	0.47	0.33
2E + 1.25AC	2.84	2.32	2.32	2.25	2.27	2.46	2.71
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	2.981
Margin of Safety	0.24	0.40	0.27	0.41	0.41	0.23	0.10
180 degrees							
Measured Erosion	0.96	0.75	0.86	0.82	0.83	0.90	1.20
Measured Char	0.85	0.75	0.76	0.69	0.67	0.70	0.48
Adjusted Char*	0.64	0.56	0.57	0.52	0.50	0.53	0.36
2E + 1.25AC	2.72	2.20	2.43	2.29	2.29	2.46	2.85
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	2.981
Margin of Safety	0.29	0.48	0.21	0.39	0.40	0.23	0.05
270 degrees							
Measured Erosion	1.08	0.87	0.94	0.87	0.86	0.94	NA
Measured Char	0.88	0.72	0.67	0.58	0.69	0.62	NA
Adjusted Char*	0.66	0.54	0.50	0.44	0.52	0.47	NA
2E + 1.25AC	2.99	2.42	2.51	2.28	2.37	2.46	NA
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	2.981
Margin of Safety	0.18	0.35	0.18	0.39	0.35	0.23	NA
120 degrees							
Measured Erosion	1.15	0.87	0.89	0.82	0.86	0.91	0.97
Measured Char	0.78	0.62	0.78	0.62	0.60	0.67	0.65
Adjusted Char*	0.59	0.47	0.59	0.47	0.45	0.50	0.49
2E + 1.25AC	3.03	2.32	2.51	2.22	2.28	2.45	2.55
RSRM Min Liner Thkns	3.508	3.252	2.950	3.182	3.200	3.026	2.981
Margin of Safety	0.16	0.40	0.17	0.43	0.40	0.24	0.17

* Measured Char Adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

Refer to Figure 38 for Station Locations

Table 5 STS-26A Nose Cap Assembly Erosion and Char Data

Angular Location	Stations												
	1.5	4	6	8	10	12	14	16	18	20	22	24	26
0 degrees													
Measured Erosion	NA	0.26	0.34	0.32	0.40	0.45	0.53	0.60	0.68	0.92	1.42	1.59	1.13
Measured Char	NA	0.60	0.54	0.59	0.56	0.55	0.47	0.46	0.45	0.40	0.58	0.68	0.70
Adjusted Char *	NA	0.48	0.43	0.47	0.45	0.44	0.38	0.37	0.36	0.32	0.46	0.54	0.53
2E + 1.25AC	NA	1.12	1.22	1.23	1.36	1.45	1.53	1.66	1.81	2.24	3.42	3.86	2.92
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.82	0.84	1.00	0.96	0.98	1.02	0.99	0.94	0.81	0.38	0.22	0.32
45 degrees													
Measured Erosion	NA	0.34	0.36	0.43	0.48	0.52	0.57	0.67	0.81	1.08	1.61	1.81	1.30
Measured Char	NA	0.59	0.56	0.58	0.53	0.48	0.53	0.49	0.48	0.47	0.71	0.77	0.77
Adjusted Char *	NA	0.47	0.45	0.46	0.42	0.38	0.42	0.39	0.38	0.38	0.57	0.62	0.58
2E + 1.25AC	NA	1.27	1.28	1.44	1.49	1.52	1.67	1.83	2.10	2.63	3.93	4.39	3.32
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.60	0.76	0.71	0.79	0.89	0.85	0.80	0.67	0.54	0.20	0.07	0.16
90 degrees													
Measured Erosion	NA	0.40	0.42	0.45	0.52	0.52	0.66	0.75	0.80	1.05	1.63	1.84	1.23
Measured Char	NA	0.62	0.66	0.65	0.64	0.63	0.60	0.50	0.54	0.62	0.74	0.82	0.85
Adjusted Char *	NA	0.50	0.53	0.52	0.51	0.50	0.48	0.40	0.43	0.50	0.59	0.66	0.64
2E + 1.25AC	NA	1.42	1.50	1.55	1.68	1.67	1.92	2.00	2.14	2.72	4.00	4.50	3.26
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.44	0.50	0.59	0.59	0.72	0.61	0.65	0.64	0.49	0.18	0.04	0.19
135 degrees													
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

* measured char adjusted to end of action time

$$\text{margin of safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char}^*} - 1$$

Refer to Figure 38 for Station Locations

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Table 5 STS-26A Nose Cap Assembly Erosion and Char Data (continued)

Angular Location	Stations												
	1.5	4	6	8	10	12	14	16	18	20	22	24	26
180 degrees													
Measured Erosion	NA	0.38	0.38	0.47	0.52	0.55	0.56	0.69	0.78	1.04	1.60	1.84	1.34
Measured Char	NA	0.62	0.61	0.60	0.55	0.52	0.58	0.59	0.56	0.56	0.73	0.80	0.75
Adjusted Char *	NA	0.50	0.49	0.48	0.44	0.42	0.46	0.47	0.45	0.45	0.58	0.64	0.56
2E + 1.25AC	NA	1.38	1.37	1.54	1.59	1.62	1.70	1.97	2.12	2.64	3.93	4.48	3.38
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.48	0.64	0.60	0.68	0.78	0.82	0.67	0.65	0.54	0.20	0.05	0.14
225 degrees													
Measured Erosion	0.28	0.22	0.30	0.33	0.39	0.44	0.52	0.63	0.77	0.97	1.41	1.62	1.05
Measured Char	0.51	0.61	0.57	0.58	0.50	0.50	0.45	0.41	0.37	0.42	0.59	0.62	0.71
Adjusted Char *	0.41	0.49	0.46	0.46	0.40	0.40	0.36	0.33	0.30	0.34	0.47	0.50	0.53
2E + 1.25AC	1.07	1.05	1.17	1.24	1.28	1.38	1.49	1.67	1.91	2.36	3.41	3.86	2.77
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	0.66	0.94	0.92	0.98	1.08	1.09	1.07	0.97	0.84	0.72	0.38	0.22	0.40
270 degrees													
Measured Erosion	NA	0.26	0.31	0.34	0.40	0.48	0.54	0.62	0.73	0.95	1.42	1.65	1.17
Measured Char	NA	0.74	0.52	0.68	0.69	0.58	0.52	0.47	0.45	0.46	0.72	0.85	0.81
Adjusted Char *	NA	0.59	0.42	0.54	0.55	0.46	0.42	0.38	0.36	0.37	0.58	0.68	0.61
2E + 1.25AC	NA	1.26	1.14	1.36	1.49	1.54	1.60	1.71	1.91	2.36	3.56	4.15	3.10
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.62	0.97	0.81	0.79	0.87	0.93	0.93	0.84	0.72	0.32	0.13	0.25
315 degrees													
Measured Erosion	NA	0.30	0.35	0.38	0.40	0.52	0.64	0.66	0.78	0.97	1.53	1.71	1.11
Measured Char	NA	0.59	0.60	0.57	0.58	0.53	0.48	0.45	0.41	0.38	0.49	0.74	0.70
Adjusted Char *	NA	0.47	0.48	0.46	0.46	0.42	0.38	0.36	0.33	0.30	0.39	0.59	0.53
2E + 1.25AC	NA	1.19	1.30	1.33	1.38	1.57	1.76	1.77	1.97	2.32	3.55	4.16	2.88
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.71	0.73	0.85	0.93	0.83	0.75	0.86	0.78	0.75	0.33	0.13	0.34

* measured char adjusted to end of action time

$$\text{margin of safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char}^*} - 1$$

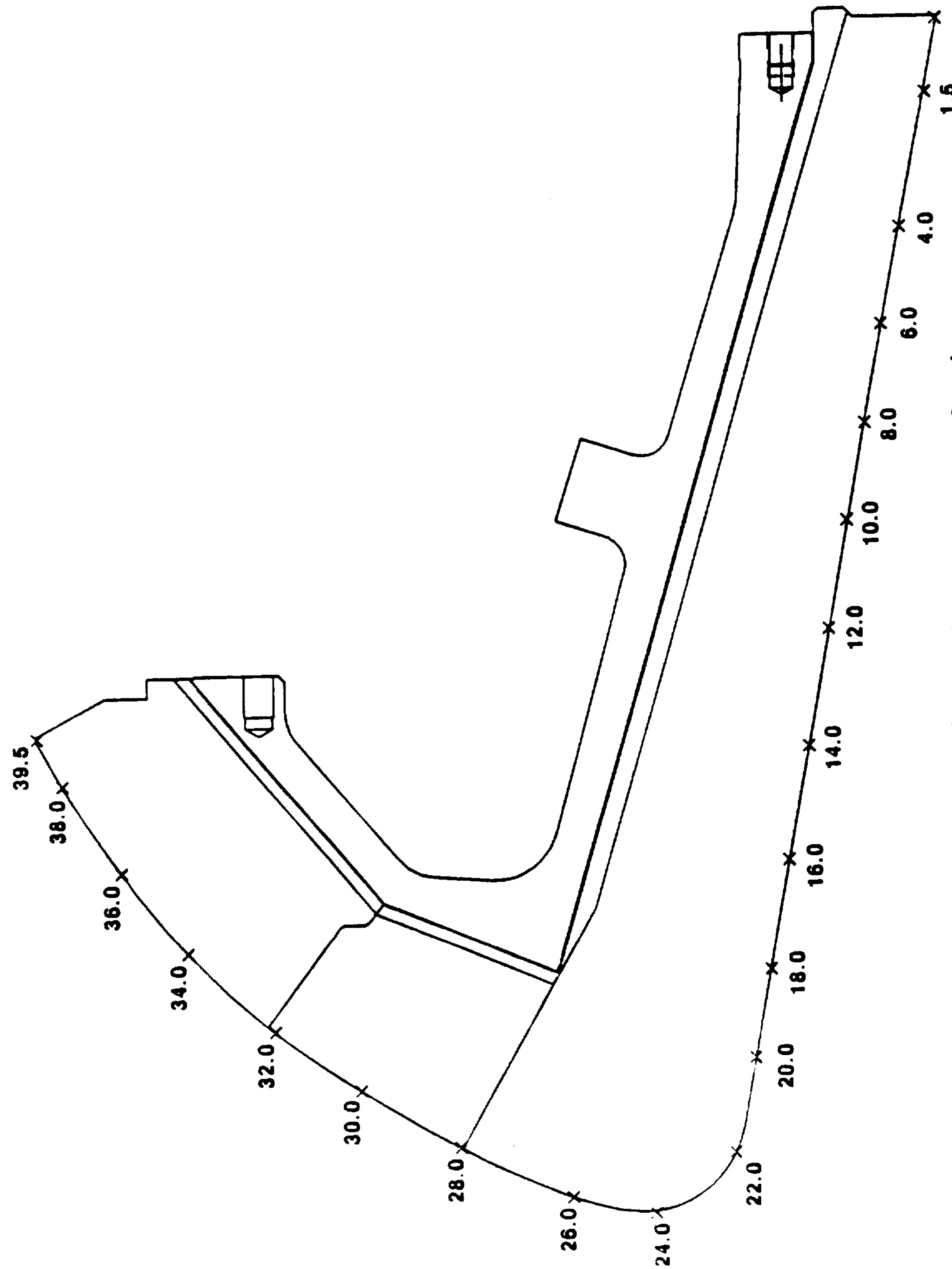

Figure 38 Nose Inlet Assembly Erosion Measurement Stations

Figure 39 STS-26A Nose Inlet Housing Bonding Surfaces - 0 Deg

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Figure 40 STS-26A Nose Inlet Housing Bonding Surfaces - 90 Deg

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Figure 41 STS-26A Nose Inlet Housing Bonding Surfaces - 180 Deg

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Figure 42 STS-26A Nose Inlet Housing Bonding Surfaces - 270 Deg

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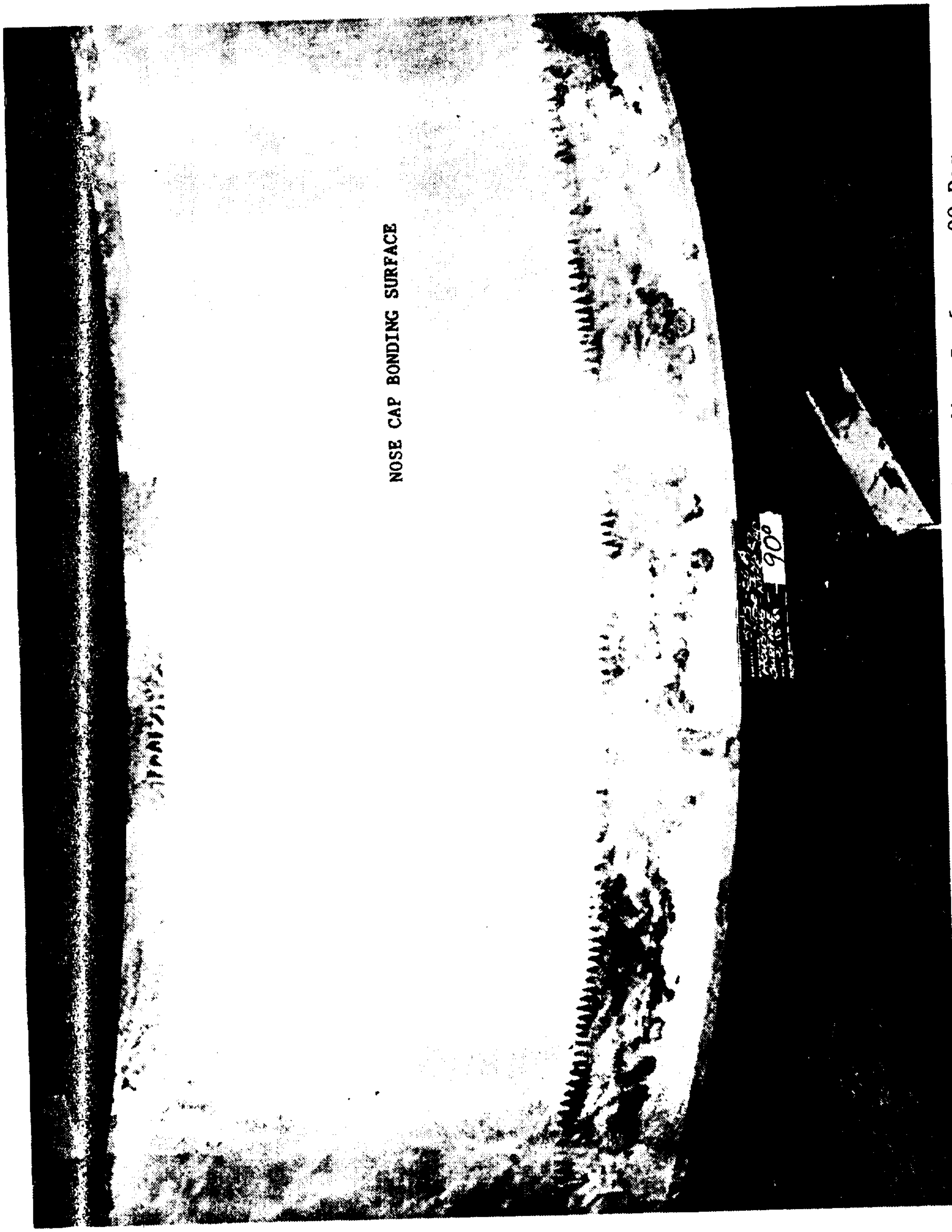

Figure 43 STS-26A Nose Inlet Housing (Nose Cap) Bonding Surface - 90 Deg

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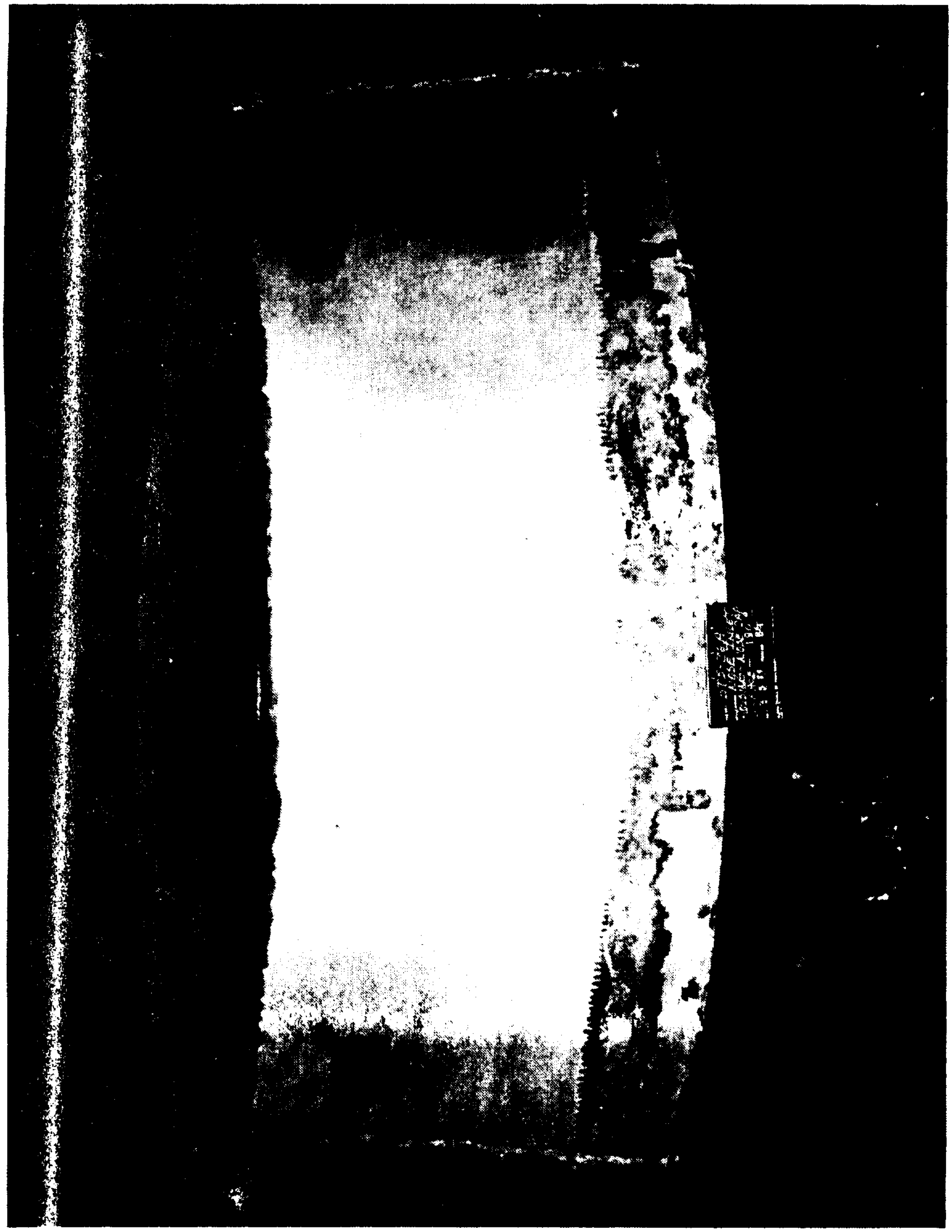

Figure 44 STS-26A Nose Inlet Housing (Nose Cap) Bonding Surface - 180 Deg

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Figure 45 STS-26A Nose Inlet Housing (-504 Ring) Bonding Surface - 90 Degrees

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Figure 46 STS-26A Nose Inlet Housing (-504 Ring) Bonding Surface - 270 Degrees

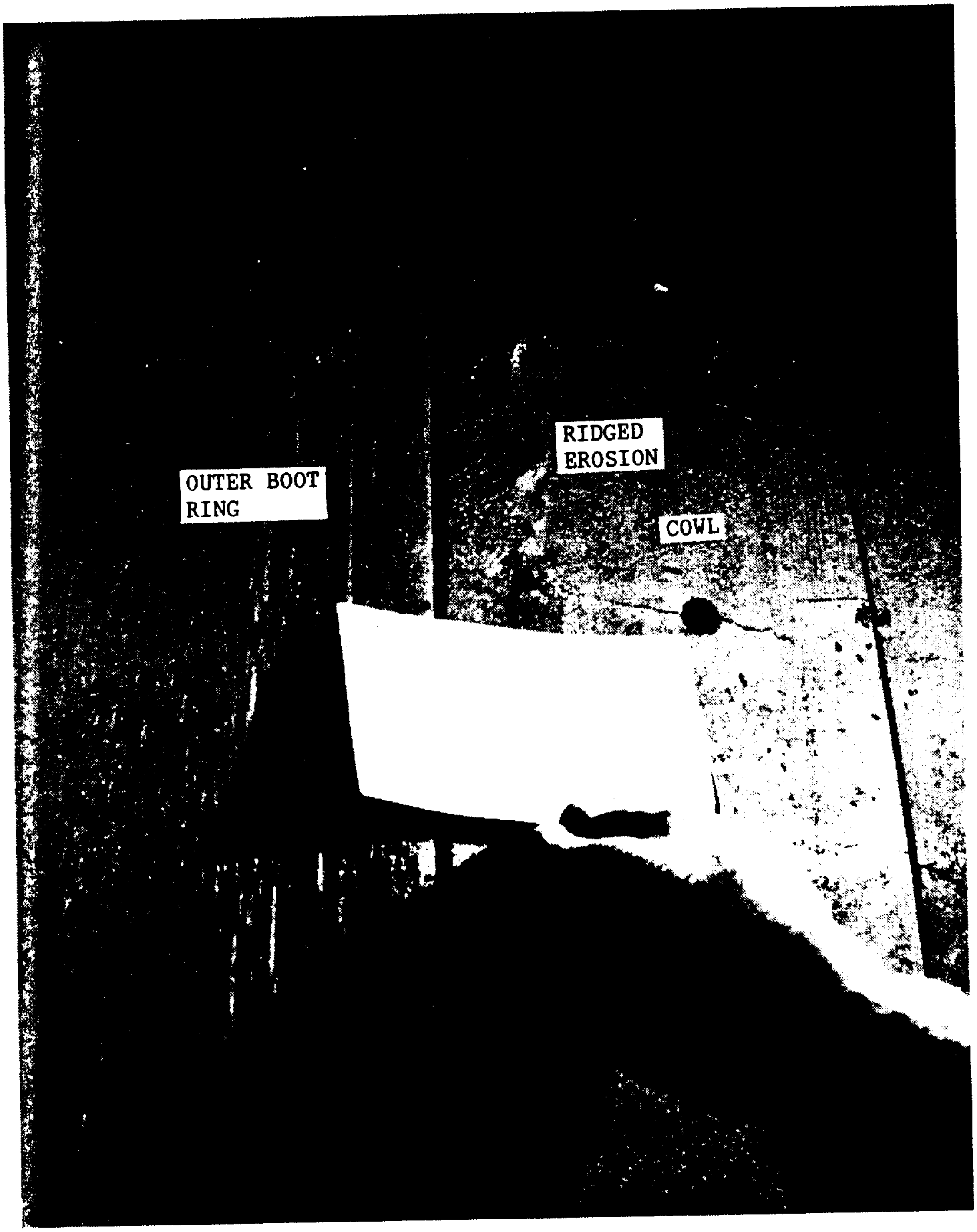

Figure 47 STS-26A Cowl/OBR Closeup (0 Degrees)

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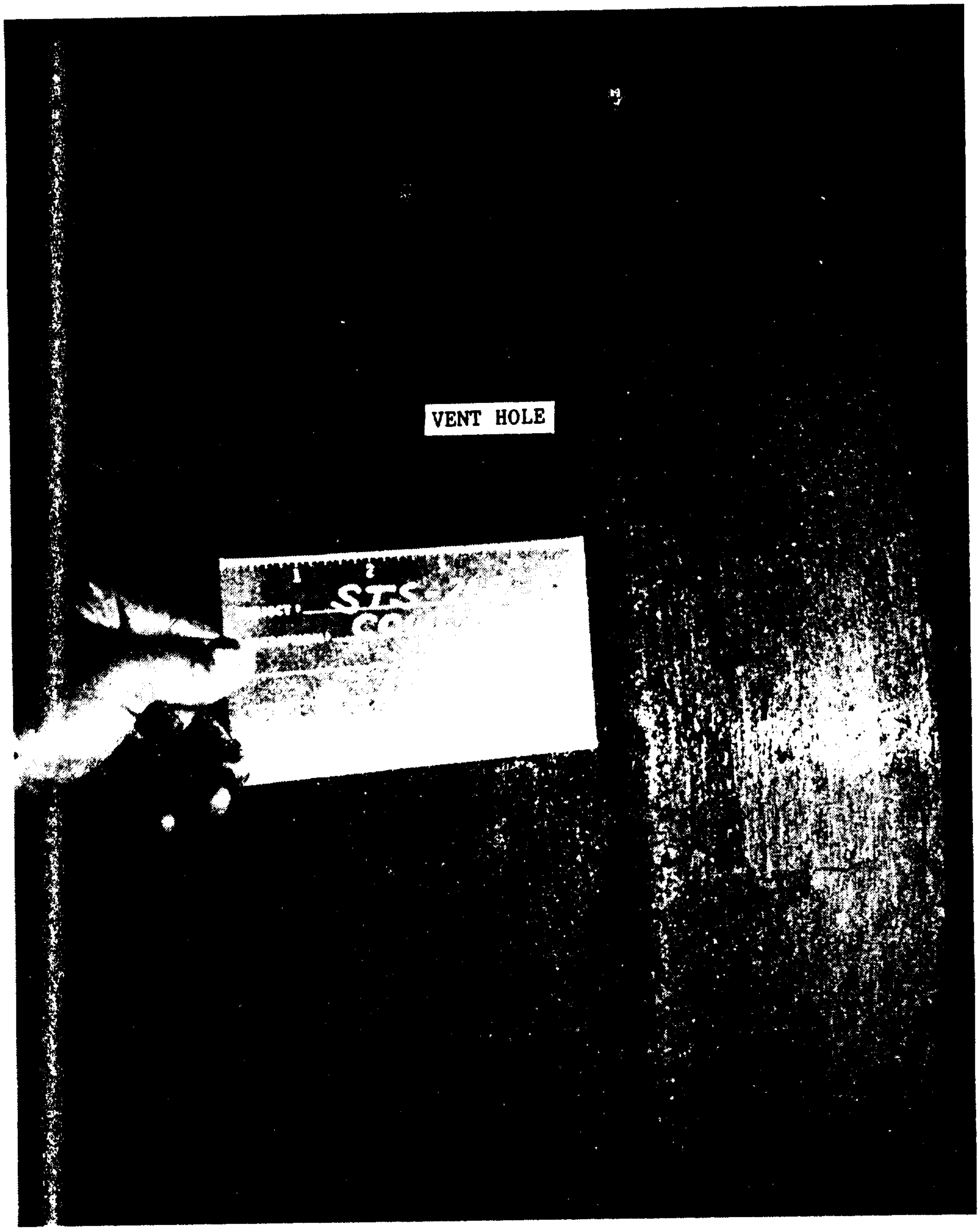

Figure 48 STS-26A Cowl/OBR Closeup (160 Degrees)

Figure 49 STS-26A Cowl/OBR Closeup (180 Degrees)

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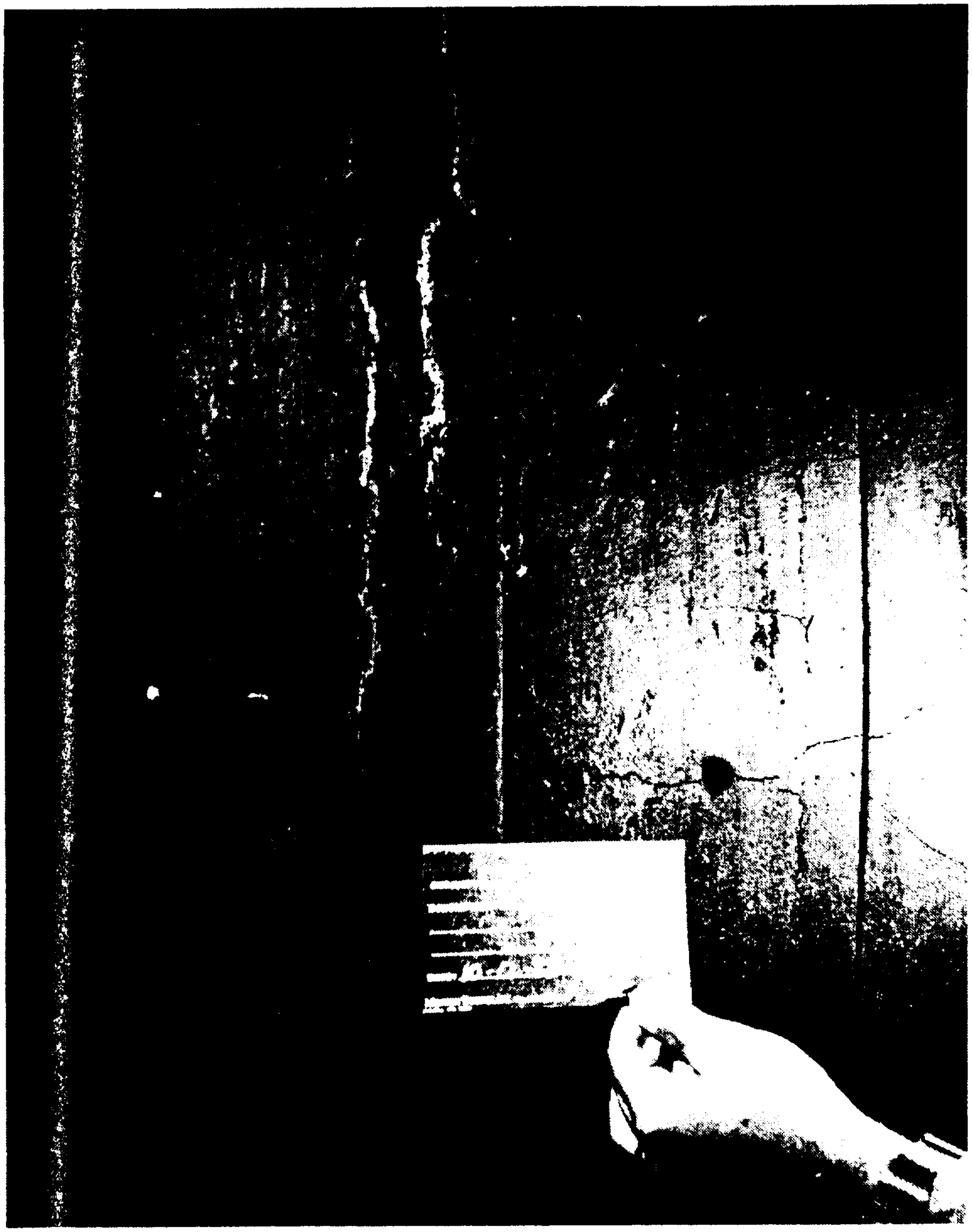

Figure 50 STS-26A Cowl/OBR Closeup (320 Degrees)

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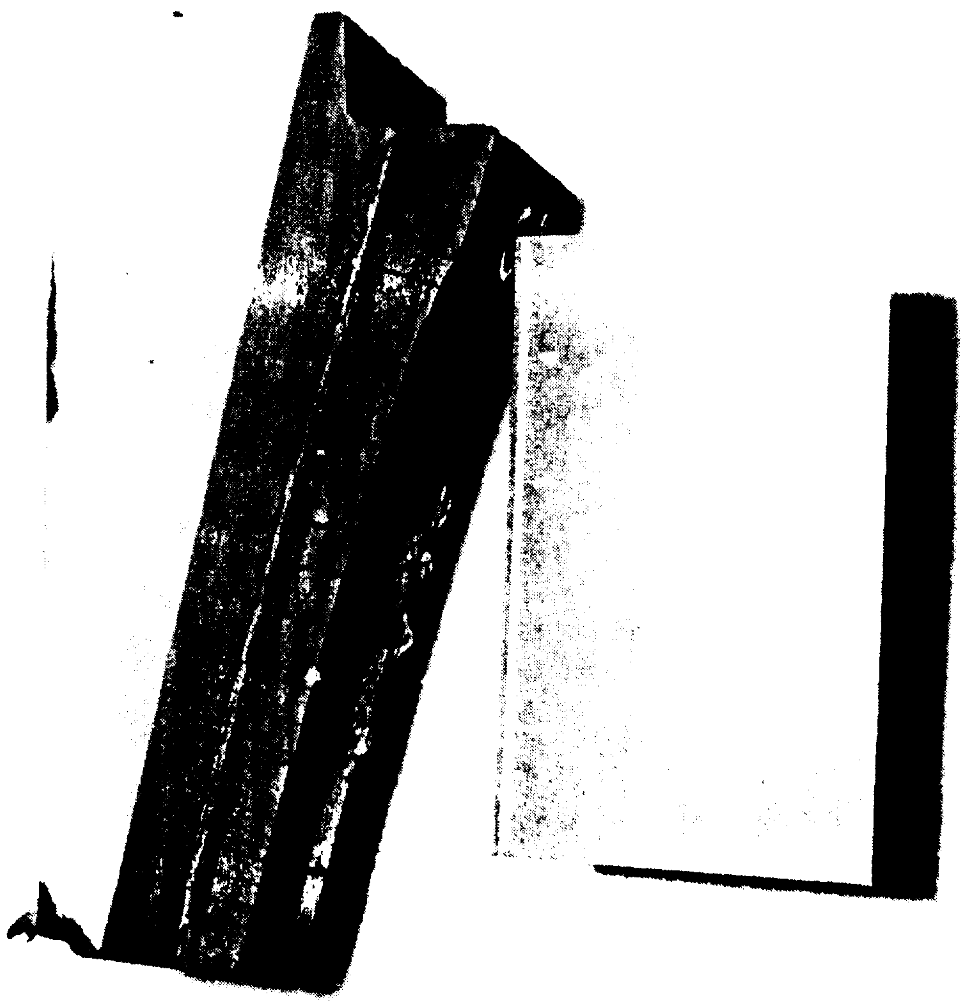

Figure 51 STS-26A Cowl Ring Section (0 Degrees)

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Figure 52 STS-26A Cowl (90 Degrees)

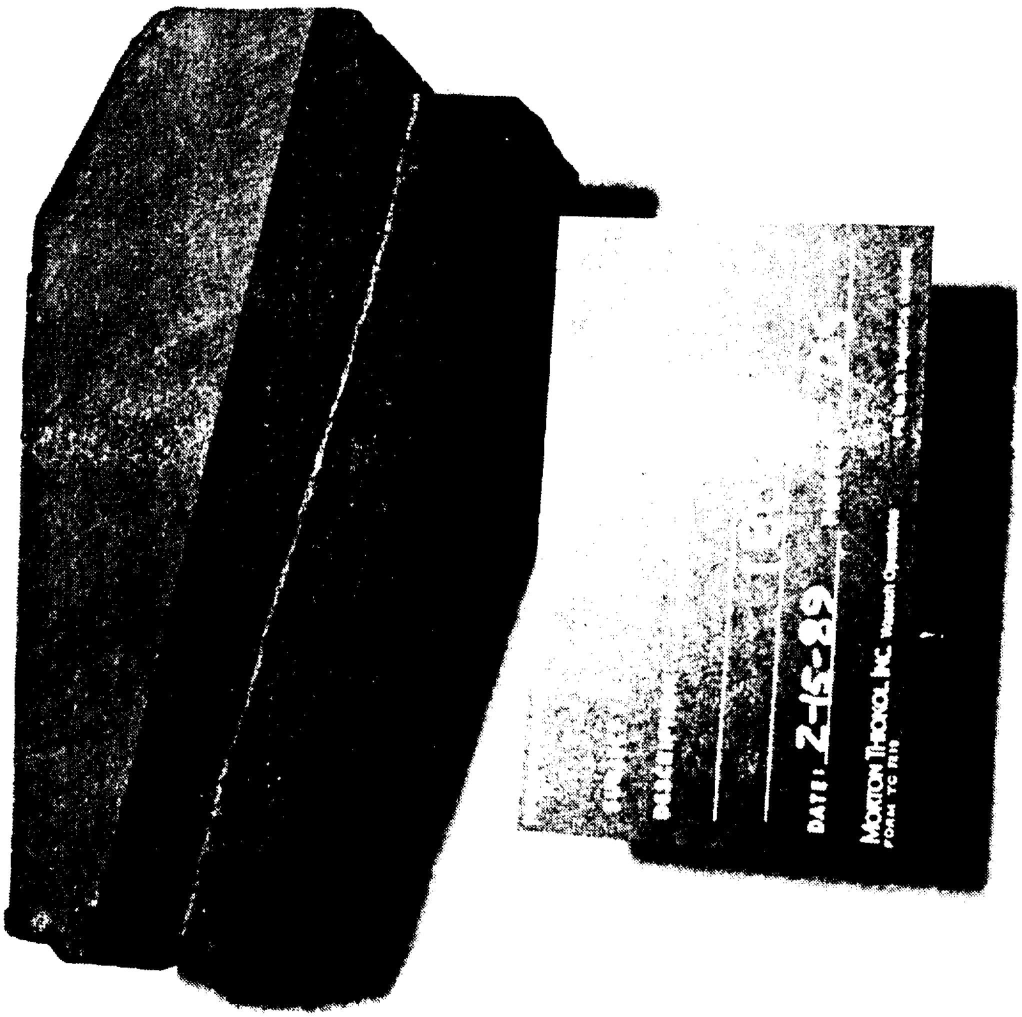

Figure 53 STS-26A Cowl (180 Degrees)

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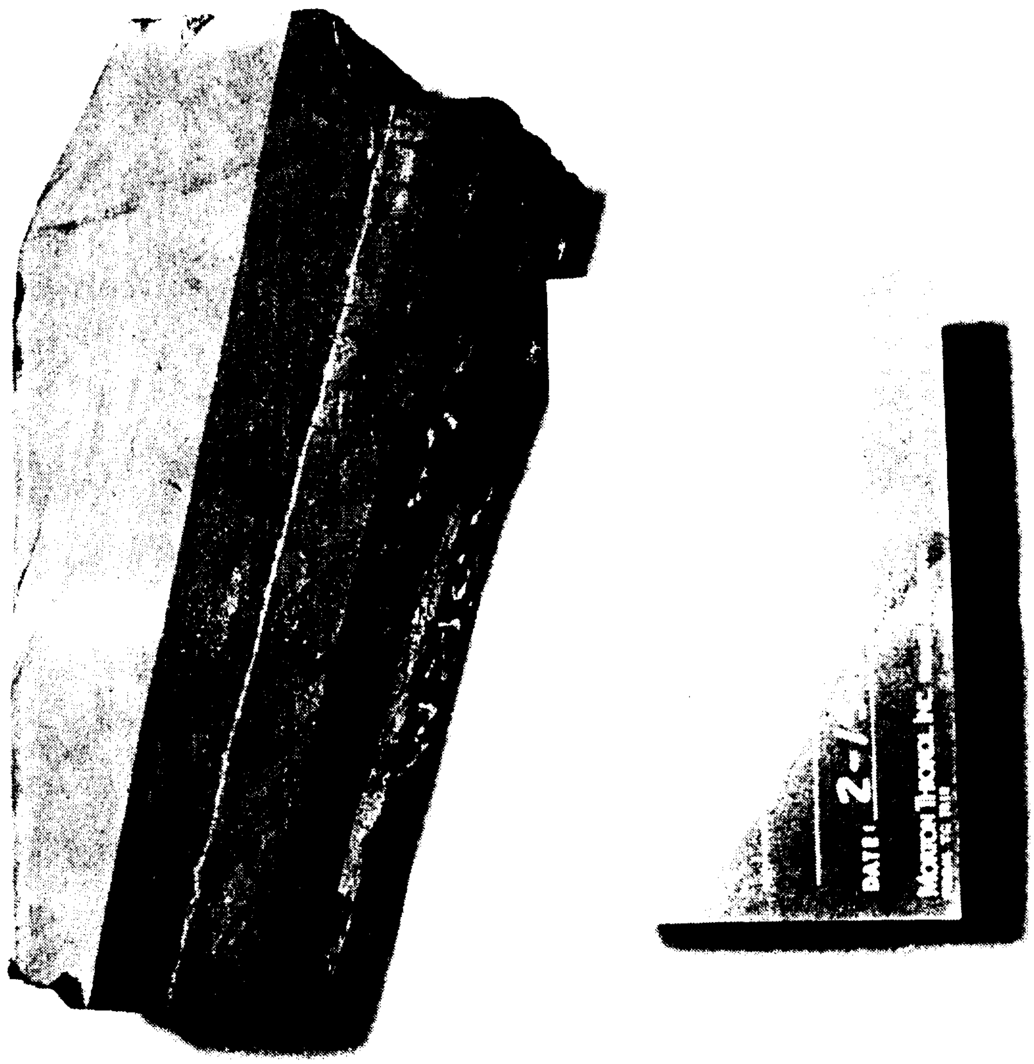

Figure 54 STS-26A Cowl (270 Degrees)

Table 6 STS-26A Cowl/OBR Erosion and Char Data

Angular Location	Stations 0	1	2	3	4	5	6	7	8	9	10	11.3
0 degrees												
Measured Erosion	0.18	0.26	0.29	0.33	0.37	0.37	0.26	0.23	NA	0.03	0.06	0.03
Measured Char	0.57	0.62	0.63	0.65	0.65	0.64	0.80	0.86	NA	0.86	0.85	0.88
Adjusted char *	0.46	0.50	0.50	0.52	0.52	0.51	0.64	0.69	NA	0.69	0.68	0.70
2E + 1.25AC	0.93	1.14	1.21	1.31	1.39	1.38	1.32	1.32	NA	0.92	0.97	0.94
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.52	0.31	0.30	0.26	0.25	0.31	0.43	0.49	NA	0.82	0.74	0.81
20 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.04	0.03	0.08
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.87	0.80	0.80
Adjusted char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.70	0.64	0.64
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.95	0.86	0.96
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.76	0.96	0.78
40 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.00	0.00
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.85	0.90	1.01
Adjusted char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.68	0.72	0.81
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.85	0.90	1.01
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.97	0.87	0.69
55 degrees												
Measured Erosion	0.28	0.26	0.29	0.32	0.33	0.34	0.32	0.20	NA	NA	NA	NA
Measured Char	0.57	0.72	0.68	0.65	0.70	0.71	0.72	0.80	NA	NA	NA	NA
Adjusted char *	0.46	0.58	0.54	0.52	0.56	0.57	0.58	0.64	NA	NA	NA	NA
2E + 1.25AC	1.13	1.24	1.26	1.29	1.36	1.39	1.36	1.20	NA	NA	NA	NA
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.25	0.21	0.25	0.28	0.27	0.30	0.39	0.64	NA	NA	NA	NA
60 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.03	0.03	0.03
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.90	0.87	0.85
Adjusted char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.72	0.70	0.68
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.96	0.93	0.91
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.74	0.81	0.87

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char}^*} - 1$$

Refer to Figure 55 for Station Locations

Table 6 STS-26A Cowl/OBR Erosion and Char Data (continued)

Angular Location	Stations 0	1	2	3	4	5	6	7	8	9	10	11.3
90 degrees												
Measured Erosion	0.26	0.26	0.35	0.35	0.36	0.30	0.22	0.15	NA	0.16	0.11	0.08
Measured Char	0.55	0.59	0.63	0.56	0.53	0.61	0.63	1.00	NA	0.74	0.72	0.72
Adjusted char *	0.44	0.47	0.50	0.45	0.42	0.49	0.50	0.80	NA	0.59	0.58	0.58
2E + 1.25AC	1.07	1.11	1.33	1.26	1.25	1.21	1.07	1.30	NA	1.06	0.94	0.88
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.32	0.35	0.19	0.31	0.39	0.50	0.77	0.51	NA	0.58	0.79	0.94
100 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.09	0.06	0.04
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.83	0.85	0.88
Adjusted char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.66	0.68	0.70
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.01	0.97	0.96
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.66	0.74	0.78
120 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.00	0.00
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.83	0.83	0.81
Adjusted char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.66	0.66	0.65
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.83	0.83	0.81
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.02	1.03	1.10
140 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.00	0.00
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.91	0.86	0.82
Adjusted char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.73	0.69	0.66
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.91	0.86	0.82
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.84	0.96	1.08
160 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.00	0.01
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.82	0.85	0.77
Adjusted char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.66	0.68	0.62
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.82	0.85	0.79
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.04	0.98	1.16

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char}^{*}} - 1$$

Table 6 STS-26A Cowl/OBR Erosion and Char Data (continued)

Angular Location	Stations											
	0	1	2	3	4	5	6	7	8	9	10	11.3
180 degrees												
Measured Erosion	0.42	0.22	0.22	0.26	0.27	0.24	0.22	0.17	NA	0.00	0.00	0.00
Measured Char	0.28	0.52	0.60	0.57	0.58	0.63	0.70	0.82	NA	0.82	0.74	0.76
Adjusted char *	0.22	0.42	0.48	0.46	0.46	0.50	0.56	0.66	NA	0.66	0.59	0.61
2E + 1.25AC	1.12	0.96	1.04	1.09	1.12	1.11	1.14	1.16	NA	0.82	0.74	0.76
RSRM Min Liner Thickness	1.417	1.499	1.577	..655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.27	0.56	0.52	0.52	0.55	0.63	0.66	0.69	NA	1.04	1.28	1.24
200 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.03	0.07	0.00
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.84	0.82	0.81
Adjusted char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.67	0.66	0.65
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.90	0.96	0.81
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.86	0.76	1.10
210 degrees												
Measured Erosion	0.18	0.26	0.24	0.24	0.23	0.20	0.21	0.17	NA	NA	NA	NA
Measured Char	0.57	0.62	0.70	0.70	0.70	0.77	0.74	0.66	NA	NA	NA	NA
Adjusted char *	0.46	0.50	0.56	0.56	0.56	0.62	0.59	0.53	NA	NA	NA	NA
2E + 1.25AC	0.93	1.14	1.18	1.18	1.16	1.17	1.16	1.00	NA	NA	NA	NA
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.52	0.31	0.34	0.40	0.49	0.55	0.63	0.96	NA	NA	NA	NA
220 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.03	0.04
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.94	0.90	0.88
Adjusted char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.75	0.72	0.70
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.94	0.96	0.96
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.78	0.76	0.78
240 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.06	0.04	0.02
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.82	0.83	0.87
Adjusted char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.66	0.66	0.70
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.94	0.91	0.91
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.78	0.85	0.87

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char}^*} - 1$$

Table 6 STS-26A Cowl/OBR Erosion and Char Data (continued)

Angular Location	Stations											
270 degrees	0	1	2	3	4	5	6	7	8	9	10	11.3
Measured Erosion	0.19	0.22	0.23	0.27	0.32	0.20	0.16	0.19	NA	0.03	0.03	0.03
Measured Char	0.62	0.57	0.63	0.63	0.60	0.70	0.80	0.80	NA	0.94	0.96	0.95
Adjusted char *	0.50	0.46	0.50	0.50	0.48	0.56	0.64	0.64	NA	0.75	0.77	0.76
2E + 1.25AC	1.00	1.01	1.09	1.17	1.24	1.10	1.12	1.18	NA	1.00	1.02	1.01
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.42	0.48	0.45	0.41	0.40	0.65	0.69	0.66	NA	0.68	0.65	0.69
280 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.00	0.00
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.89	0.83	0.85
Adjusted char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.71	0.66	0.68
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.89	0.83	0.85
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.88	1.03	1.00
300 degrees												
Measured Erosion	0.16	0.22	0.24	0.30	0.31	0.19	0.15	0.17	NA	0.01	0.02	0.01
Measured Char	0.60	0.64	0.66	0.63	0.66	0.76	0.78	0.82	NA	0.80	0.81	0.81
Adjusted char *	0.48	0.51	0.53	0.50	0.53	0.61	0.62	0.66	NA	0.64	0.65	0.65
2E + 1.25AC	0.92	1.08	1.14	1.23	1.28	1.14	1.08	1.16	NA	0.82	0.85	0.83
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.54	0.39	0.38	0.35	0.35	0.59	0.75	0.69	NA	1.04	0.98	1.05

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

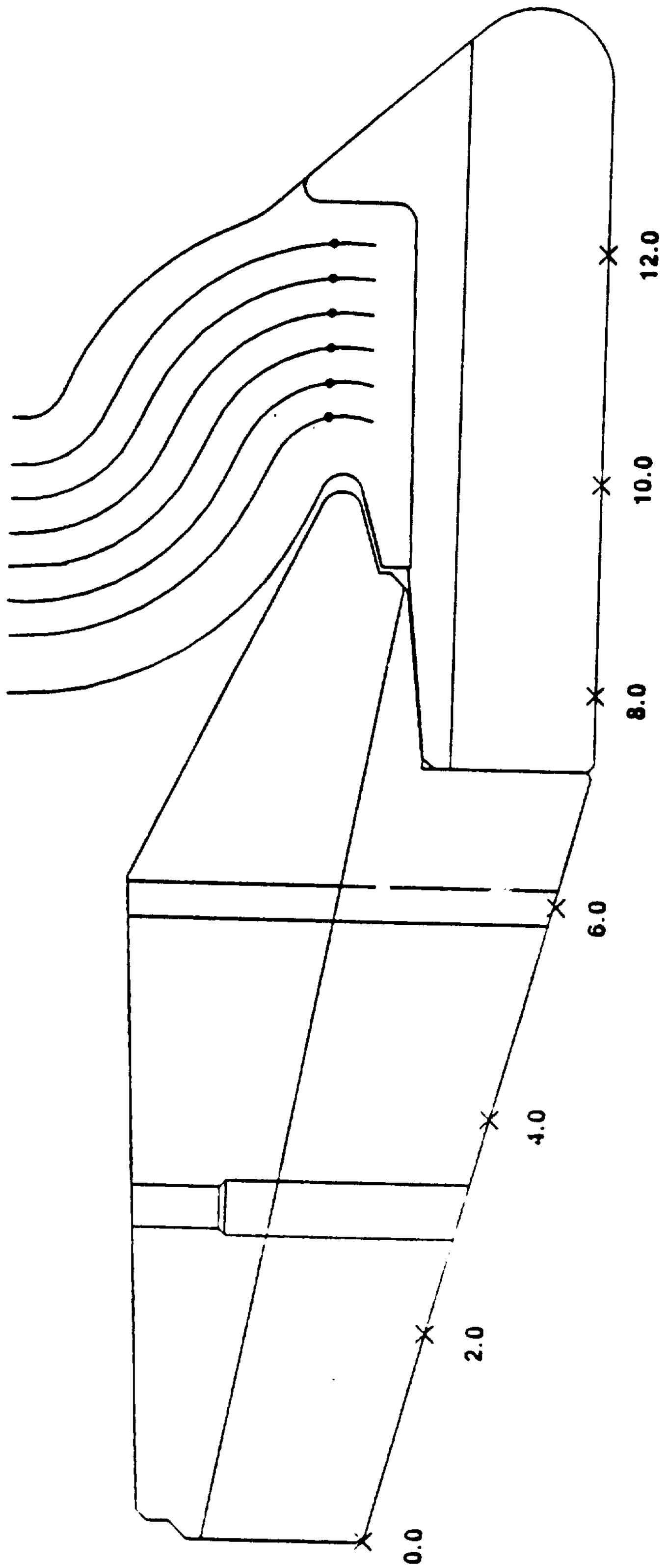

Figure 55 Cowl Ring and Outer Boot Ring Erosion Measurement Stations

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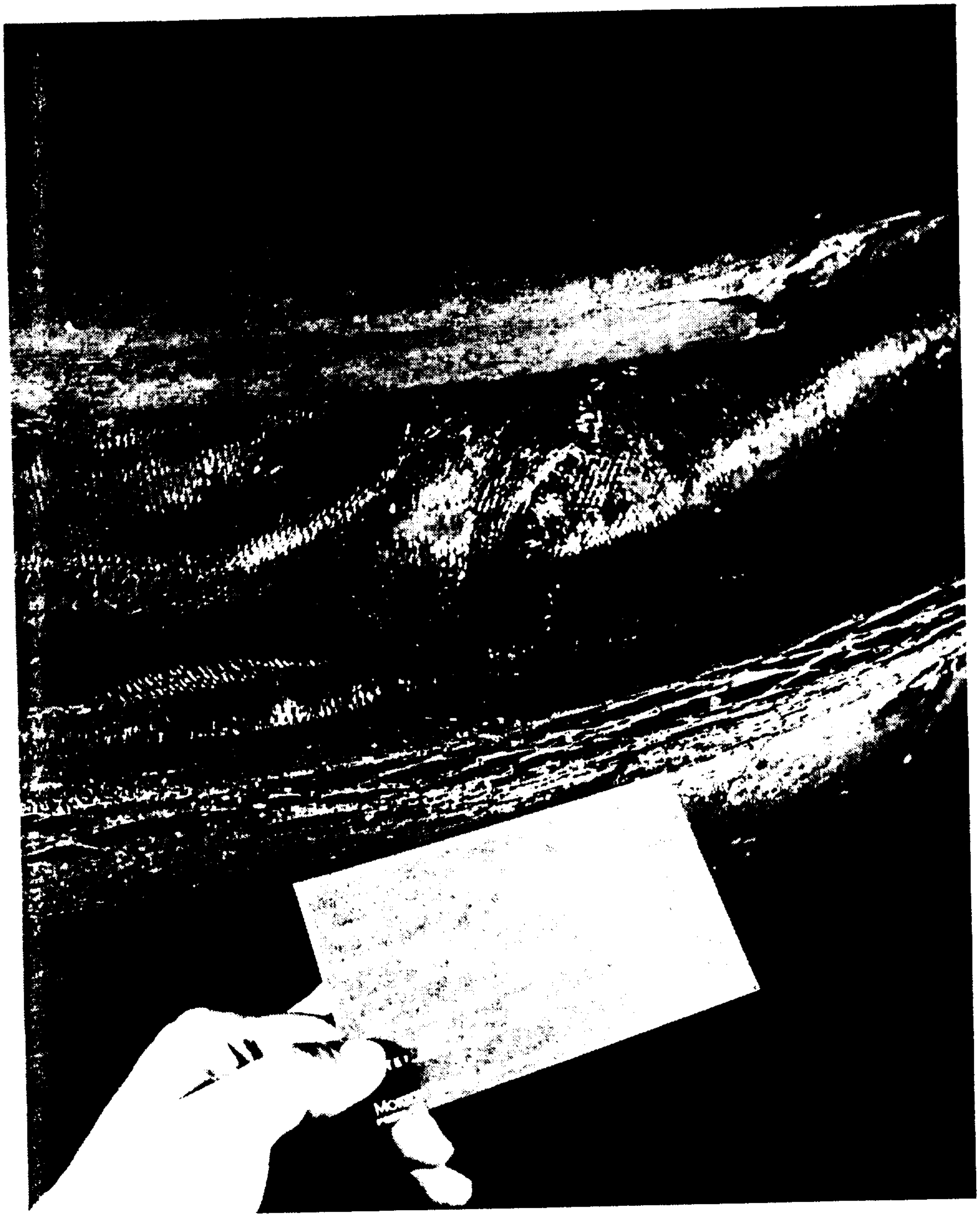

Figure 56   STS-26A OBR Aft End Delaminations (260 Degrees)

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Figure 57 STS-26A Fractured OBR Aft Tip Adjacent to Flex Boot

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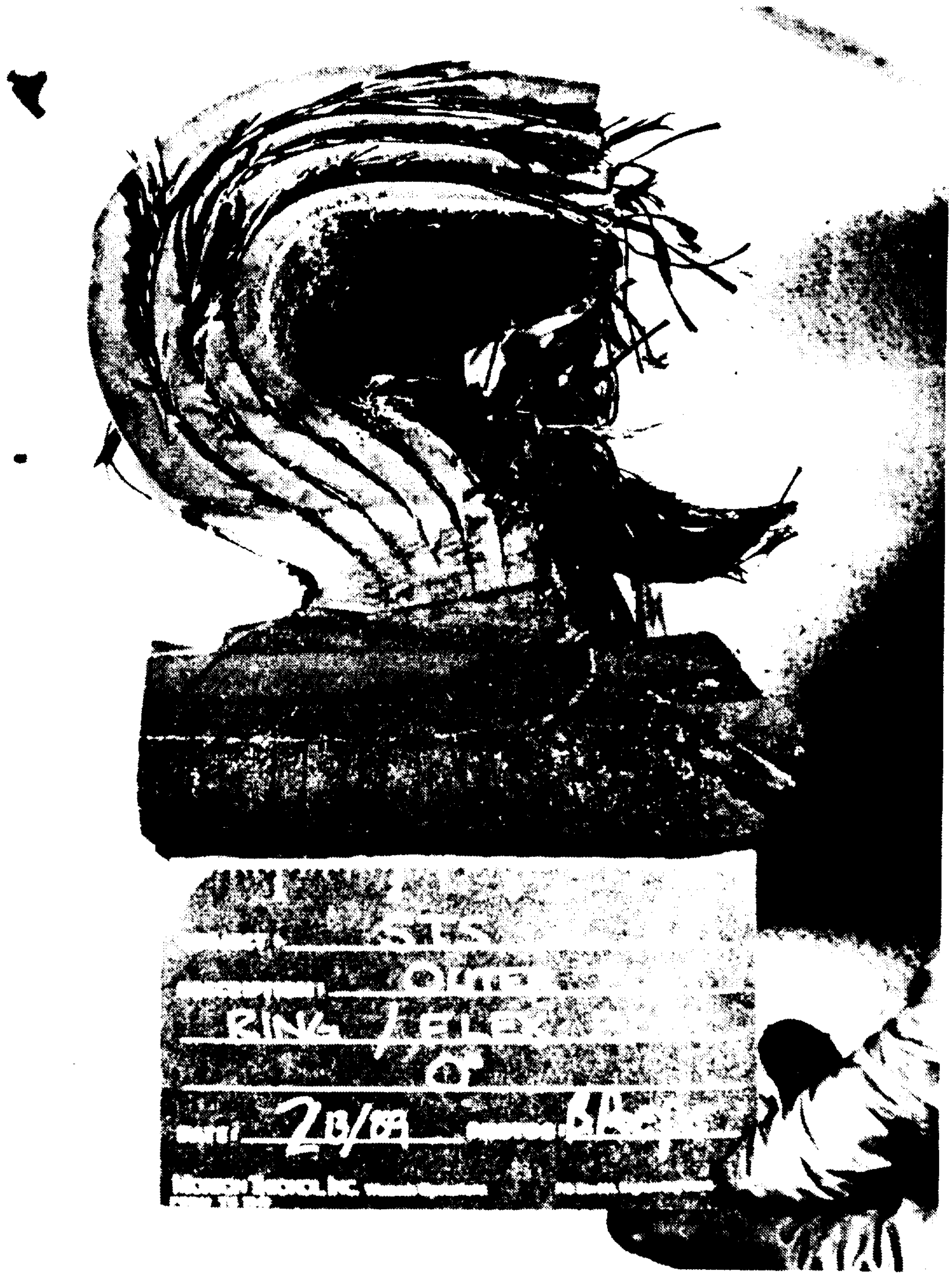

Figure 58 STS-26A Outer Boot Ring Section (0 Degrees)

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Figure 59 STS-26A Outer Boot Ring/Flex Boot (90 Degrees)

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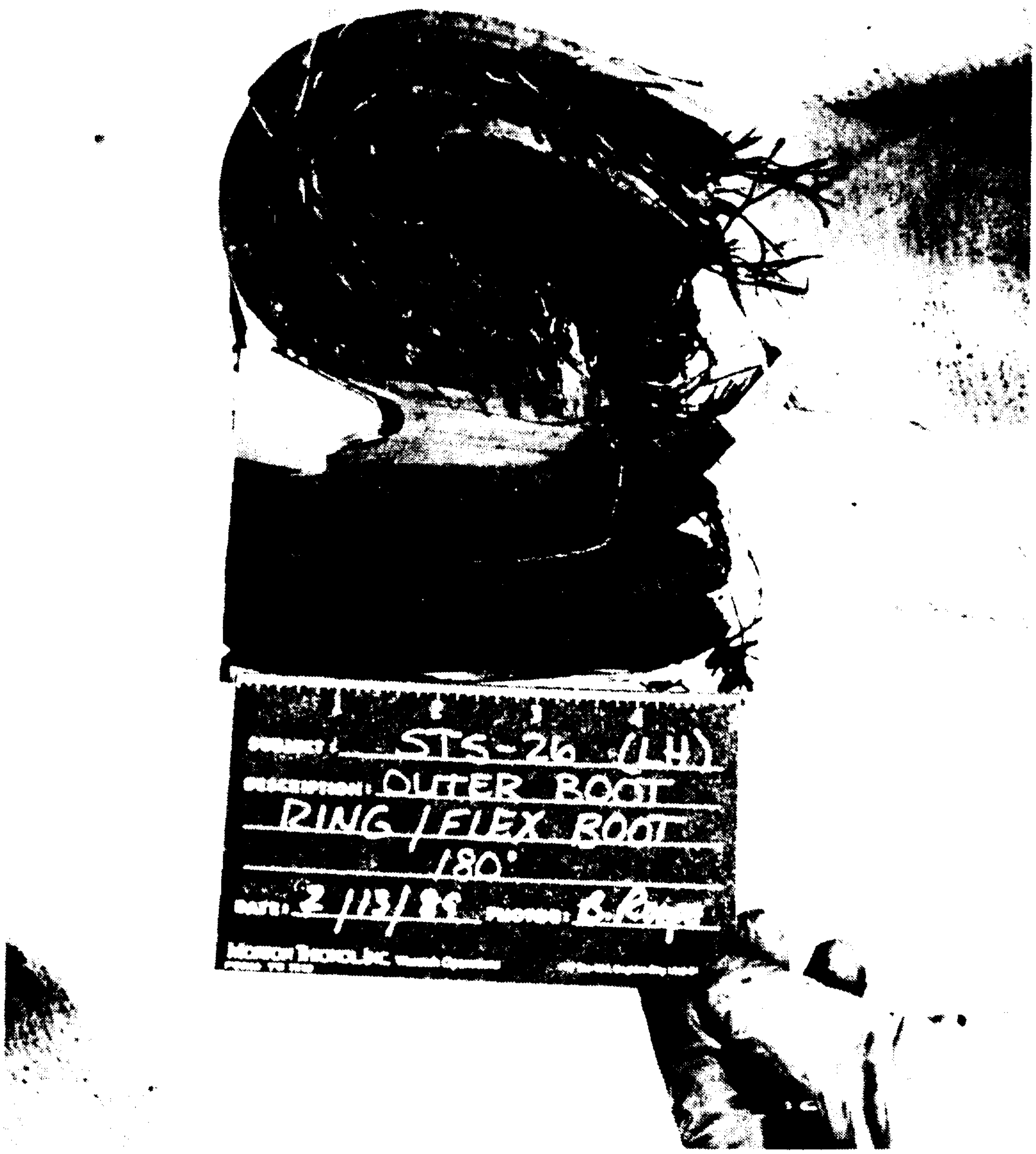

Figure 60 STS-26A Outer Boot Ring/Flex Boot (180 Degrees)

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Figure 61 STS-26A Outer Boot Ring/Flex Boot (280 Degrees)

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Figure 62 STS-26A Flex Boot (Cavity Side - 0 Degrees)

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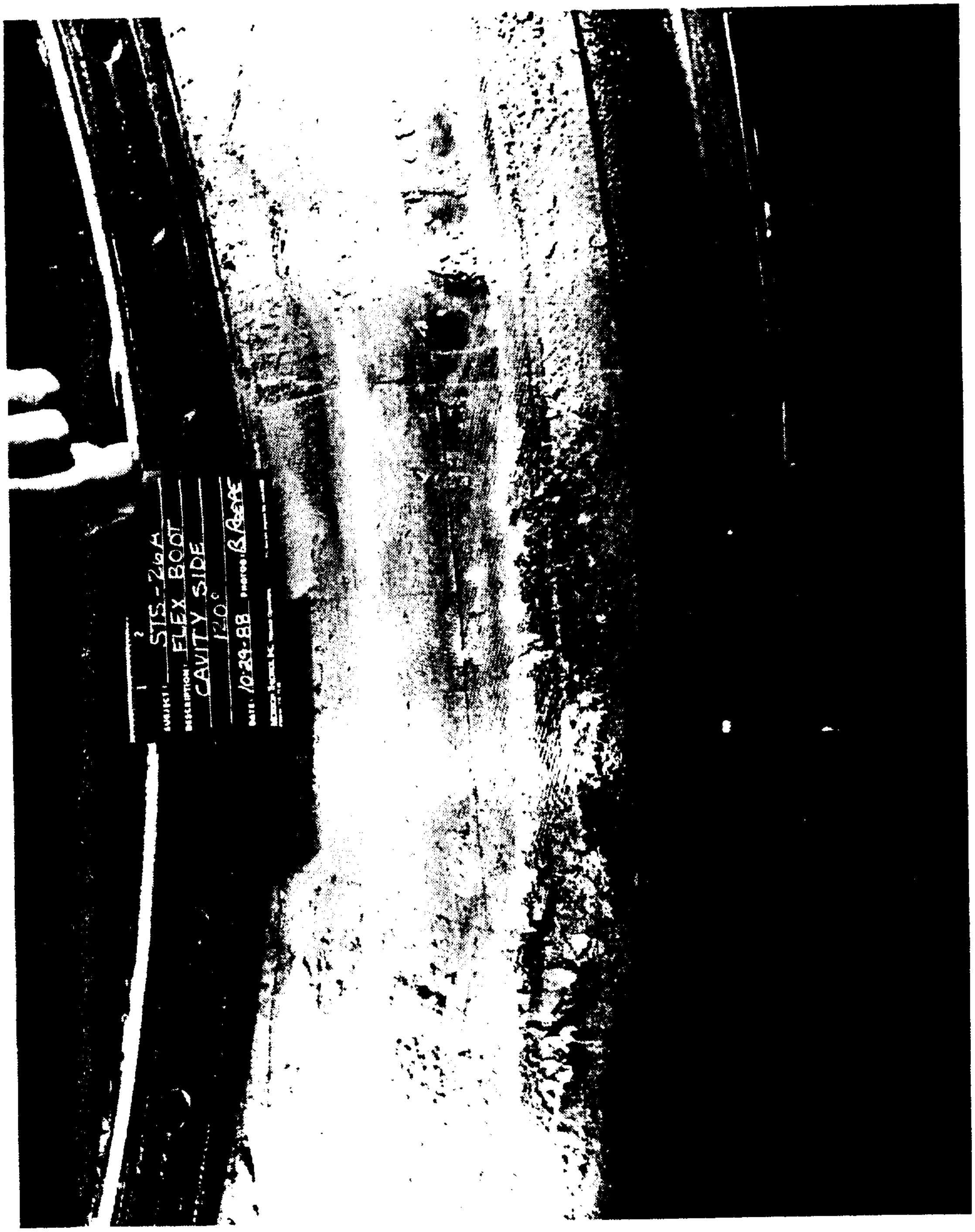

Figure 63 STS-26A Flex Boot (Cavity Side - 120 Degrees)

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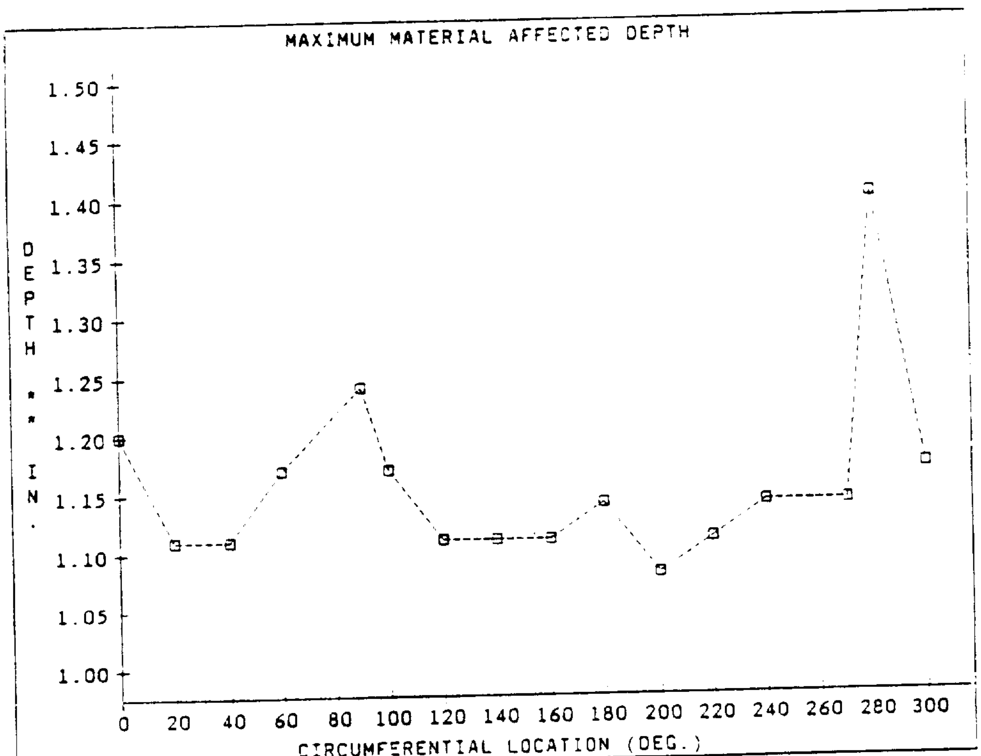
Figure 64 STS-26A Flex Boot (Cavity Side - 240 Degrees)

Table 7 STS-26A Flex Boot Data Performance Margins of Safety

Degree Location	Remaining Plies	Max Material Affected Depth (in.)	Margin of Safety*
0	3.6	1.20	0.39
20	3.9	1.11	0.50
40	3.9	1.11	0.50
60	3.7	1.17	0.42
90	3.5	1.24	0.34
100	3.7	1.17	0.42
120	3.9	1.11	0.50
140	3.9	1.11	0.50
160	3.9	1.11	0.50
180	3.8	1.14	0.46
200	4.0	1.08	0.54
220	3.9	1.11	0.50
240	3.8	1.14	0.46
270	3.8	1.14	0.46
280	3.0	1.40	0.19
300	3.7	1.17	0.42

$$* \text{ PMS} = \frac{\text{minimum overall thickness}}{(1.5 \times \text{max material affected depth})} - 1$$



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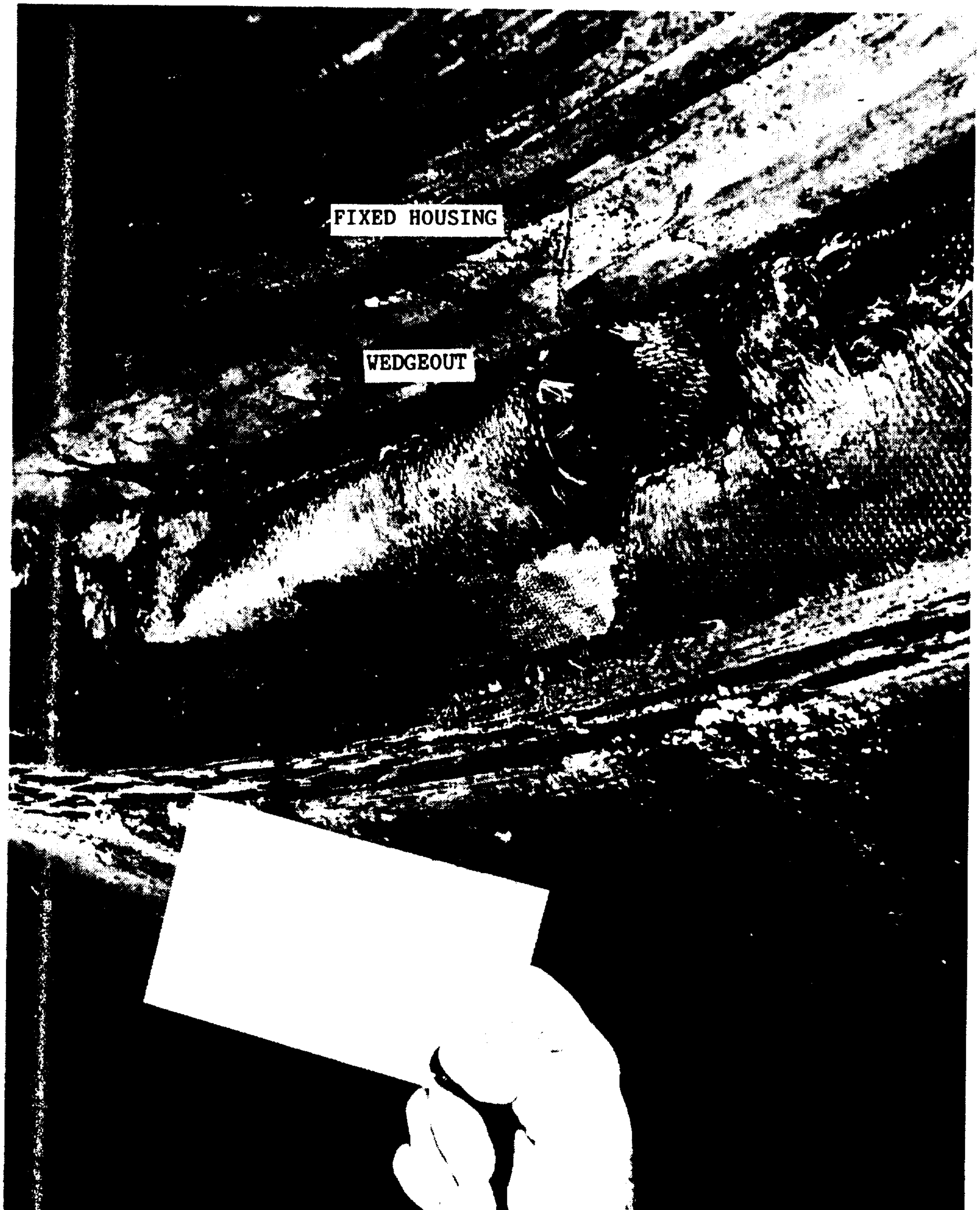

Figure 65 STS-26A Fixed Housing Wedgeout (280 Degrees)

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Figure 66 STS-26A Fixed Housing Section (0 Degrees)

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Figure 67 STS-26A Fixed Housing Section (90 Degrees)

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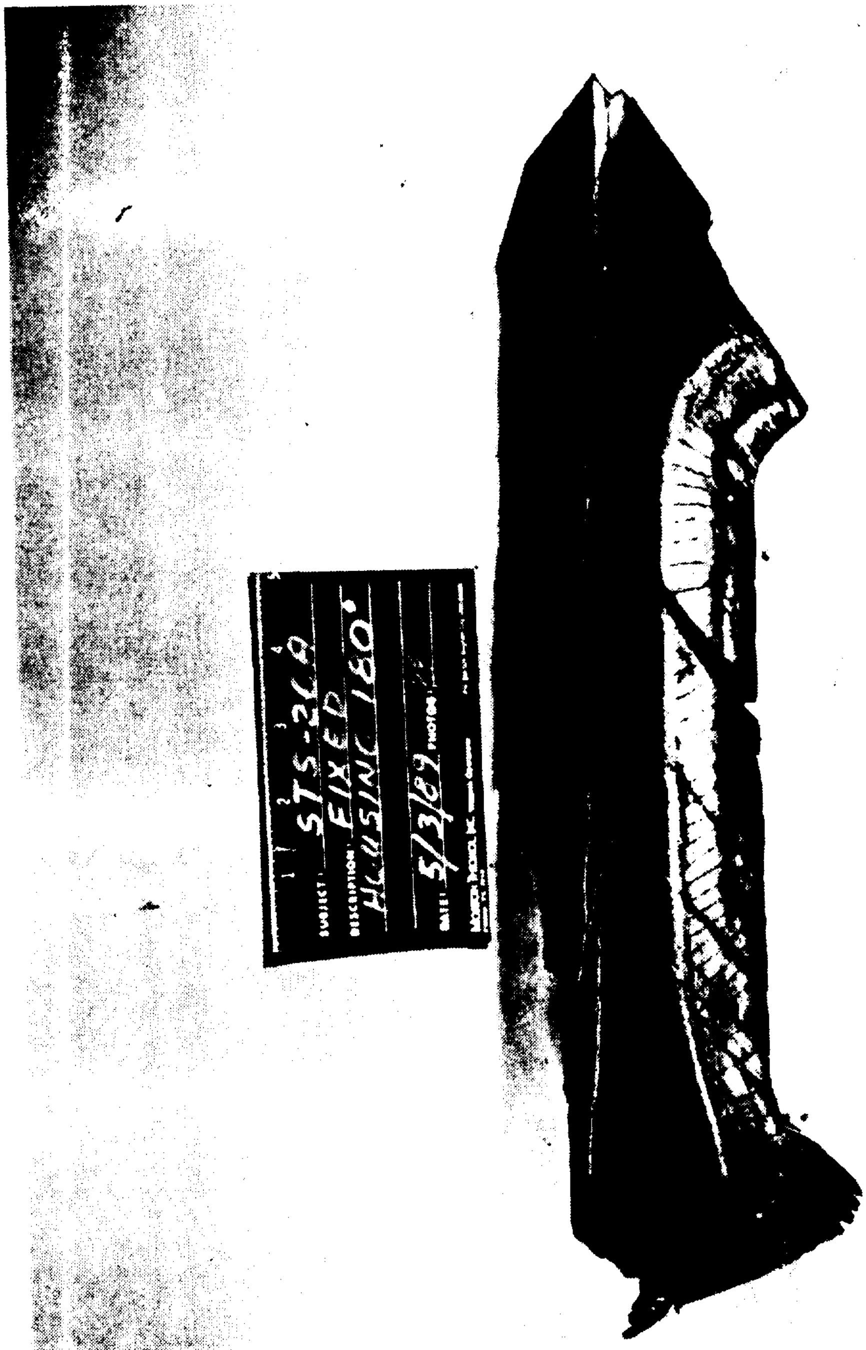

Figure 68 STS-26A Fixed Housing Section (180 Degrees)

Figure 69 STS-26A Fixed Housing Section (270 Degrees)

Table 8 STS-26A Fixed Housing Insulation Erosion and Char Data

Angular Location	Stations 0	1	2	3	4	5	6	7	8	9	11
0 degrees											
Measured Erosion	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Measured Char	1.35	1.25	1.11	1.05	1.01	1.01	0.98	0.99	0.90	1.06	1.90
Adjusted Char*	1.08	1.00	0.89	0.84	0.81	0.81	0.78	0.79	0.72	0.85	1.52
2E + 1.25AC	1.43	1.31	1.11	1.05	1.01	1.01	0.98	0.99	0.90	1.06	1.96
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	1.66	0.59	0.64	0.74	0.81	0.81	0.87	0.85	1.04	1.29	0.56
90 degrees											
Measured Erosion	0.03	0.01	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.00
Measured Char	1.20	1.21	1.06	1.05	1.03	1.07	1.02	1.00	0.82	0.92	1.91
Adjusted Char*	0.96	0.97	0.85	0.84	0.82	0.86	0.82	0.80	0.66	0.74	1.53
2E + 1.25AC	1.26	1.23	1.14	1.05	1.03	1.07	1.06	1.00	0.82	0.94	1.91
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	2.02	0.69	0.60	0.74	0.78	0.71	0.73	0.83	1.24	1.58	0.60
180 degrees											
Measured Erosion	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Measured Char	1.18	1.17	1.14	1.12	1.08	1.06	1.05	0.99	0.86	0.75	1.63
Adjusted Char*	0.94	0.94	0.91	0.90	0.86	0.85	0.84	0.79	0.69	0.60	1.30
2E + 1.25AC	1.26	1.17	1.14	1.12	1.08	1.06	1.05	0.99	0.86	0.75	1.63
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	2.02	0.78	0.60	0.63	0.69	0.73	0.74	0.85	1.13	2.23	0.87
270 degrees											
Measured Erosion	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA
Measured Char	1.20	1.10	1.07	1.11	1.11	1.05	1.09	1.05	0.95	NA	NA
Adjusted Char*	0.96	0.88	0.86	0.89	0.89	0.84	0.87	0.84	0.76	NA	NA
2E + 1.25AC	1.28	1.16	1.07	1.11	1.11	1.05	1.09	1.05	0.95	NA	NA
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	1.97	0.79	0.71	0.65	0.65	0.74	0.68	0.75	0.93	NA	NA

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{Erosion} + 1.25 \times \text{Adj Char*}} - 1$$

Refer to Figure 70 for Station Locations

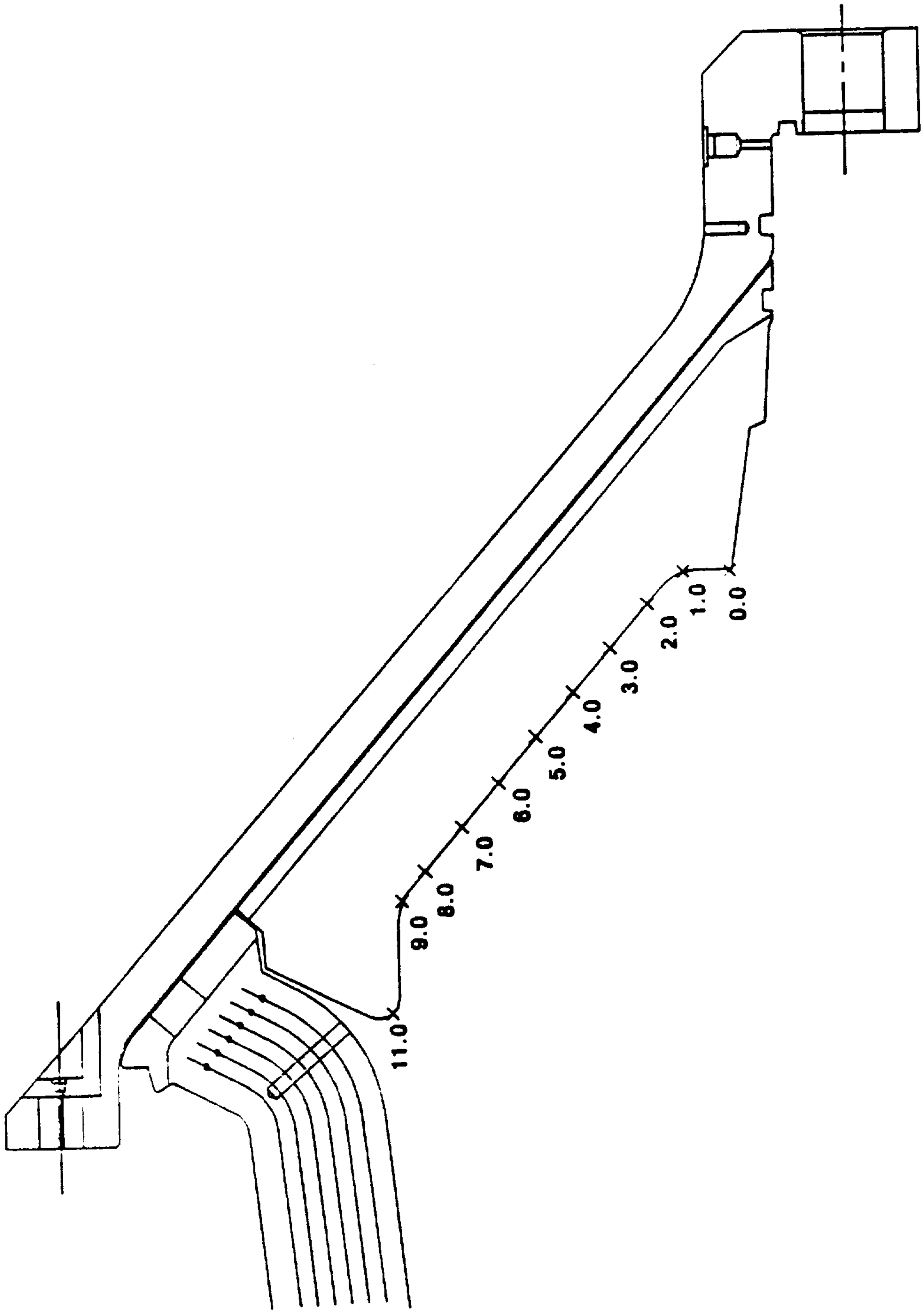

Figure 70 Fixed Housing Liner Erosion Measurement Station

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Figure 71 STS-26A Bearing Protector (0 Degrees)

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Figure 72 STS-26A Bearing Protector (120 Degrees)

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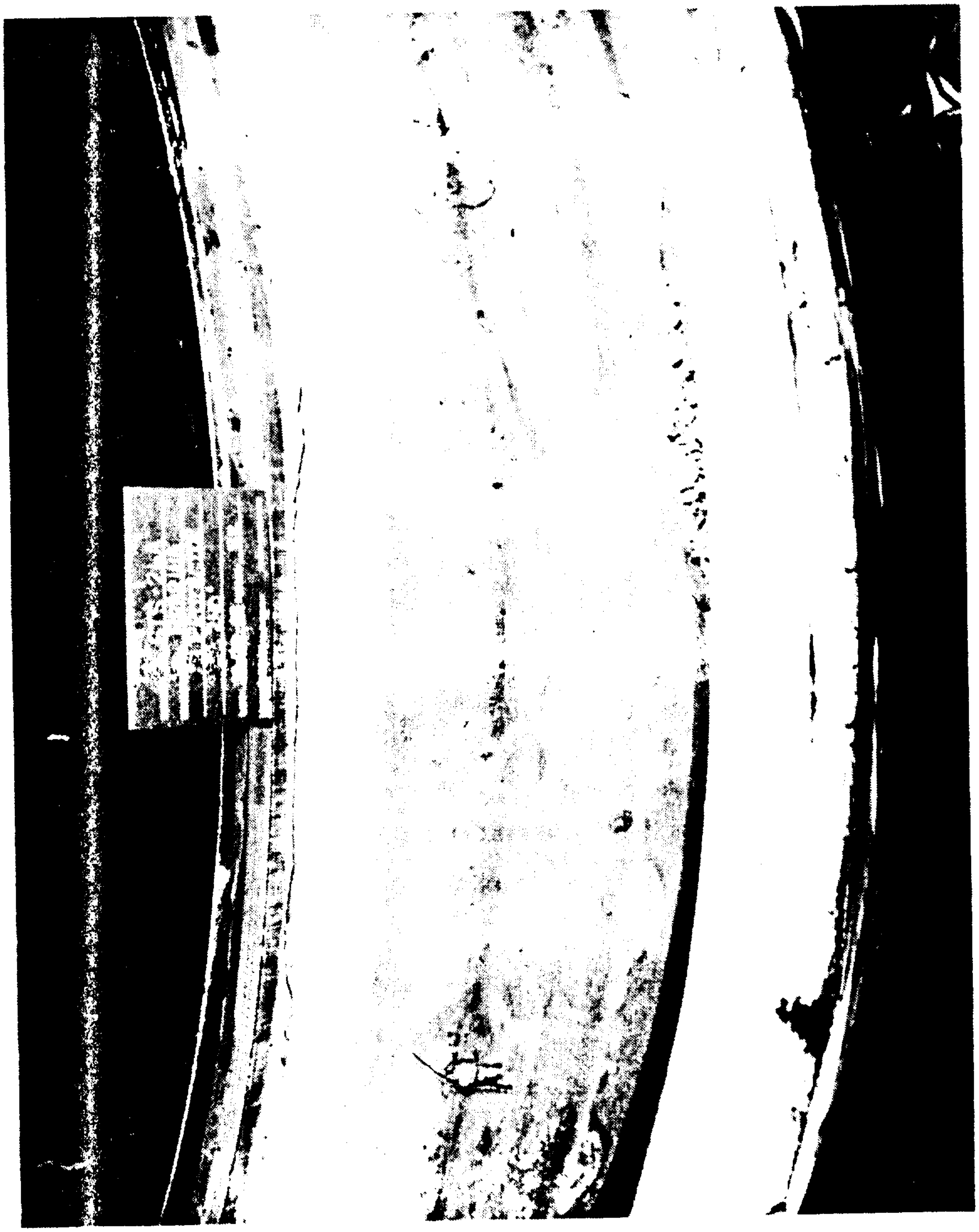

Figure 73 STS-26A Bearing Protector (240 Degrees)

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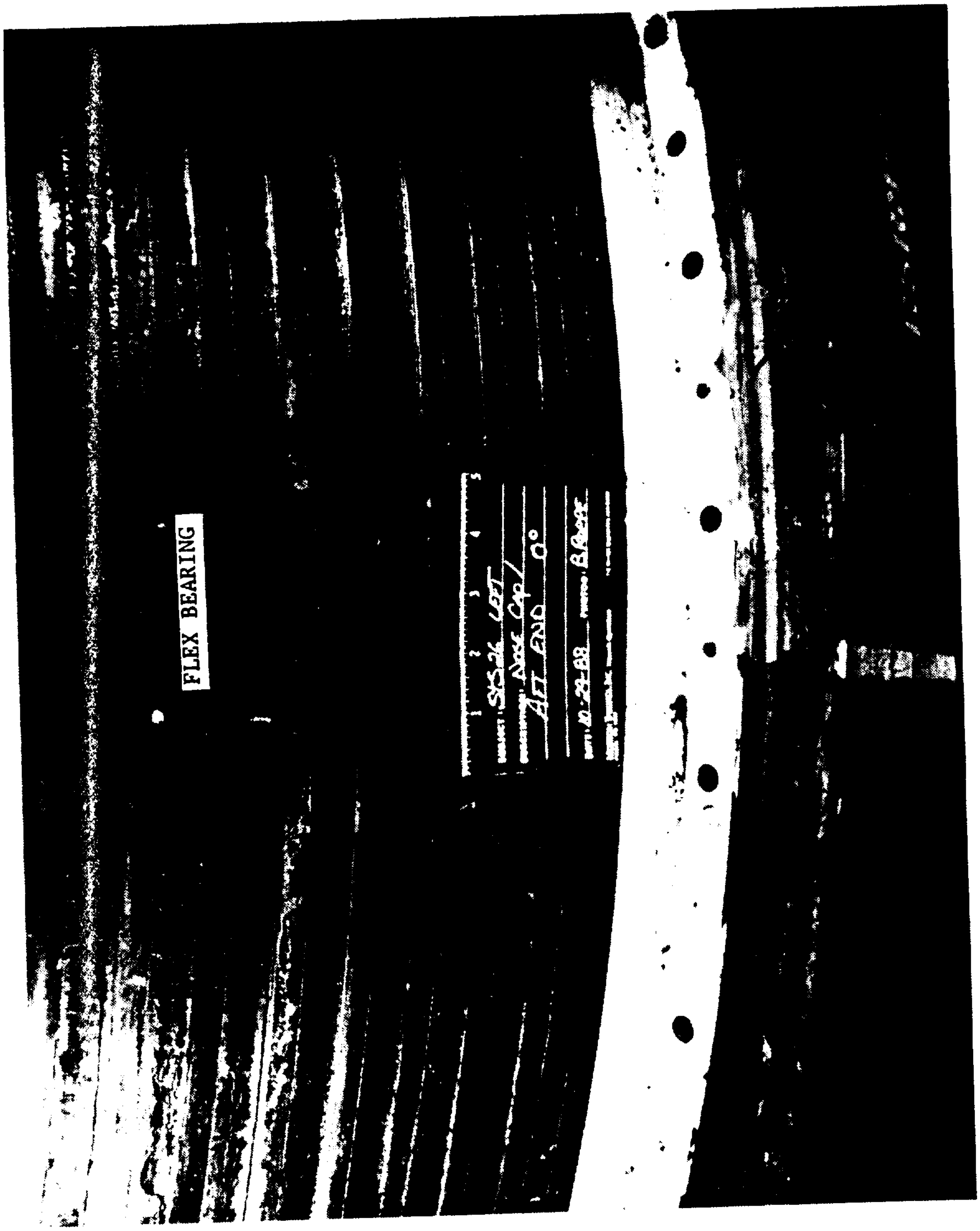

Figure 74 STS-26A Flex Bearing (0 Degrees)

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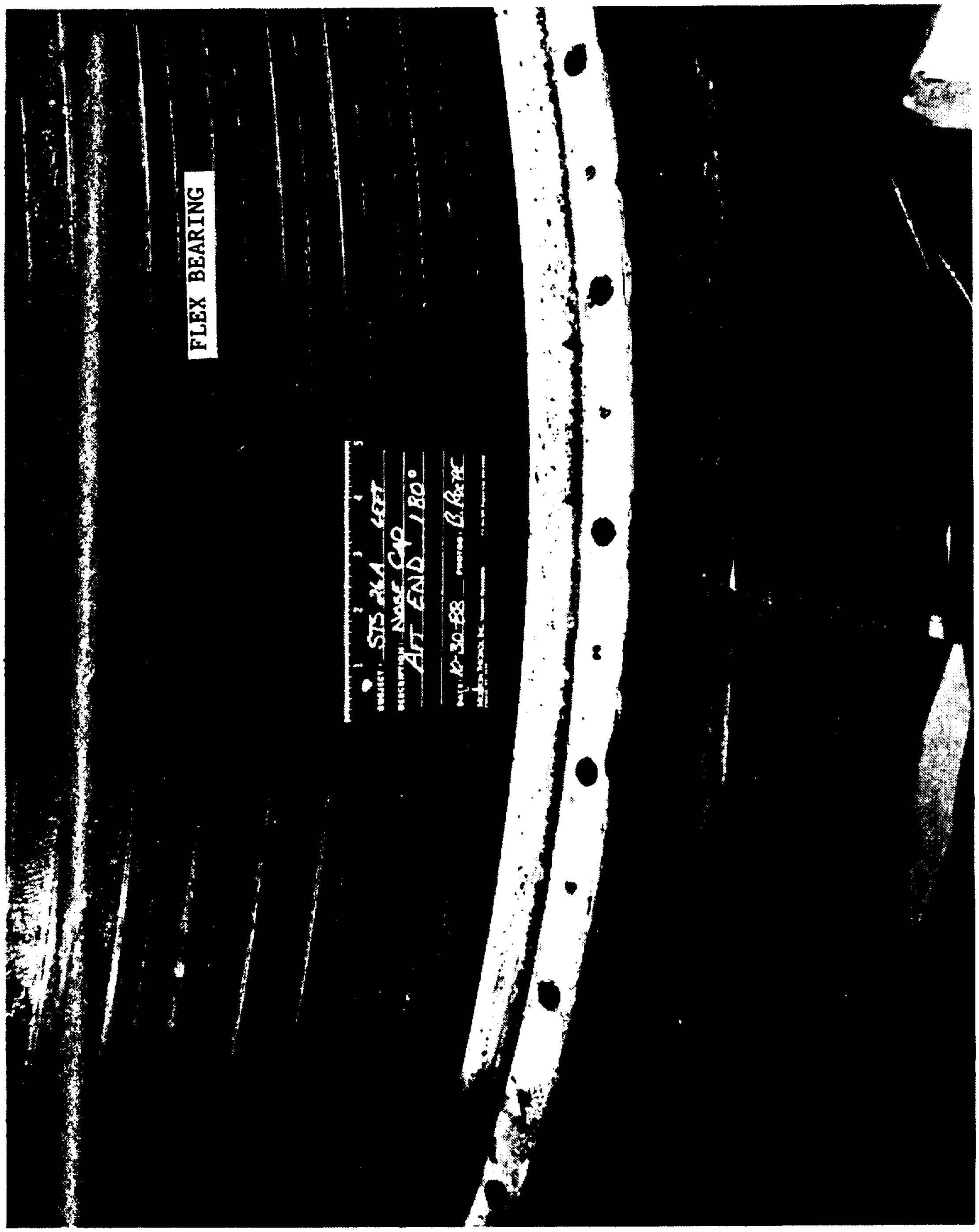

Figure 75 STS-26A Flex Bearing (180 Degrees)

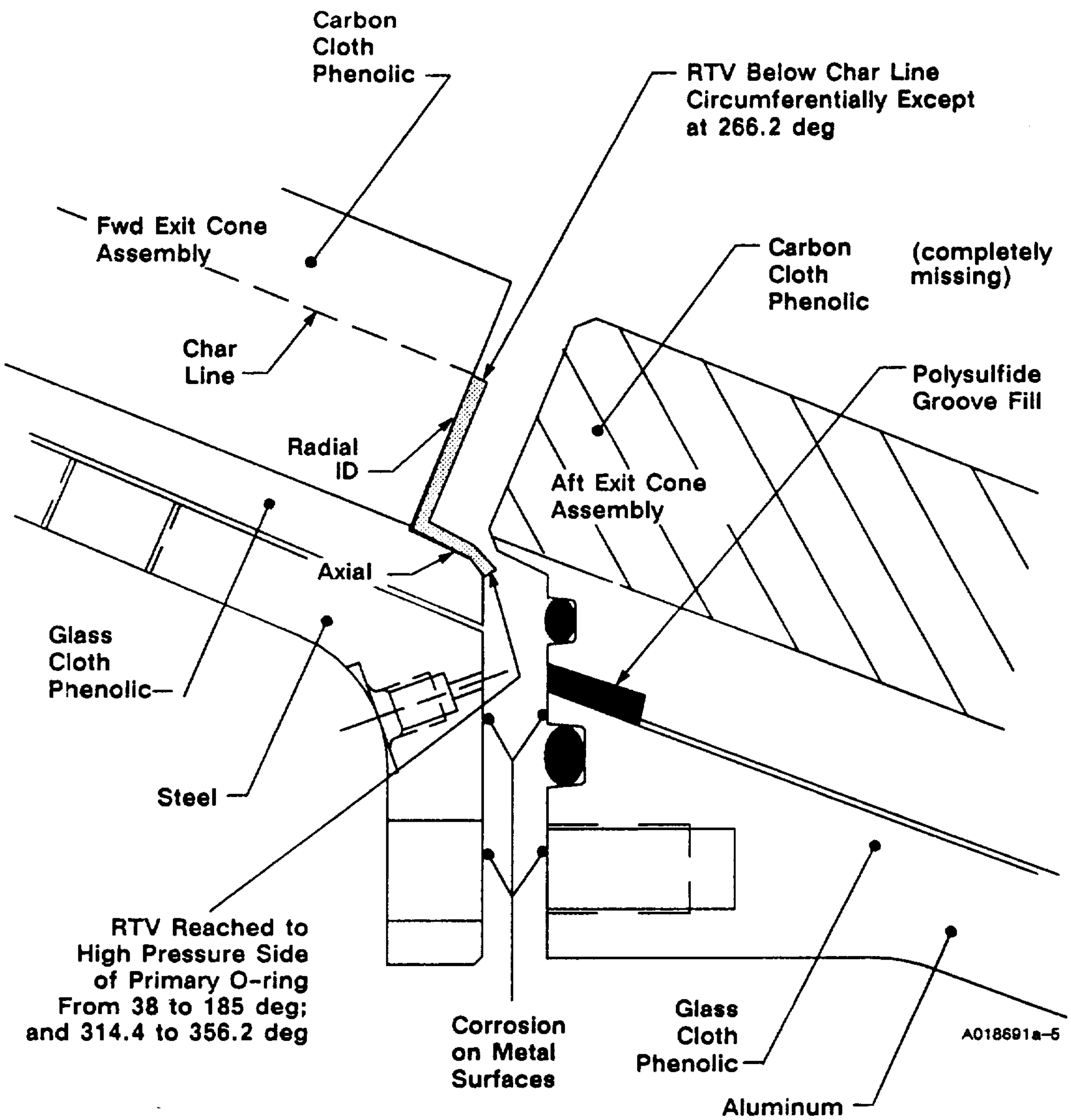

Figure 76 STS-26A—Forward Exit Cone-to-Aft Exit Cone Joint Interface

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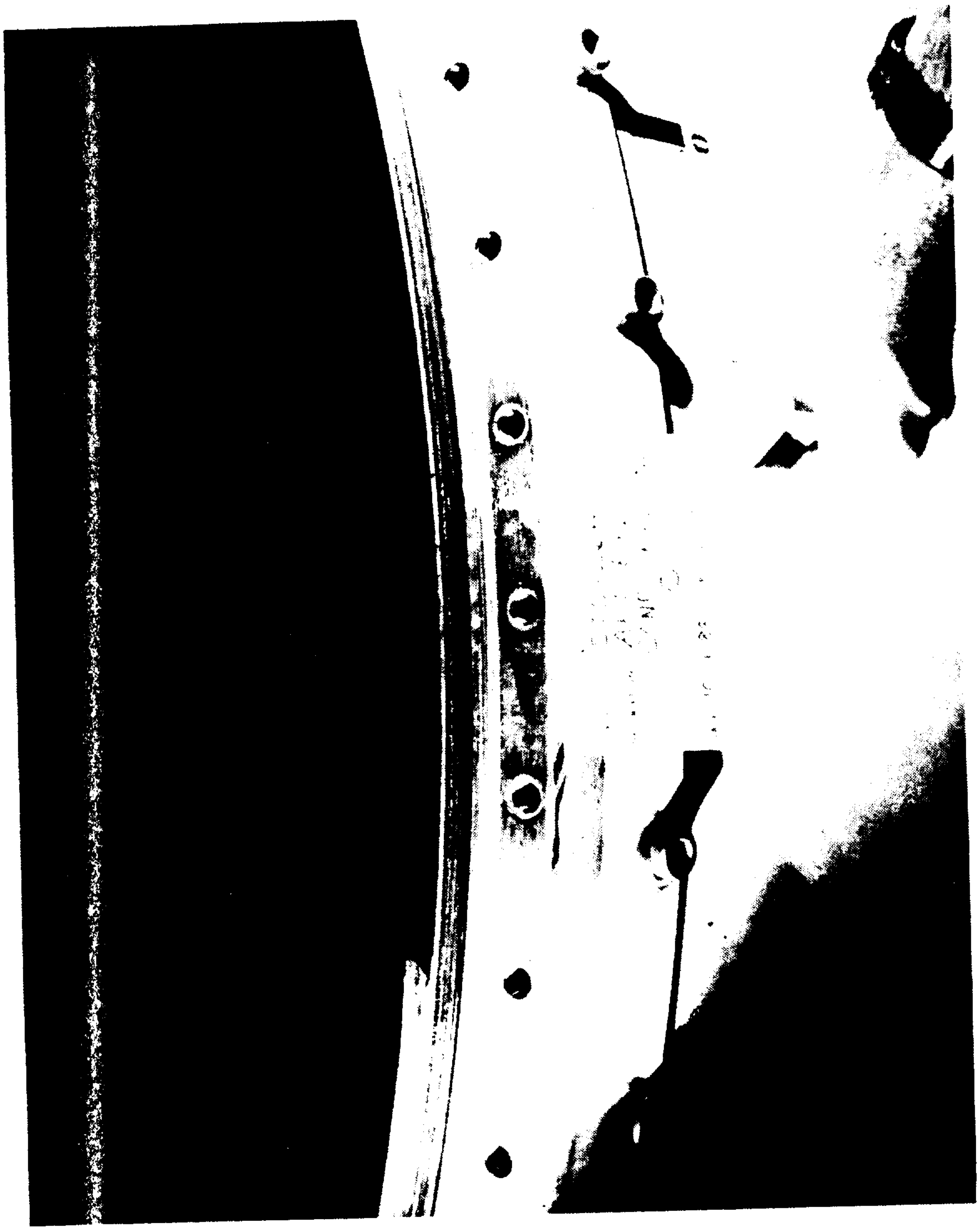

Figure 77 STS-26A Aft Exit Cone Forward End (0 Degrees)

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Figure 78 STS-26A Aft Exit Cone Forward End (120 Degrees)

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Figure 79 STS-26A Aft Exit Cone-Forward End (240 Degrees)

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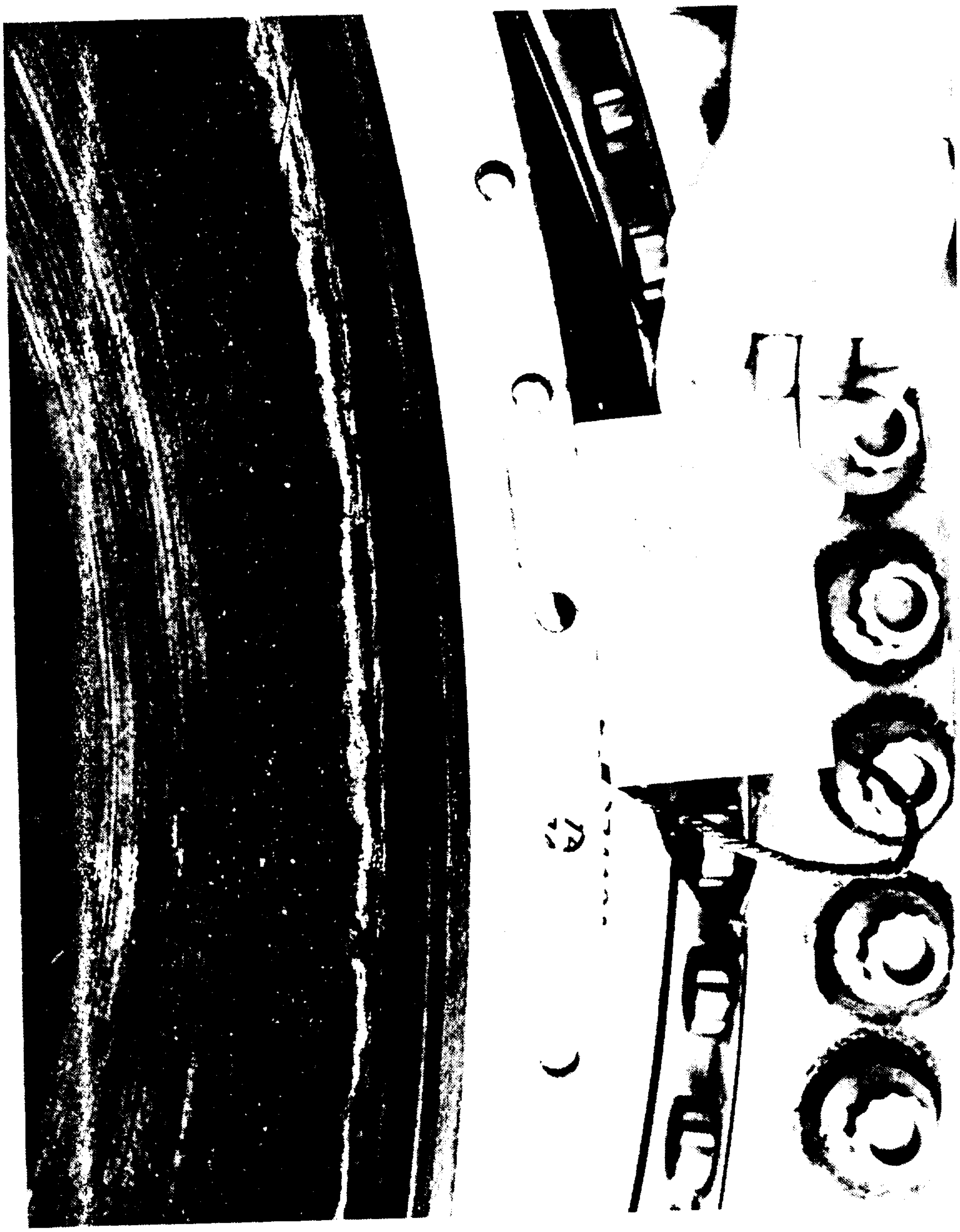

Figure 80 STS-26A Forward Exit Cone-Aft End (0 Degrees)

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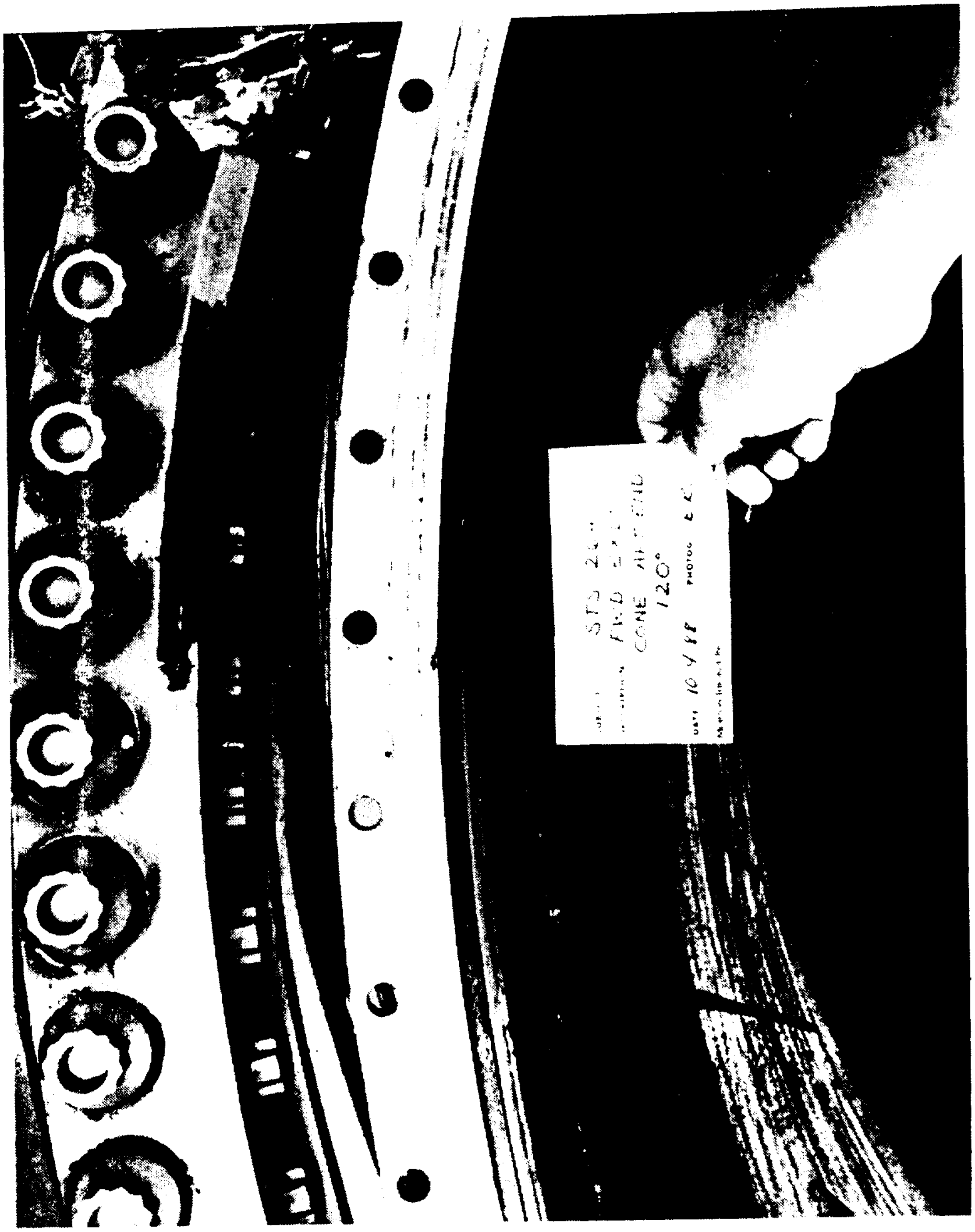

Figure 81 STS-26A Forward Exit Cone-Aft End (120 Degrees)

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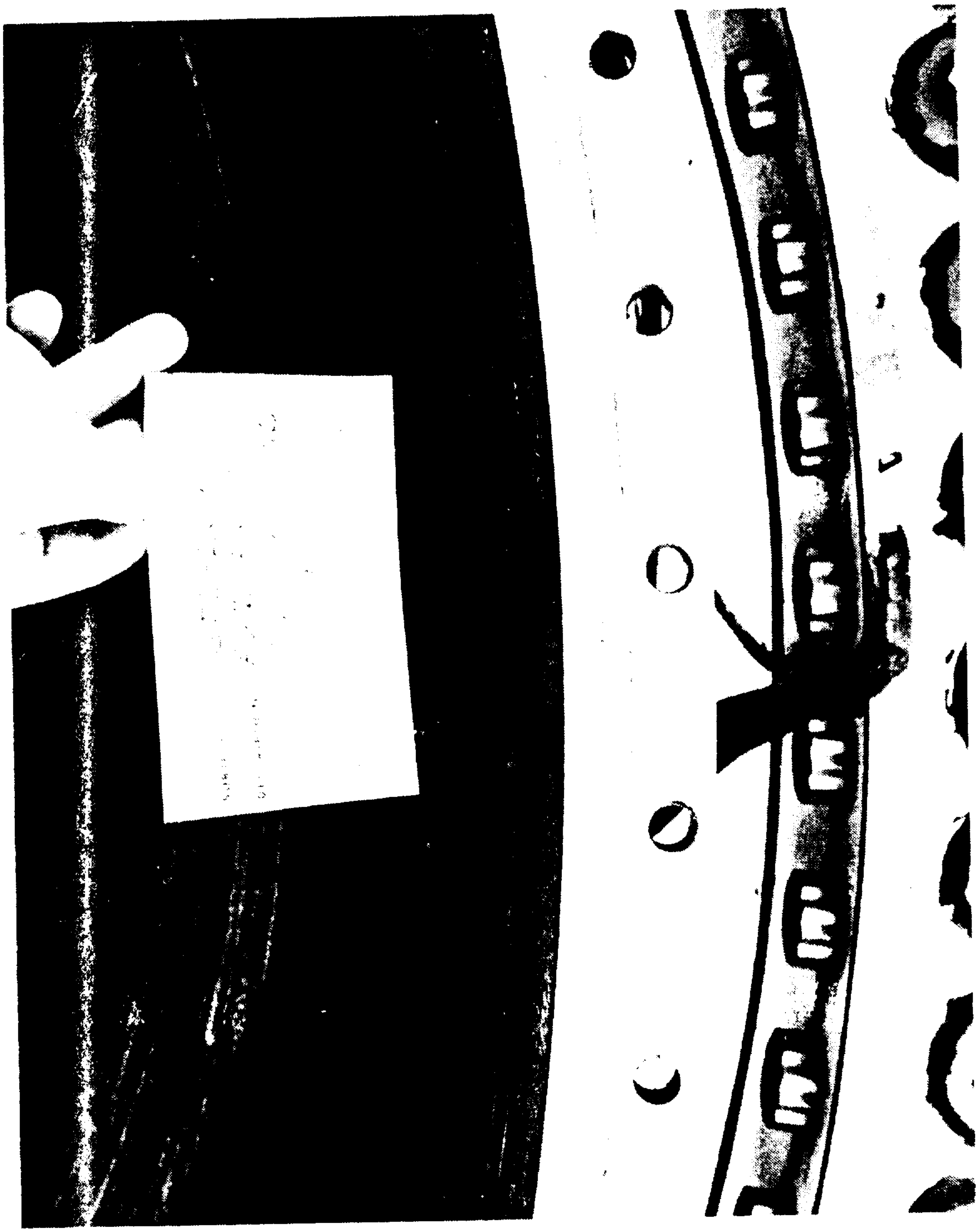

Figure 82 STS-26A Forward Exit Cone-Aft End (240 Degrees)

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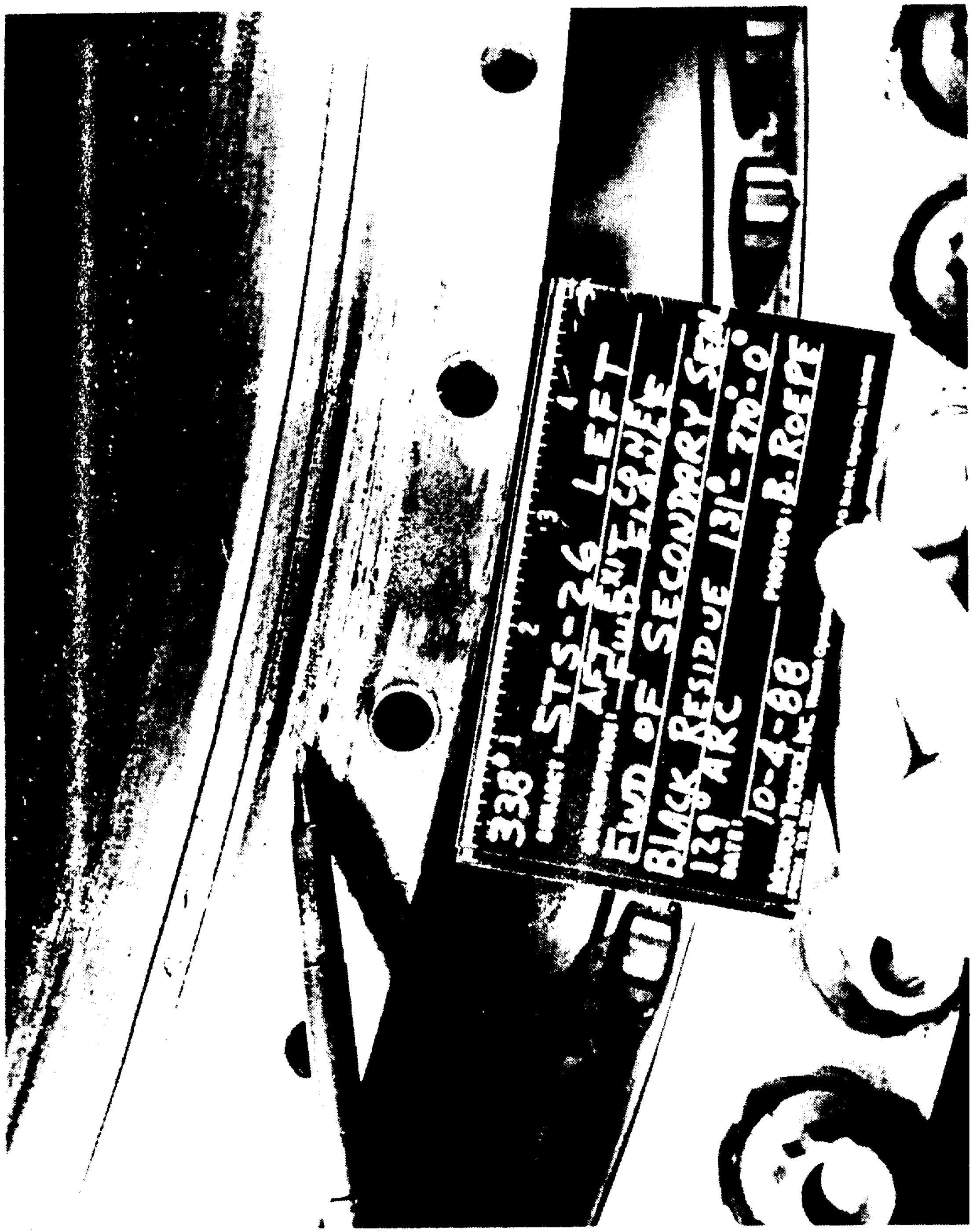

Figure 83 STS-26A Forward Exit Cone Aft End Black Corrosion (338 Degrees)

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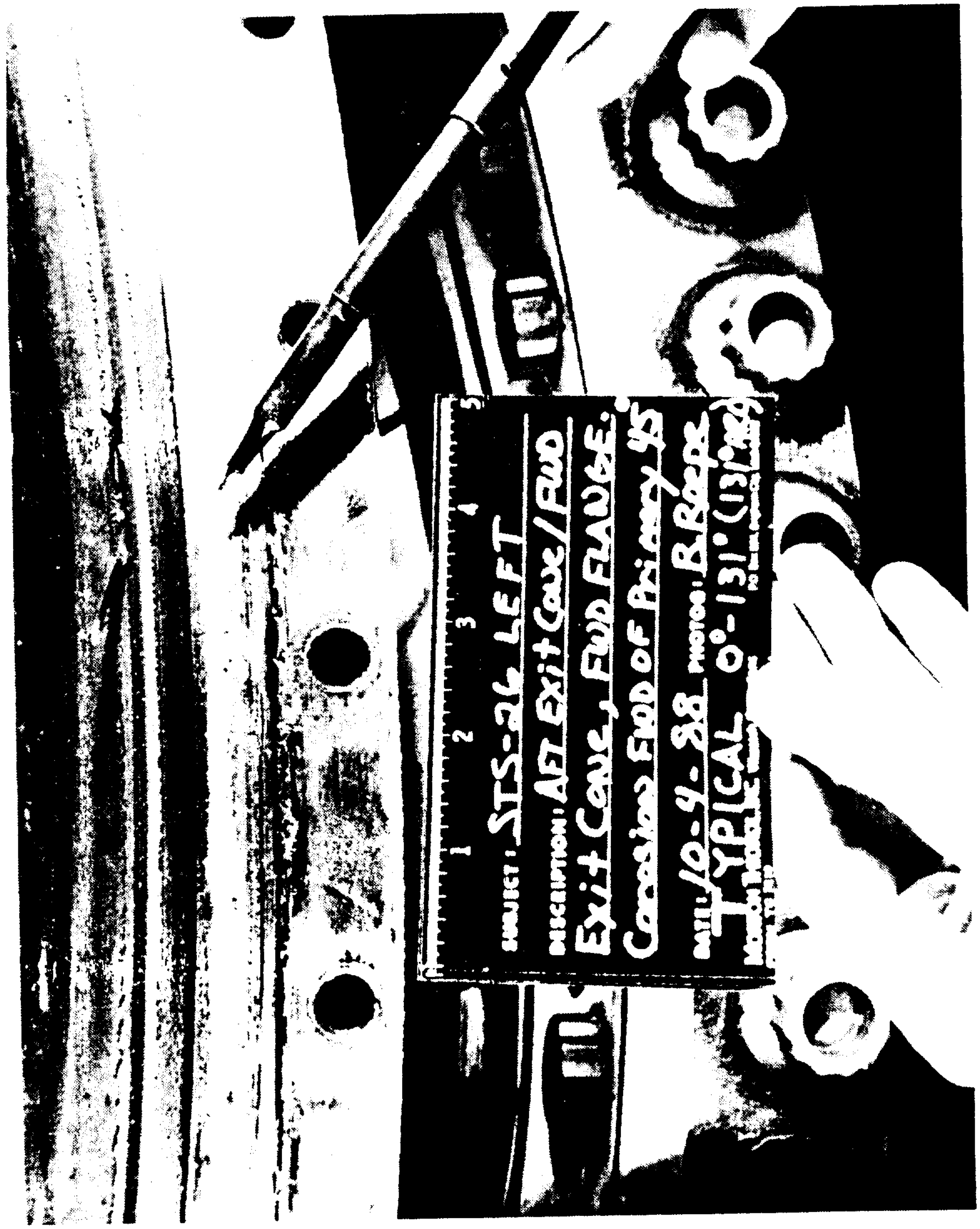

Figure 84 STS-26A Forward Exit Cone-Aft End White Corrosion (45 Degrees)

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Figure 85 STS-26A Forward Exit Cone-Aft End Scratch Mark (90 Degrees)

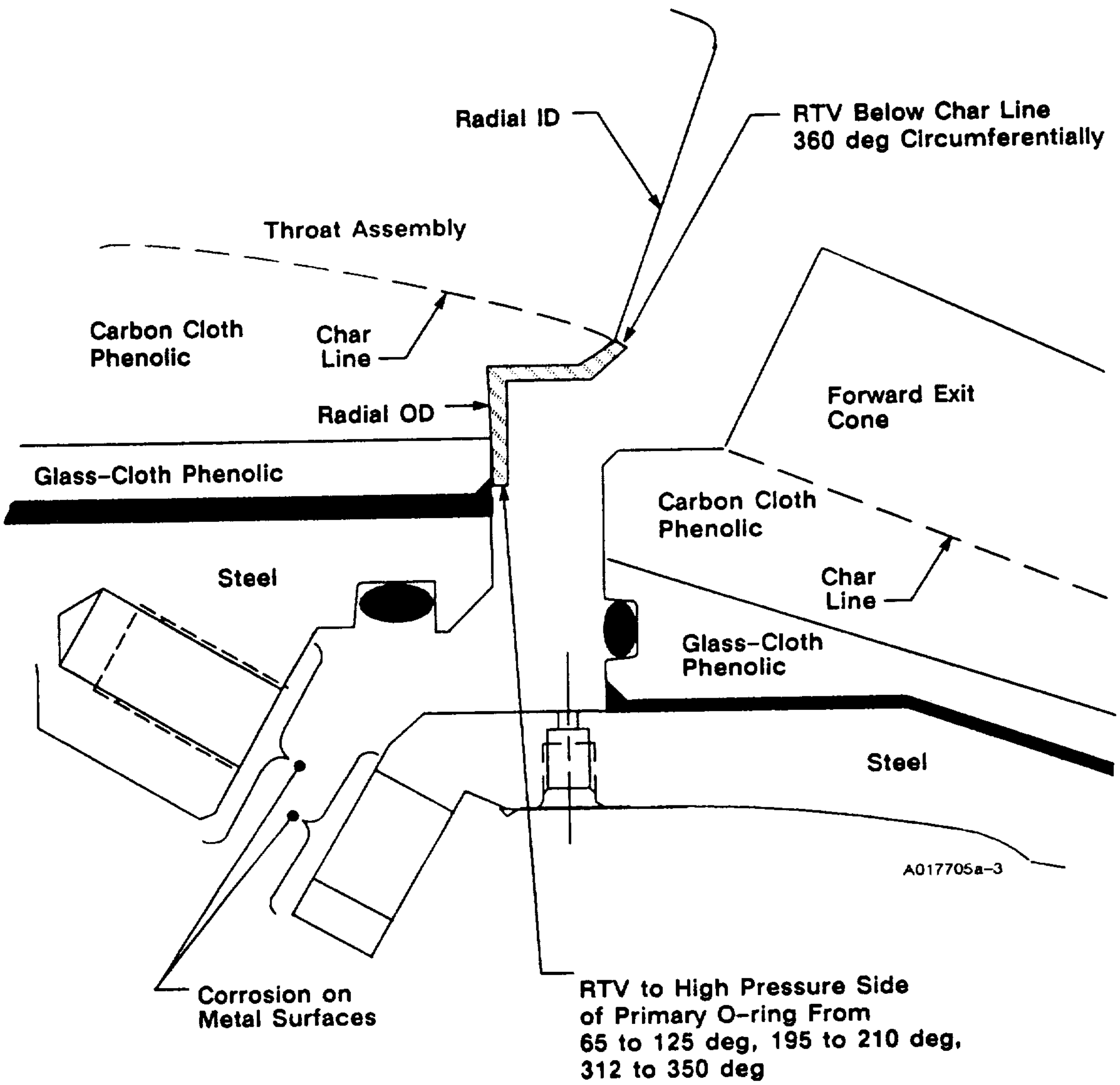

Figure 86 STS-26A Throat/Forward Exit Cone Joint

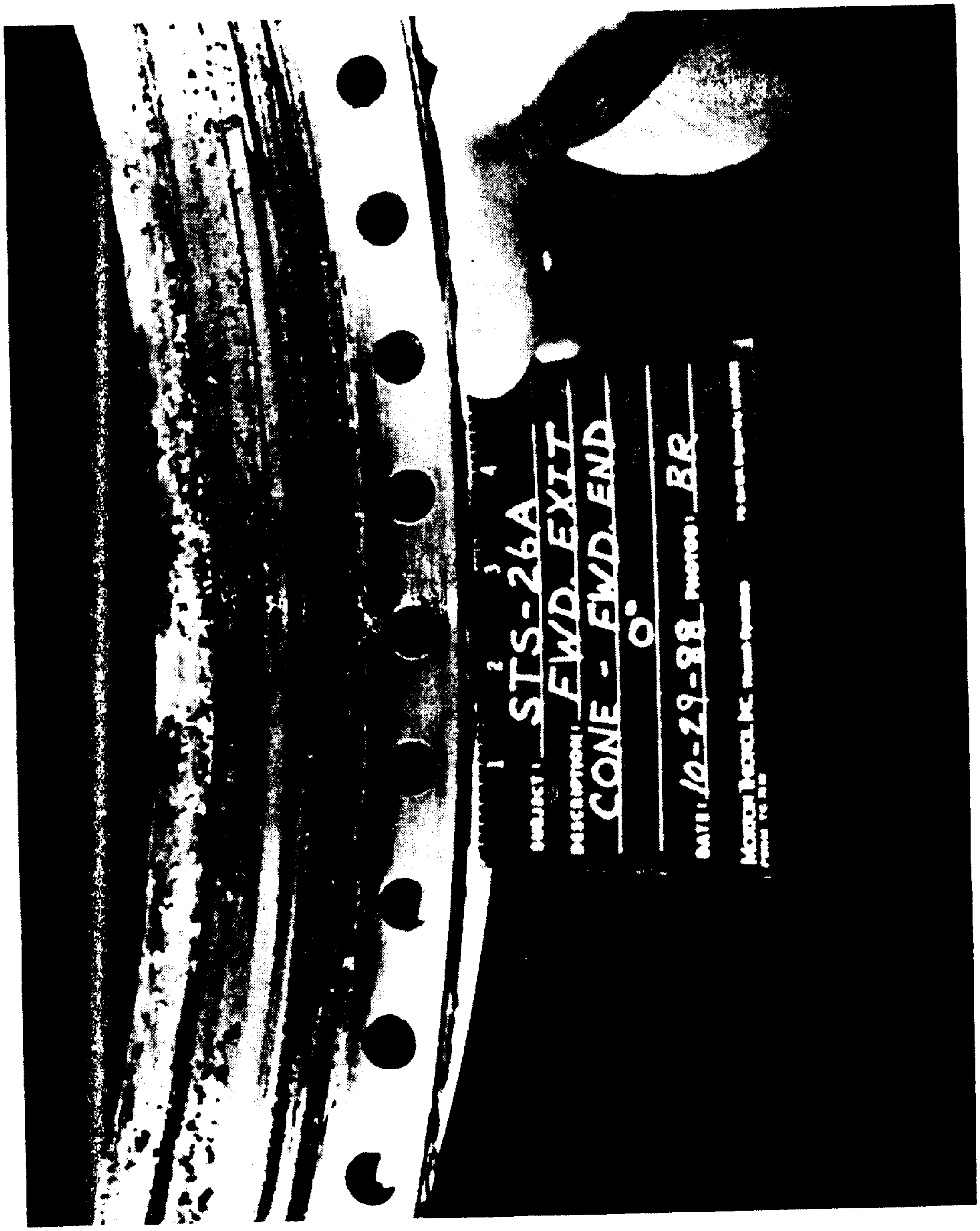

Figure 87 STS-26A Forward Exit Cone-Forward End (0 Degrees)

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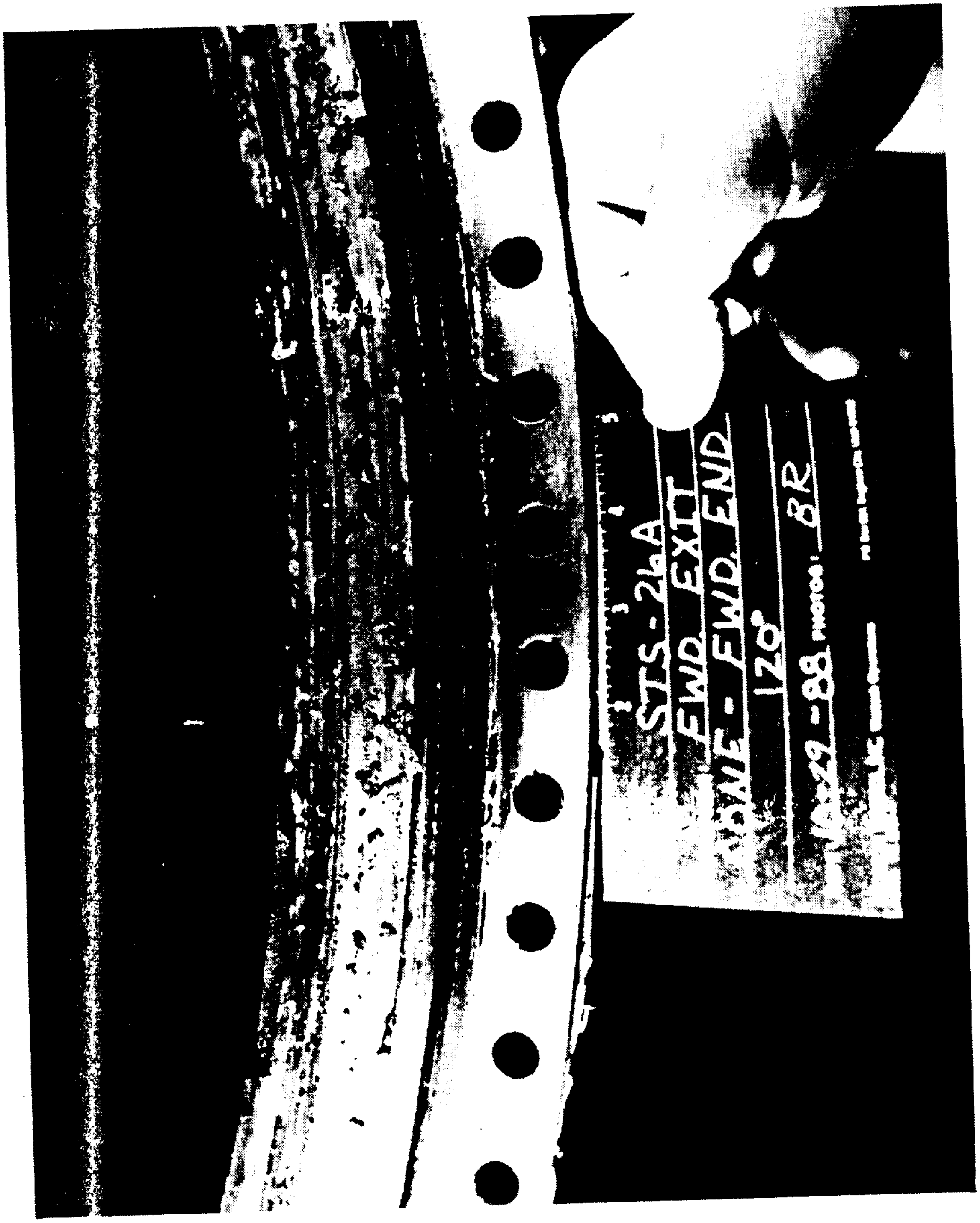

Figure 88 STS-26A Forward Exit Cone-Forward End (120 Degrees)

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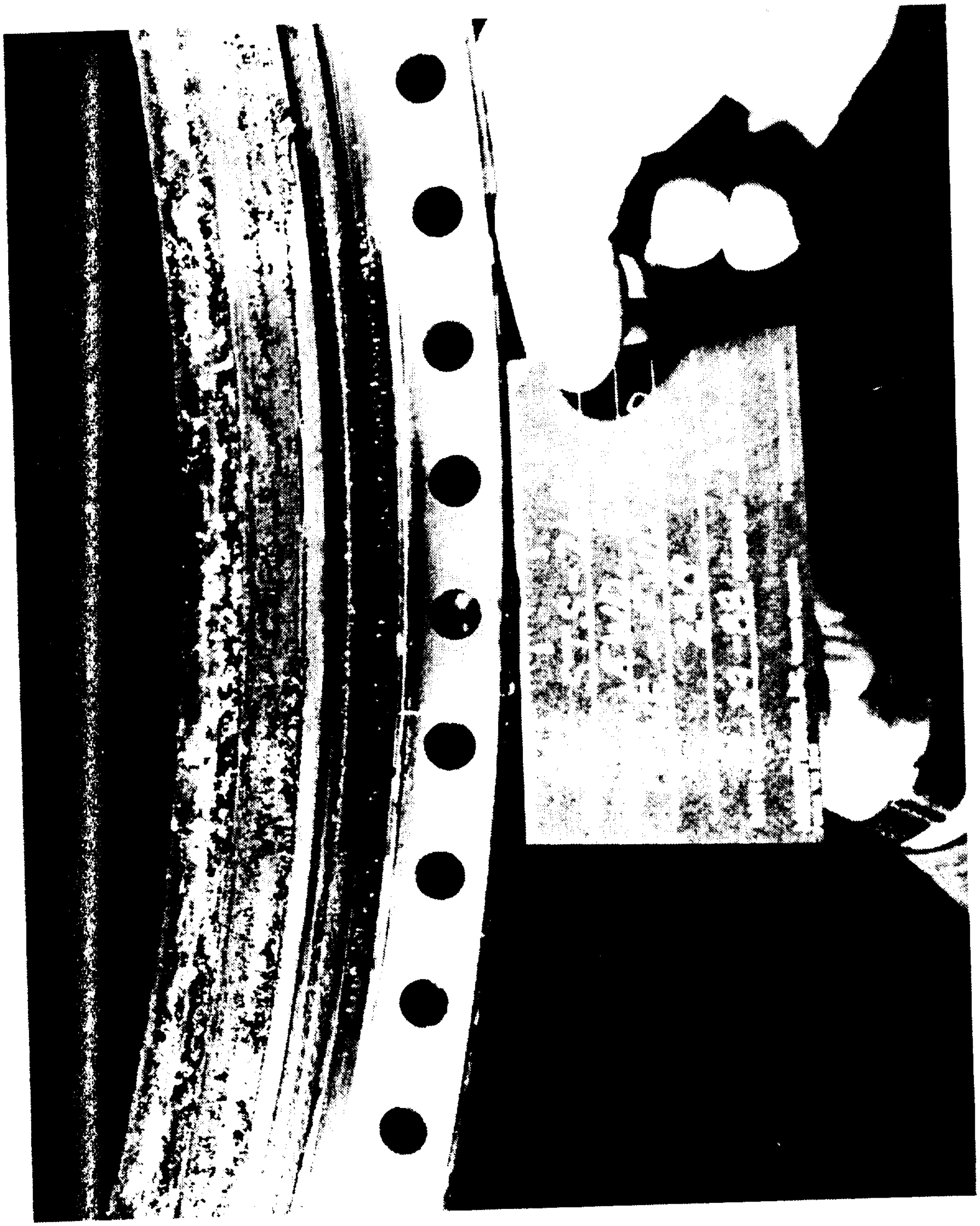

Figure 89 STS-26A Forward Exit Cone-Forward End (240 Degrees)

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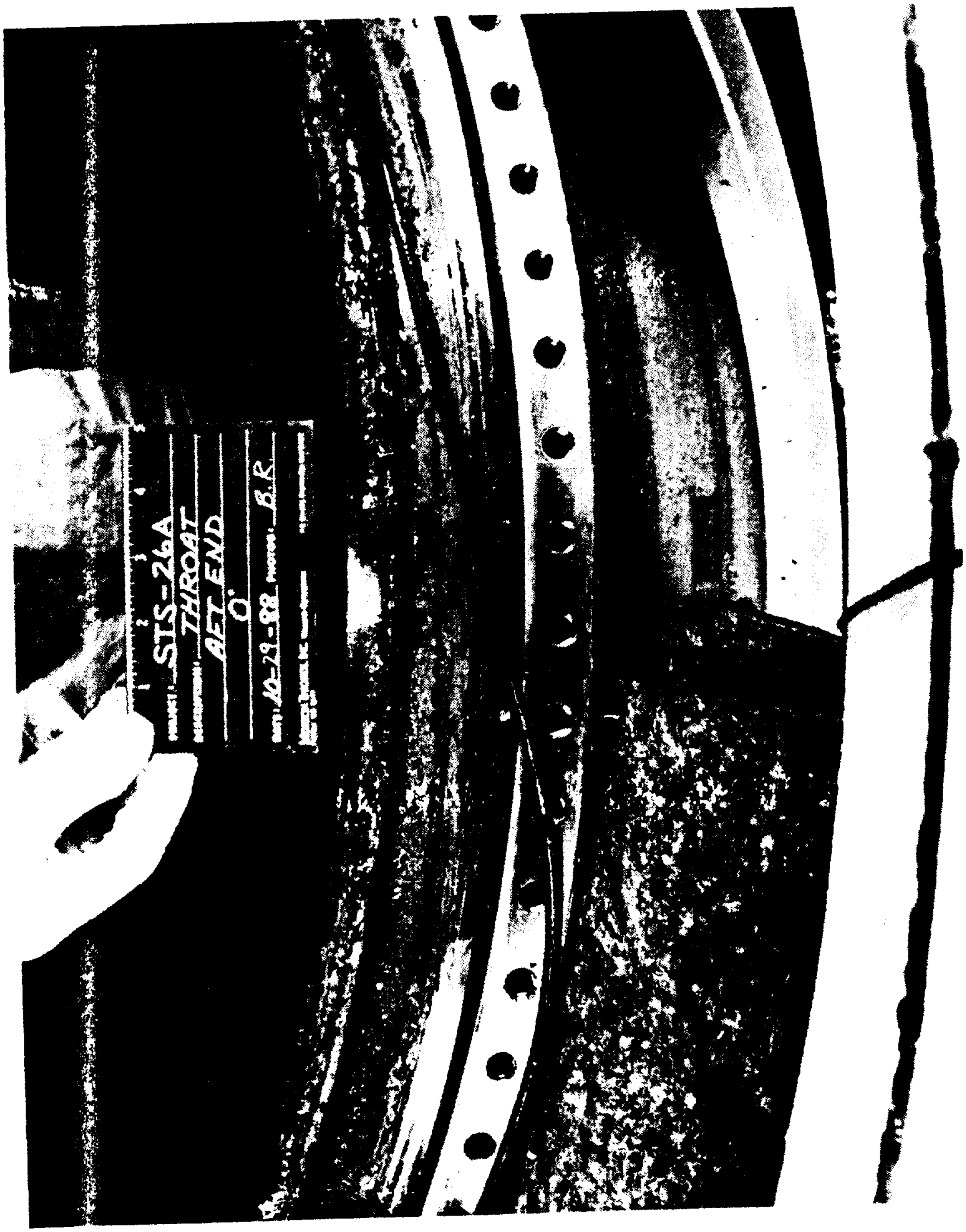

Figure 90 STS-26A Throat Aft End (0 Degrees)

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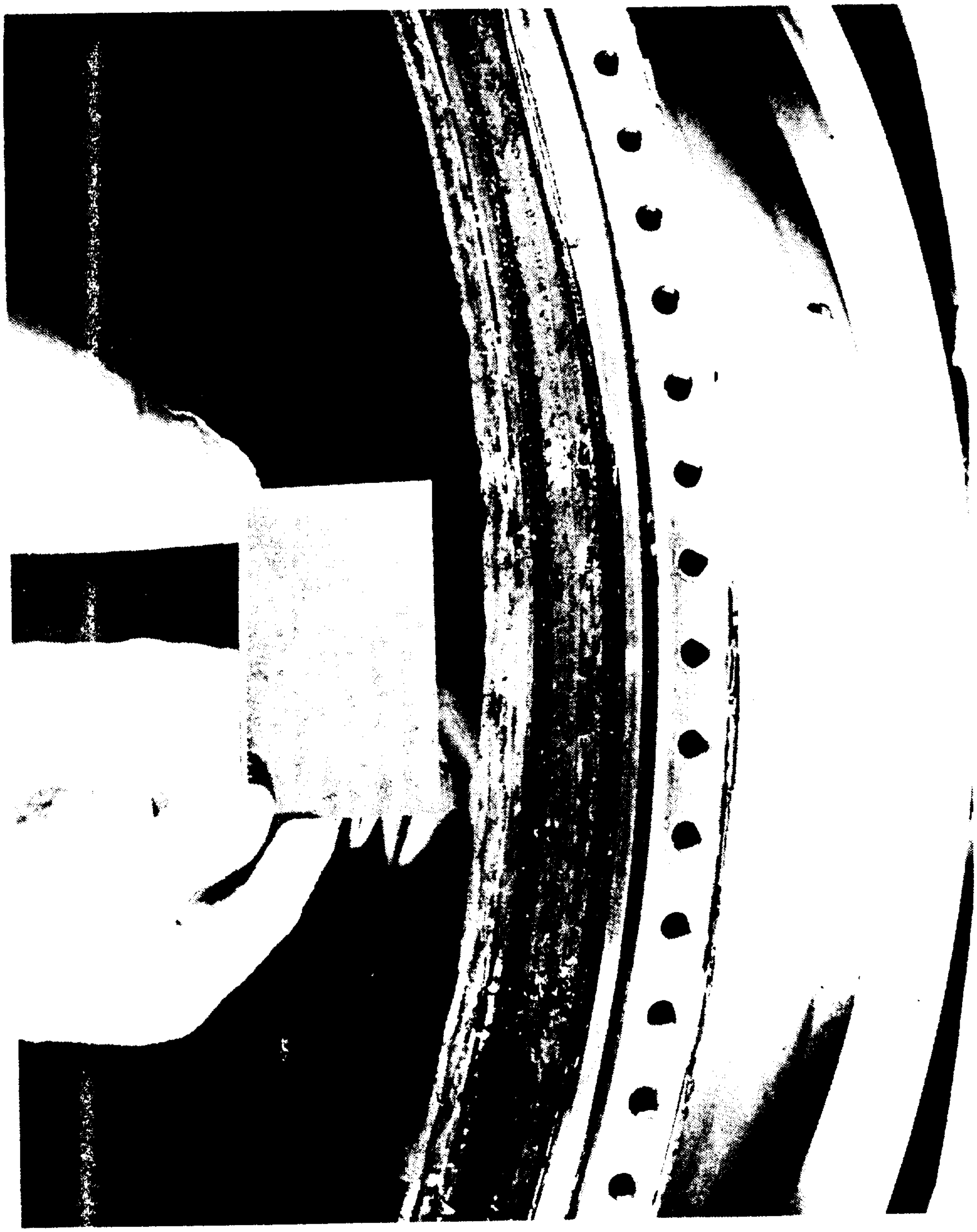

Figure 91 STS-26A Throat Aft End (120 Degrees)

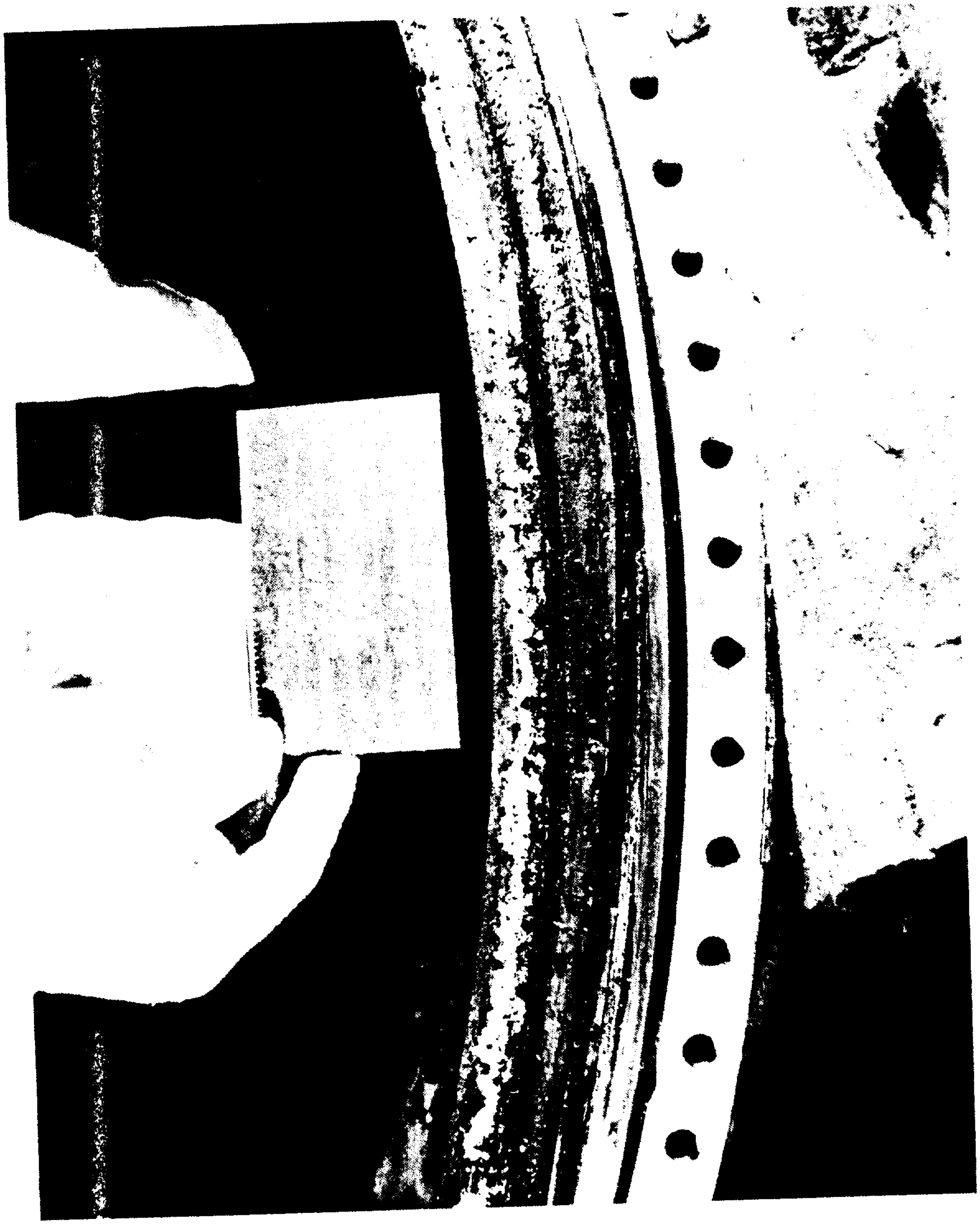

Figure 92 STS-26A Throat-Aft End (240 Degrees)

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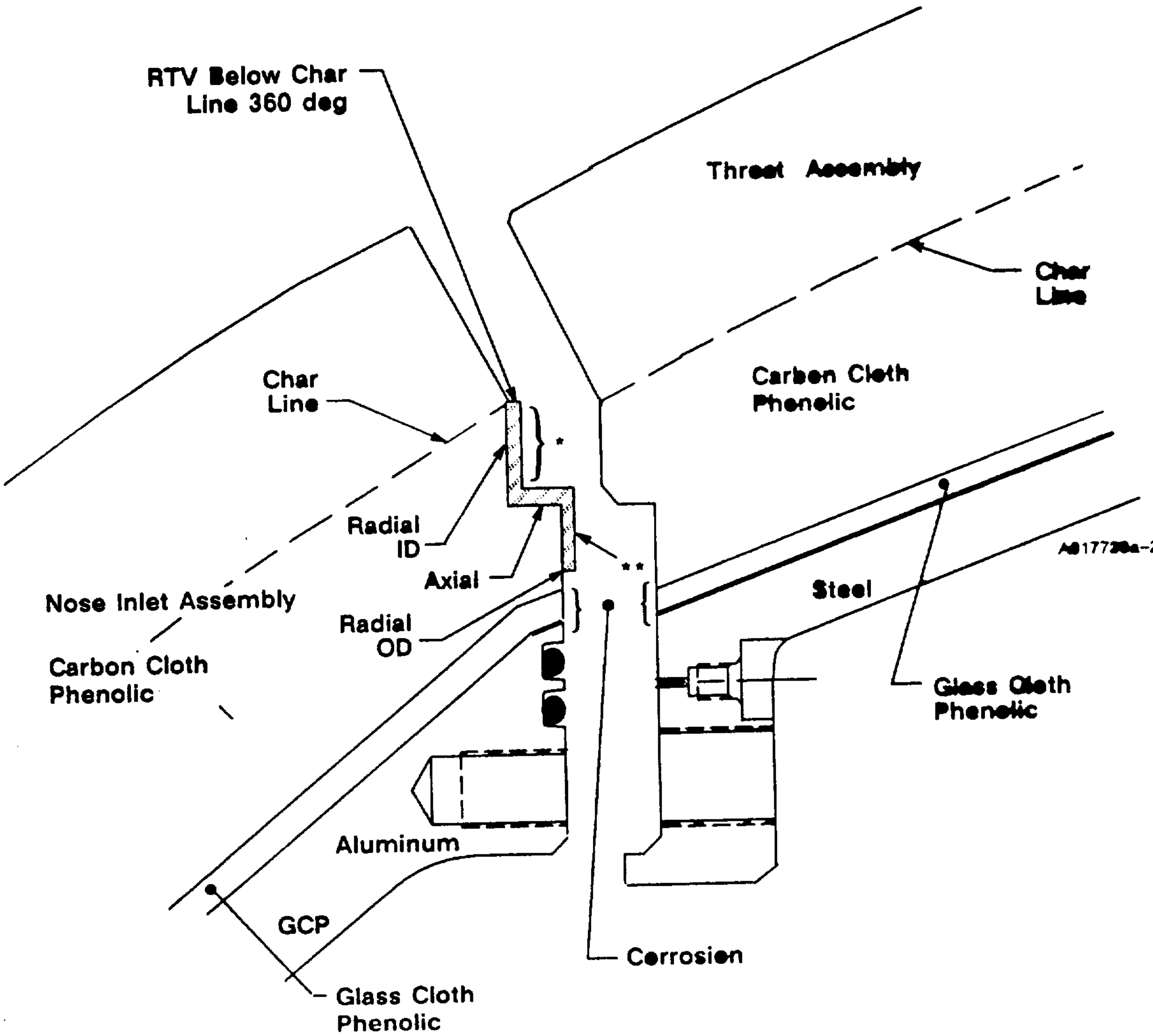
Figure 93 STS-26A Throat Aft End-Blowpath (310 Degrees)



*RTV filled radial ID circumferentially except from 309 deg to 313 deg
**RTV extended onto radial OD intermittently around circumference

Figure 94 STS-26A—Nose Inlet/Throat Housing Joint

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Figure 95 STS-26A Throat-Forward End (0 Degrees)

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Figure 96 STS-26A Throat-Forward End (120 Degrees)

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Figure 97 STS-26A Throat-Forward End (240 Degrees)

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Figure 98 STS-26A Aft Inlet (-504) Ring-Aft End (0 Degrees)

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Figure 99 STS-26A Aft Inlet (-504) Ring-Aft End (120 Degrees)

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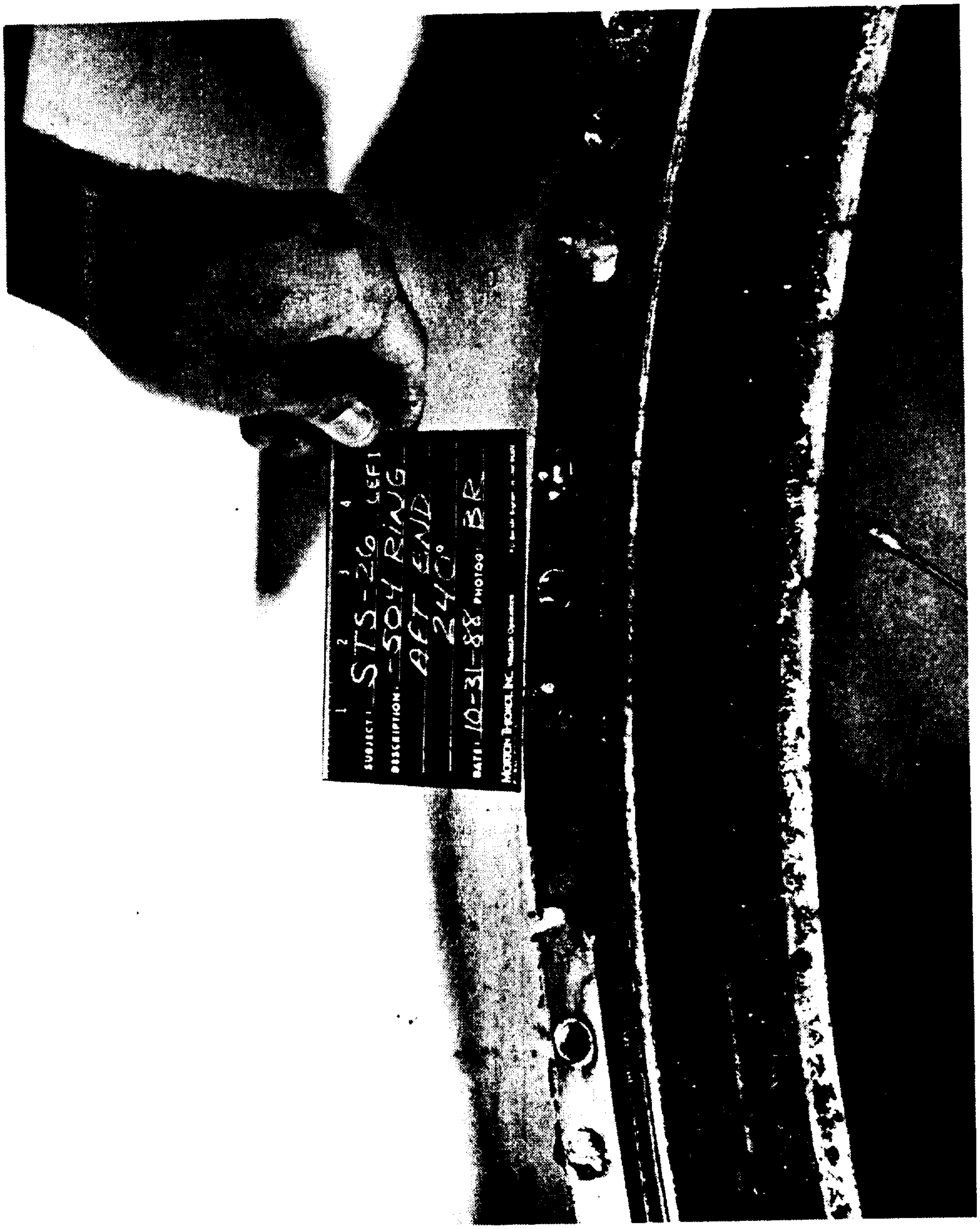

Figure 100 STS-26A Aft Inlet (-504) Ring-Aft End (240 Degrees)

Figure 101 STS-26A Throat-Forward End Blowpath (136 Degrees)

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Figure 102 STS-26A Aft Inlet (-504) Ring-Aft End Blowpath (136 Degrees)

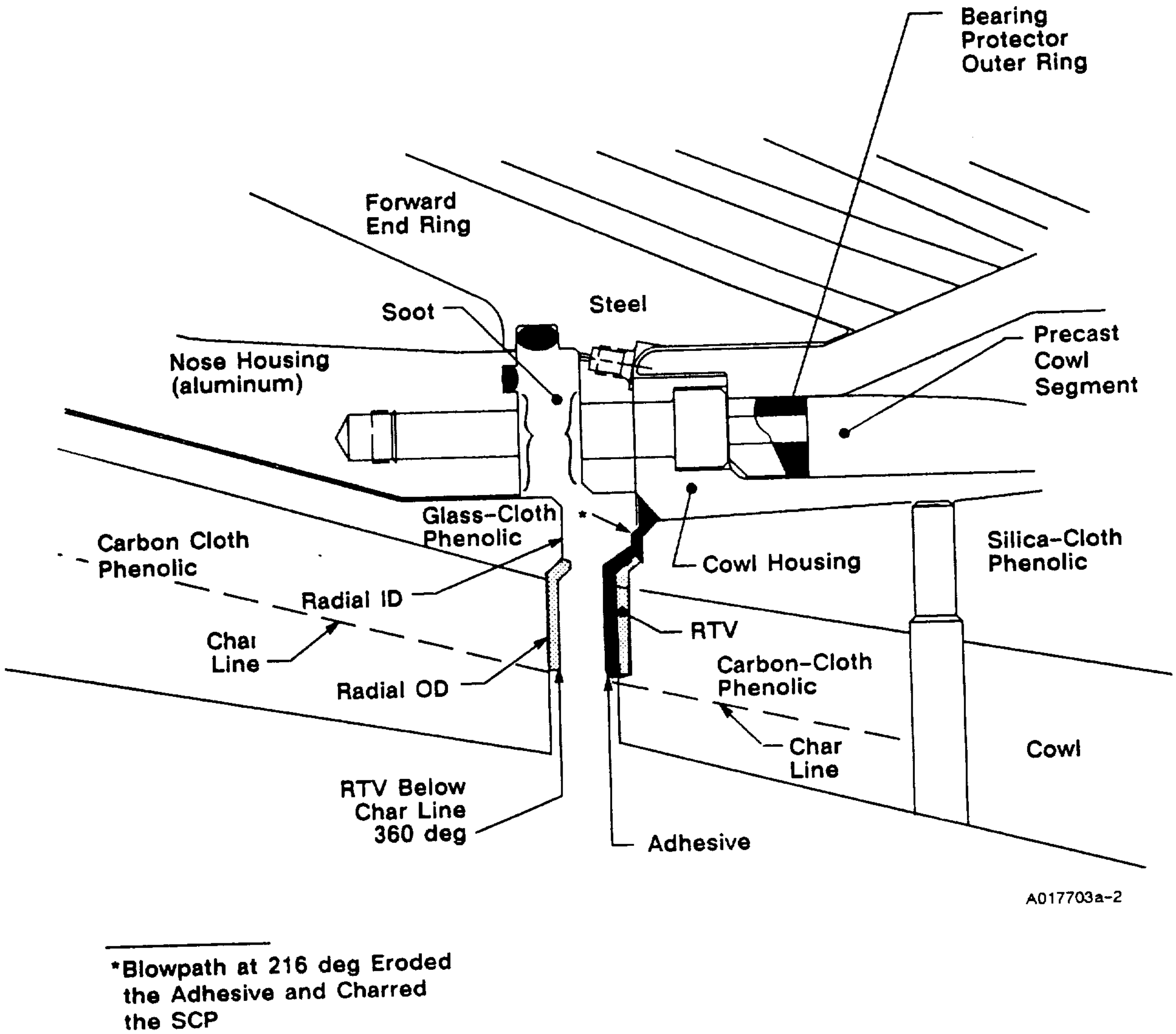

Figure 103 STS-26A Nose Inlet Housing/Flex Bearing Joint

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Figure 104 STS-26A Cowl-Forward End (0 Degrees)

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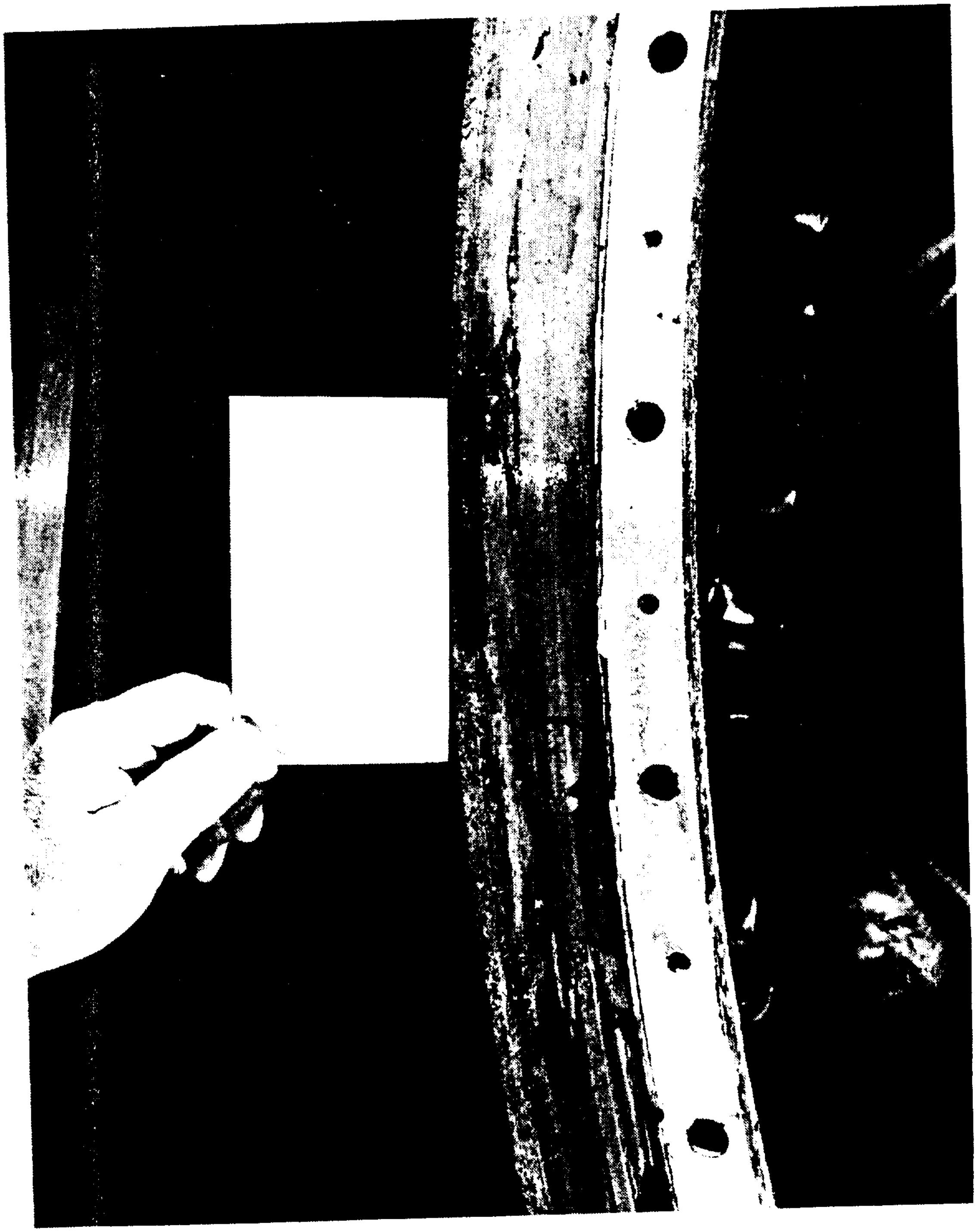

Figure 105 STS-26A Cowl-Forward End (120 Degrees)

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Figure 106 STS-26A Cowl-Forward End (240 Degrees)

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Figure 107 STS-26A Nose Cap-Aft End (0 Degrees)

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Figure 108 STS-26A Nose Cap-Aft End (120 Degrees)

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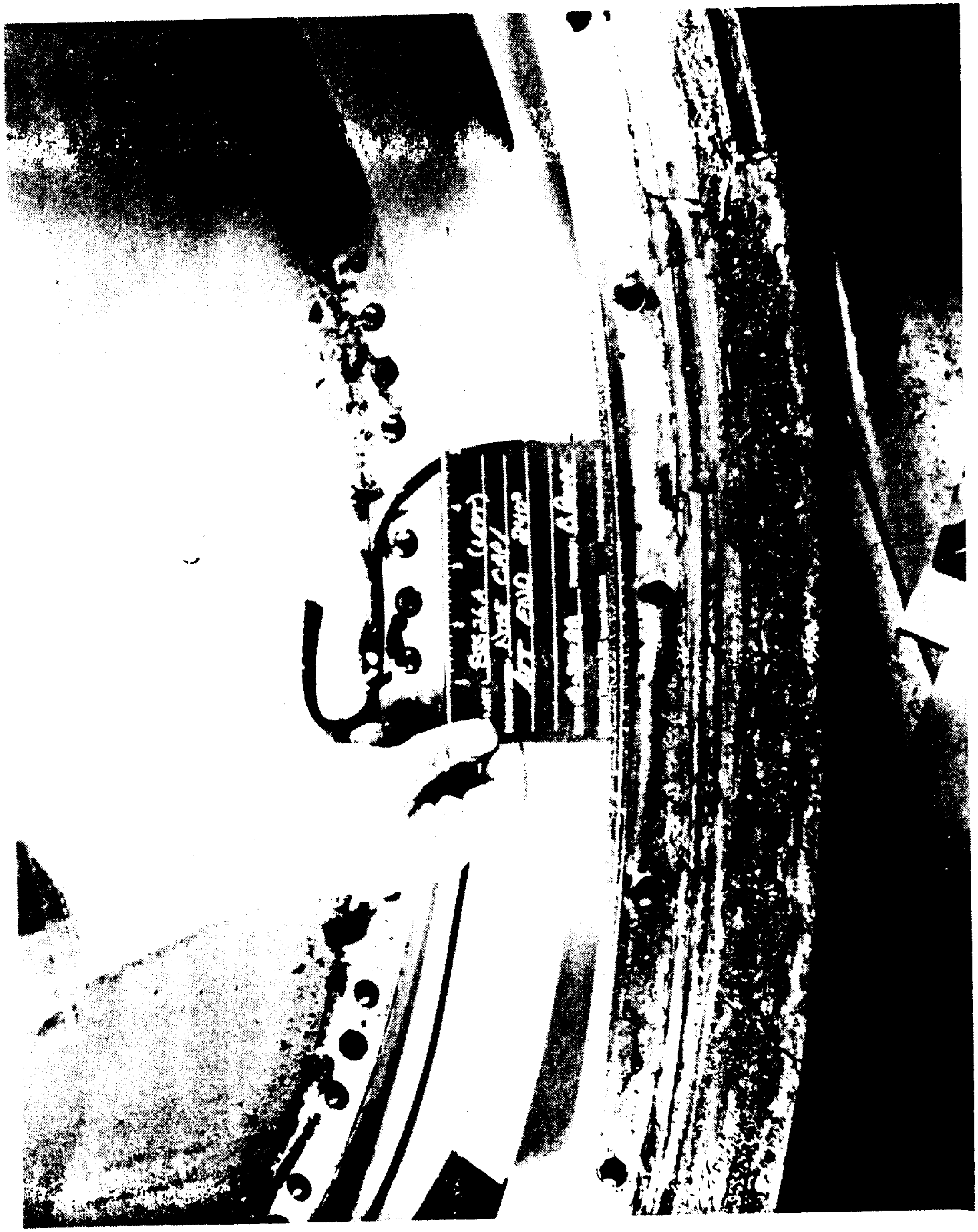

Figure 109 STS-26A Nose Cap-Aft End (240 Degrees)

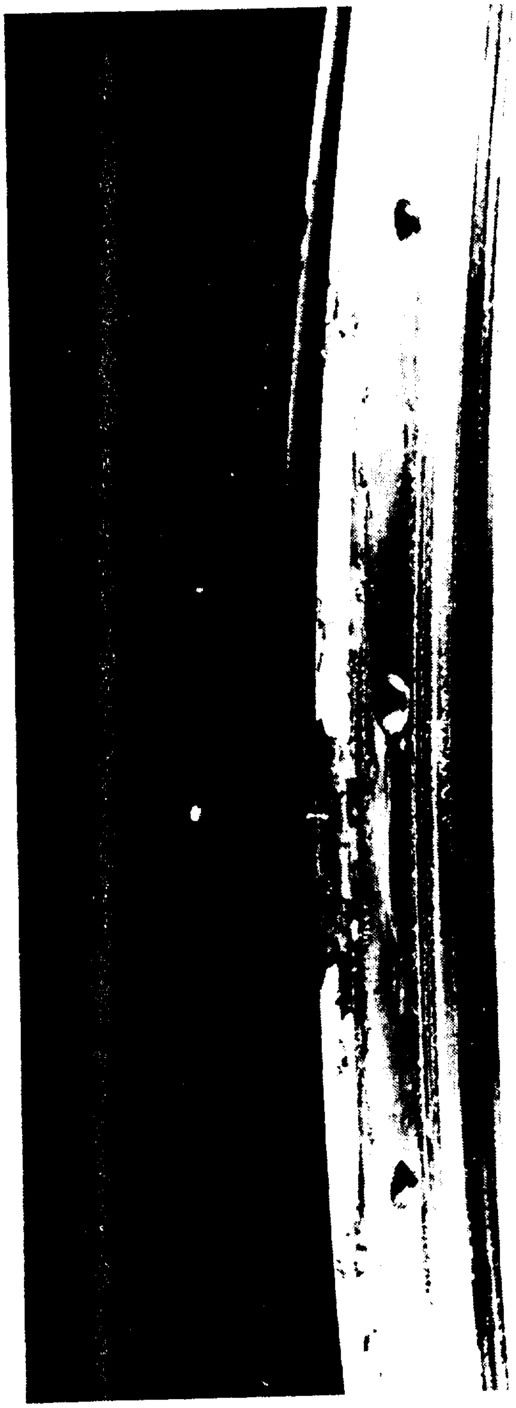

Figure 110 STS-26A Bearing Forward End Ring (0 Degrees)

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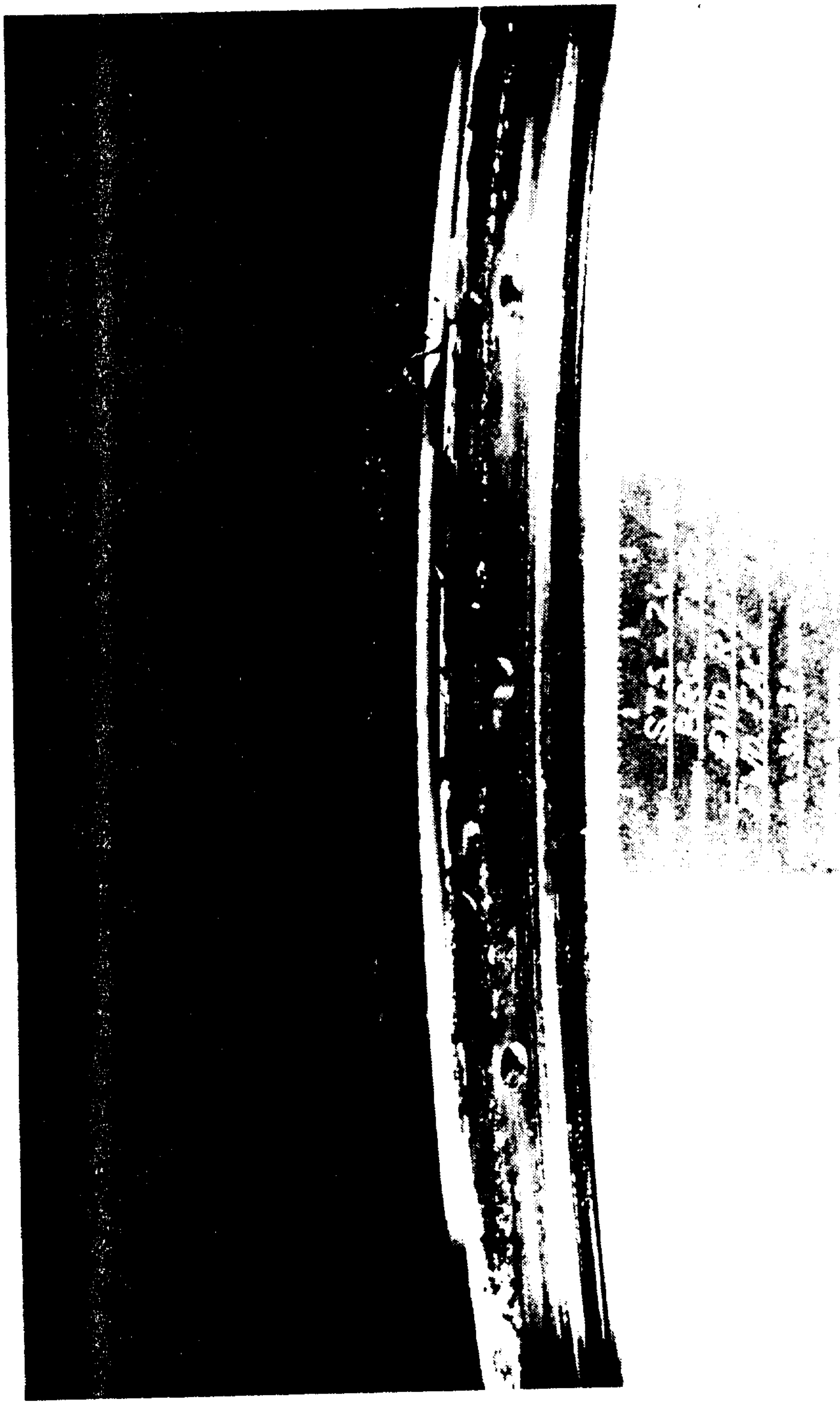

Figure 111 STS-26A Bearing Forward End Ring (120 Degrees)

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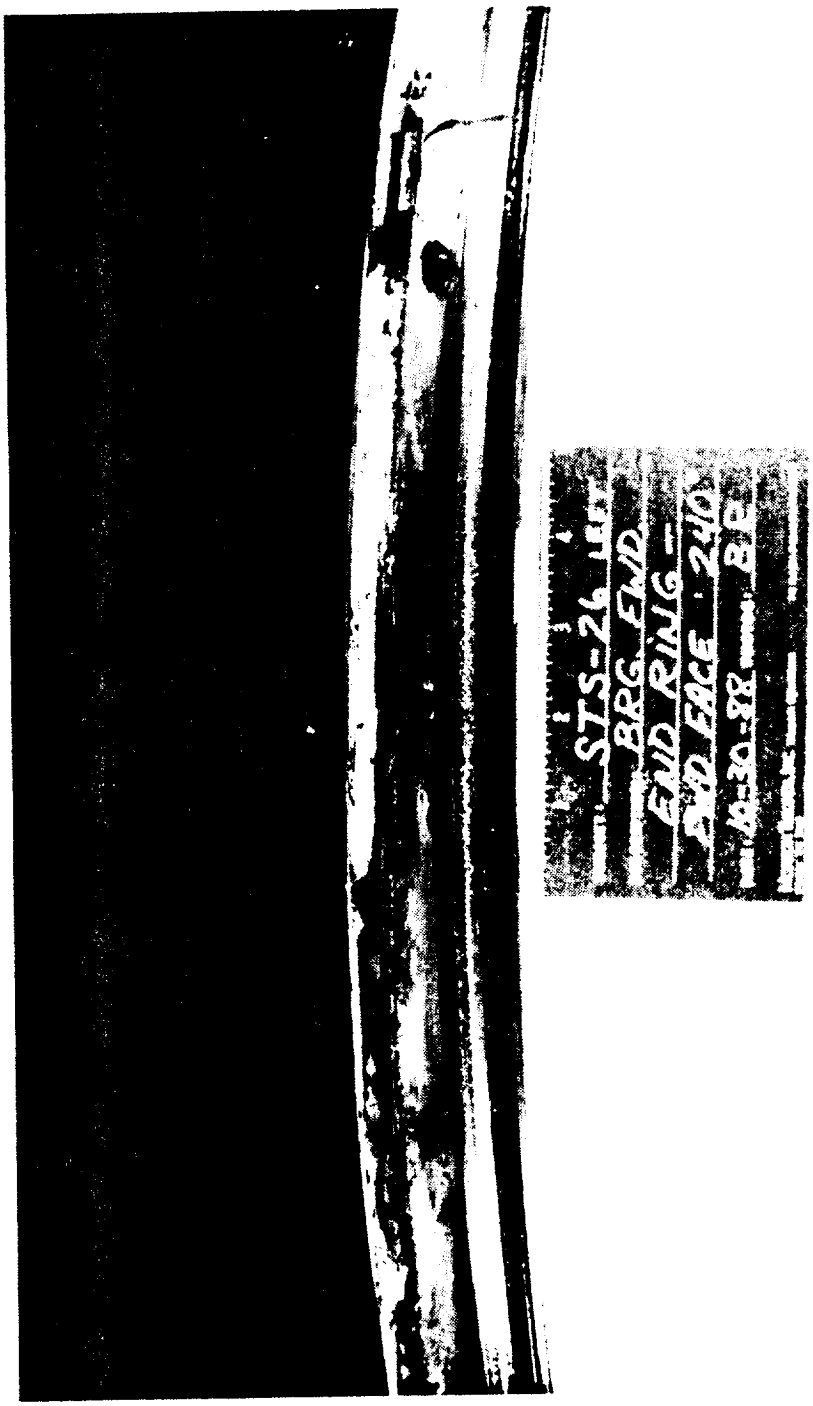

Figure 112 STS-26A Bearing Forward End Ring (240 Degrees)

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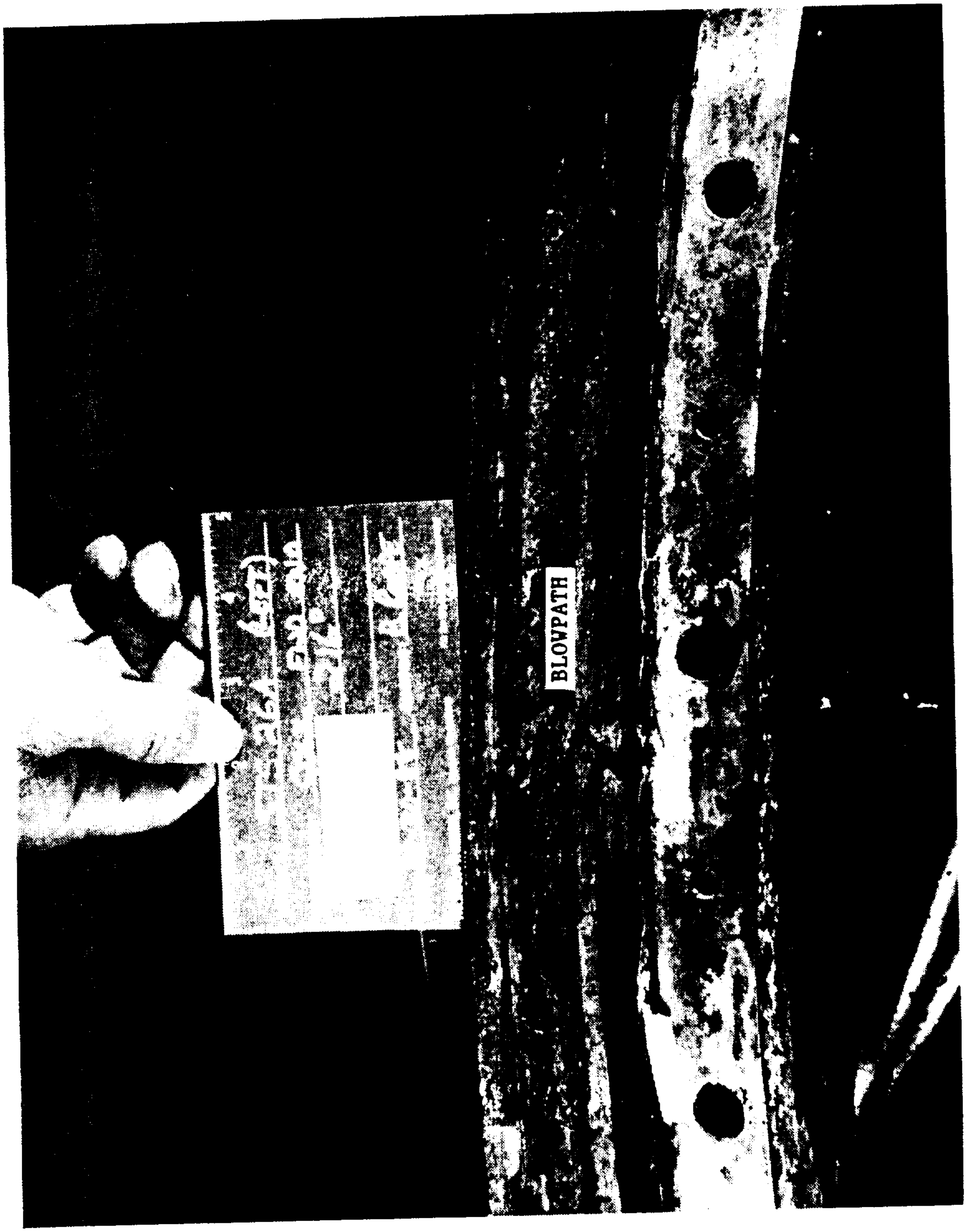

Figure 113 STS-26A Cowl Forward End-Blowpath Location (216 Degrees)

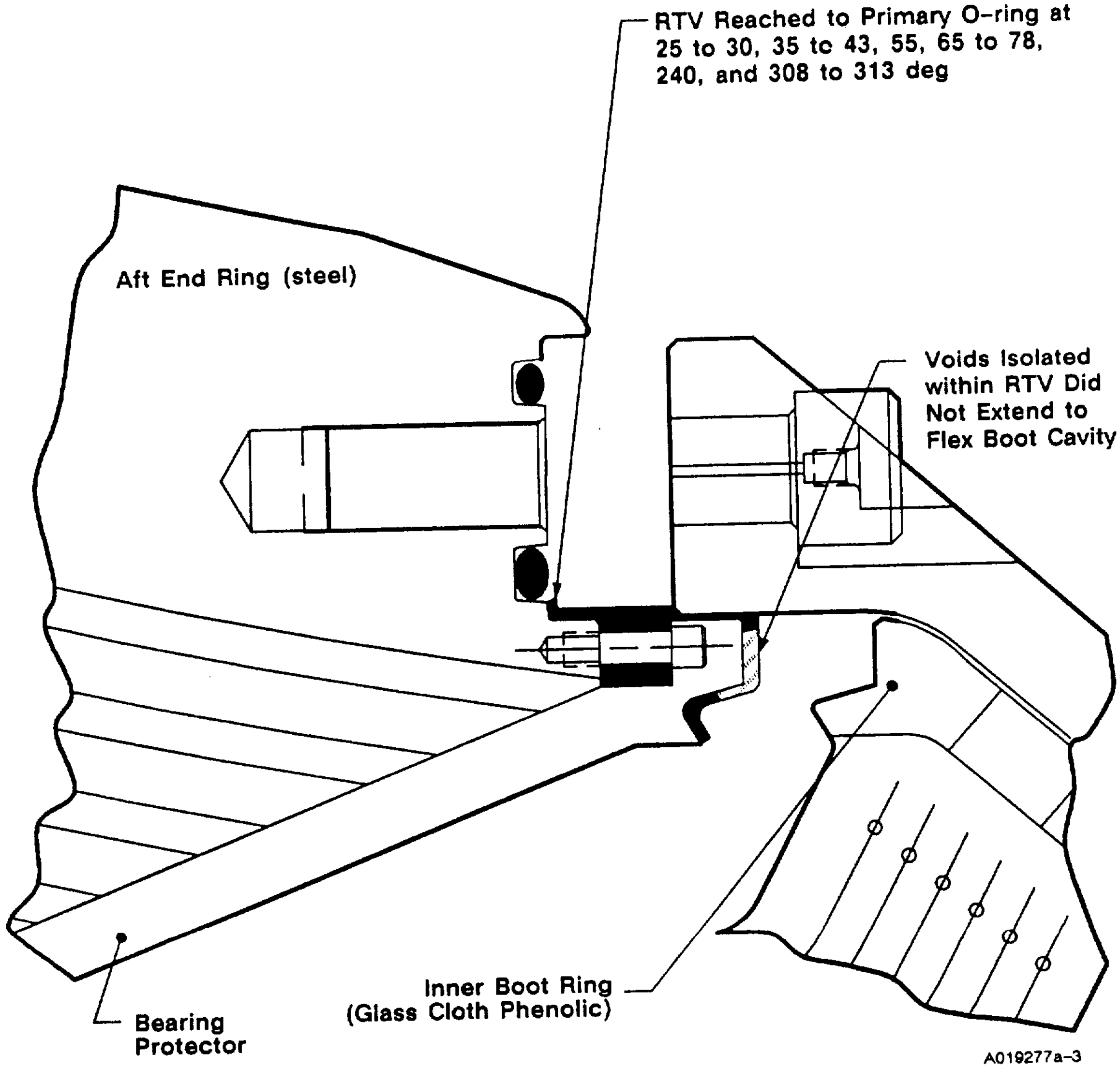

Figure 114 STS-26A—Flex Bearing/Fixed Housing Joint

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Figure 115 STS-26A Fixed Housing Forward End (0 Degrees)

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Figure 116 STS-26A Fixed Housing Forward End (120 Degrees)

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Figure 117 STS-26A Fixed Housing Forward End (240 Degrees)

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Figure 118 STS-26A Bearing Aft End Ring (0 Degrees)

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Figure 119 STS-26A Bearing Aft End Ring (120 Degrees)

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Figure 120 STS-26A Bearing Aft End Ring (240 Degrees)

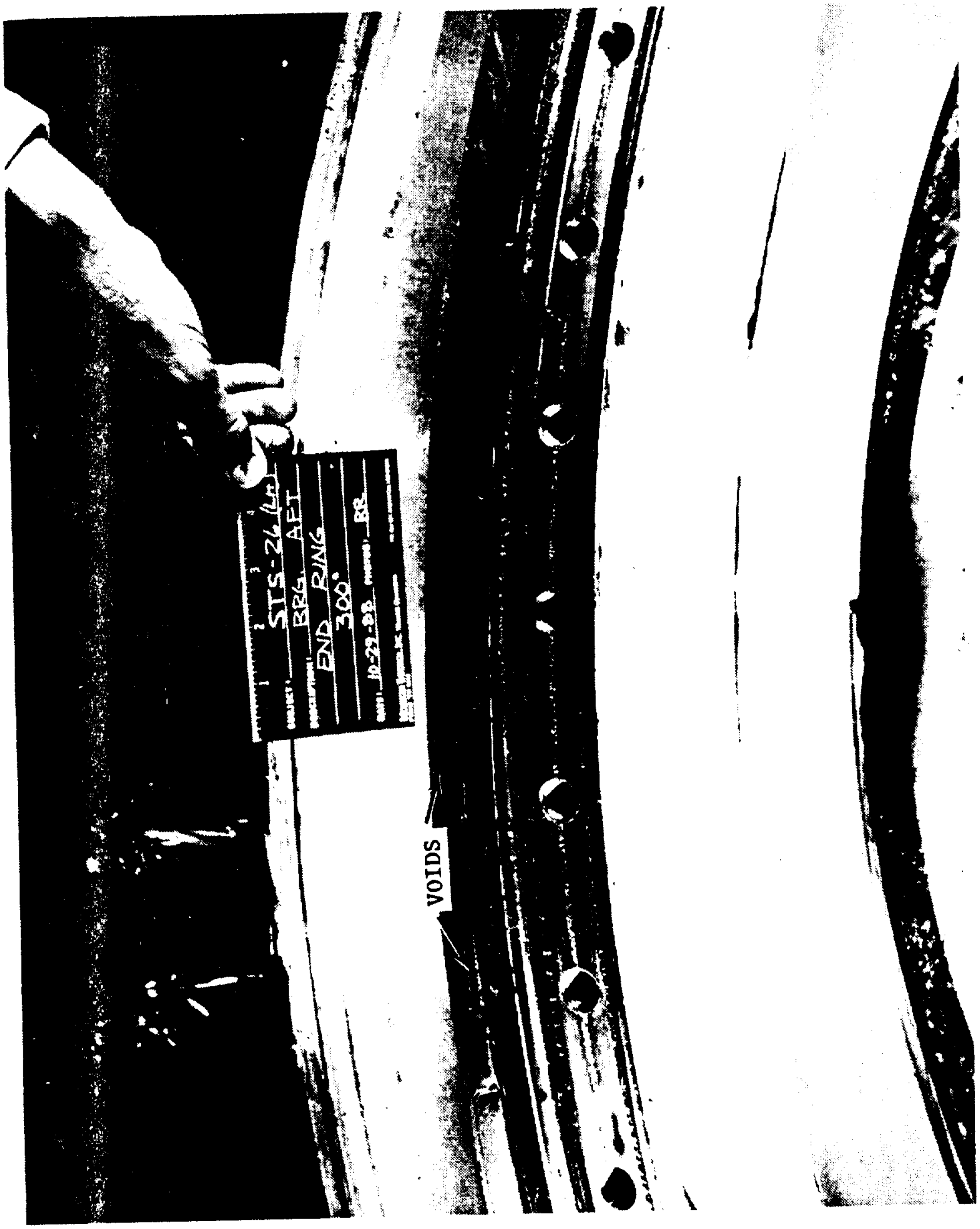

Figure 121 STS-26A Bearing Aft End Ring (300 Degrees)

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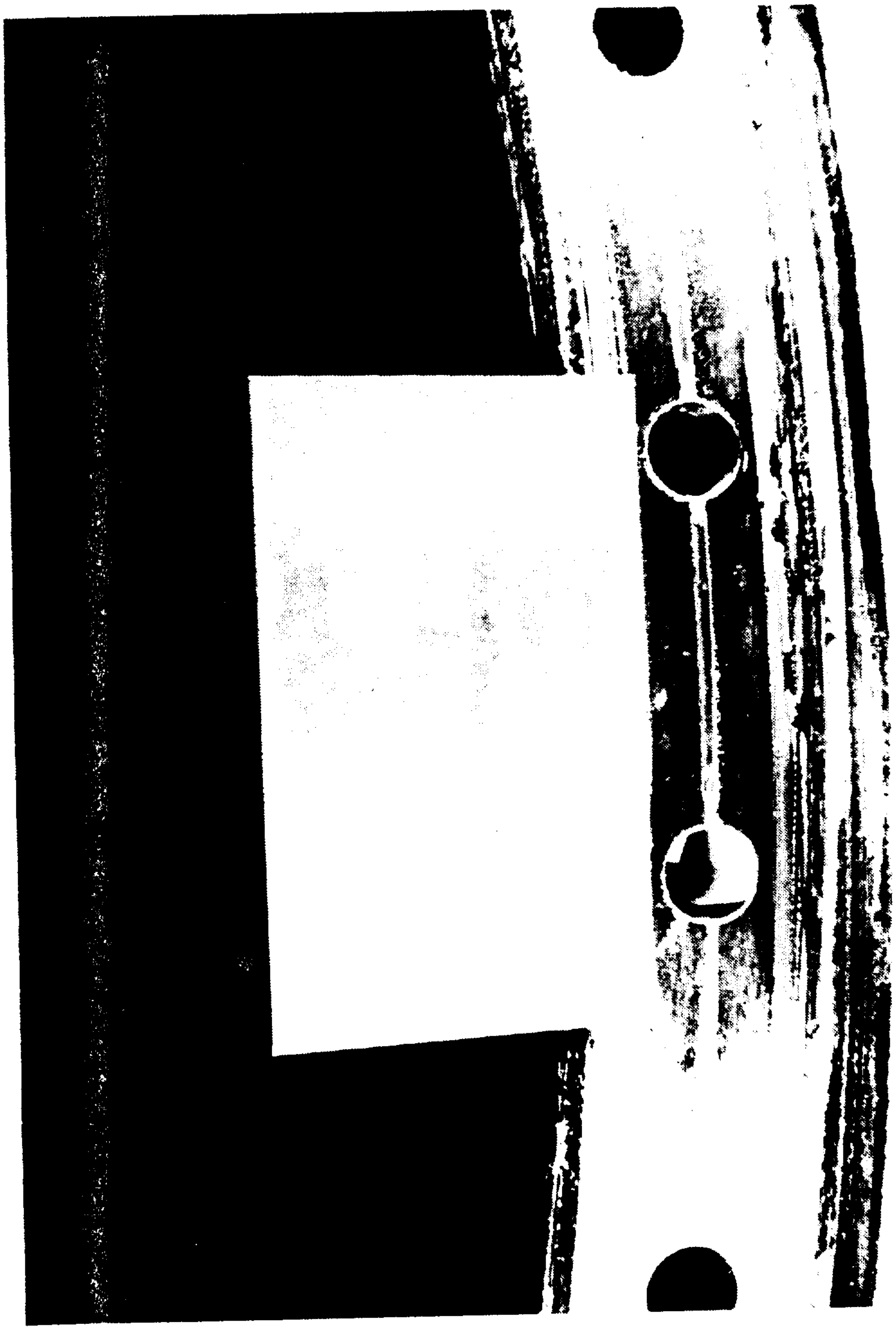

Figure 122 STS-26A Fixed Housing Forward End Rust on Metal Surfaces (15 Degrees)

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Figure 123 STS-26A Bearing Aft End Ring-White Corrosion Spot (260 Degrees)

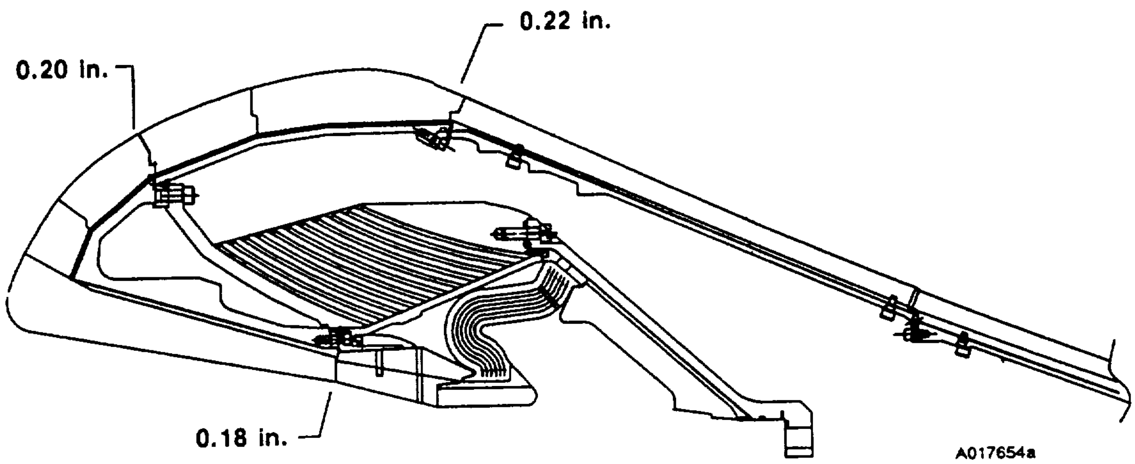

Figure 124 STS-26B Joint Flow Surface Gap Openings

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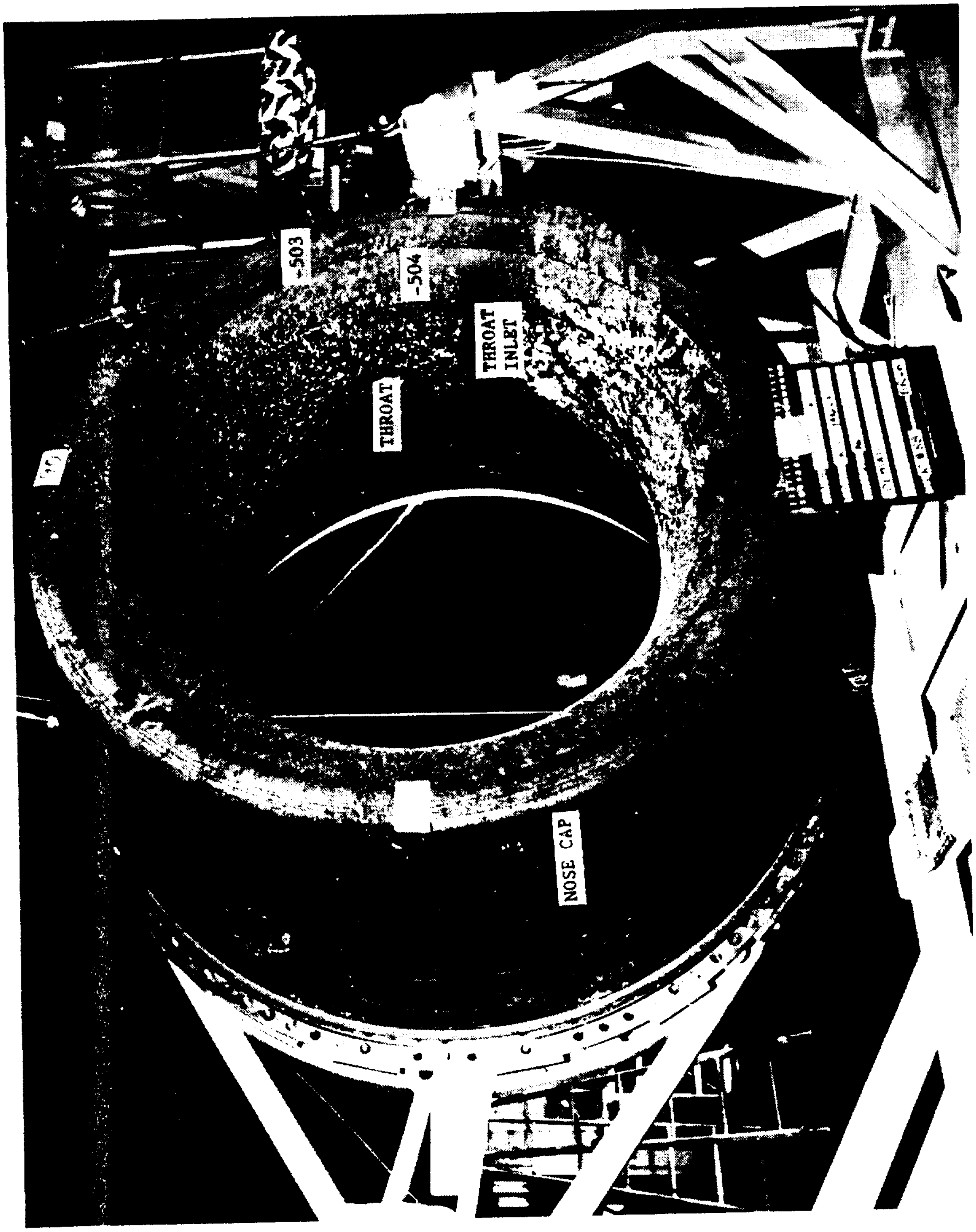

Figure 125 STS-26B Forward Nozzle Assembly

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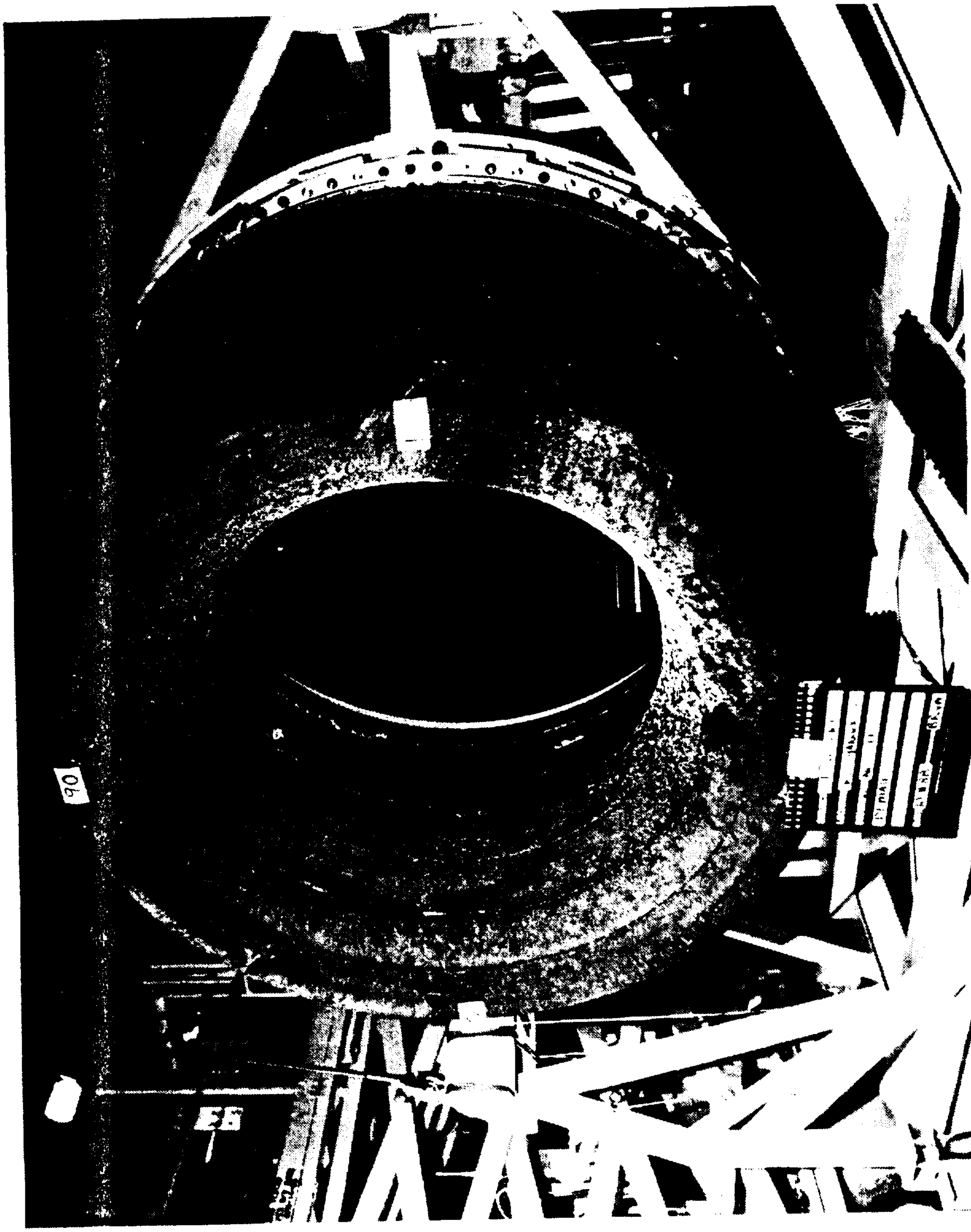

Figure 126 STS-26B Forward Nozzle Assembly

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Figure 127 STS-26B Forward Nozzle Assembly (External) 0° to 90° to 180°

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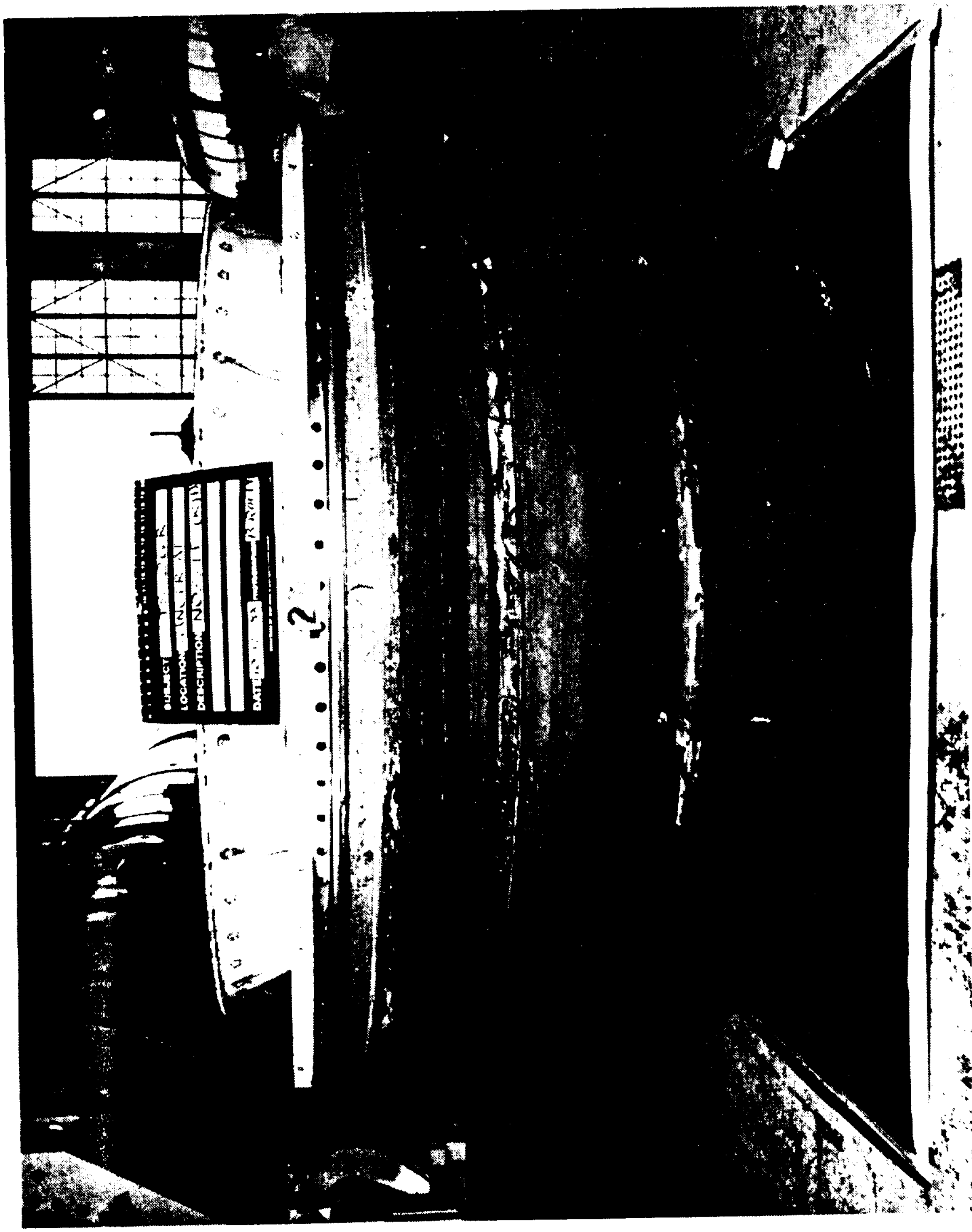

Figure 128 STS-26B Forward Nozzle Assembly (External) 180° to 270° to 0°

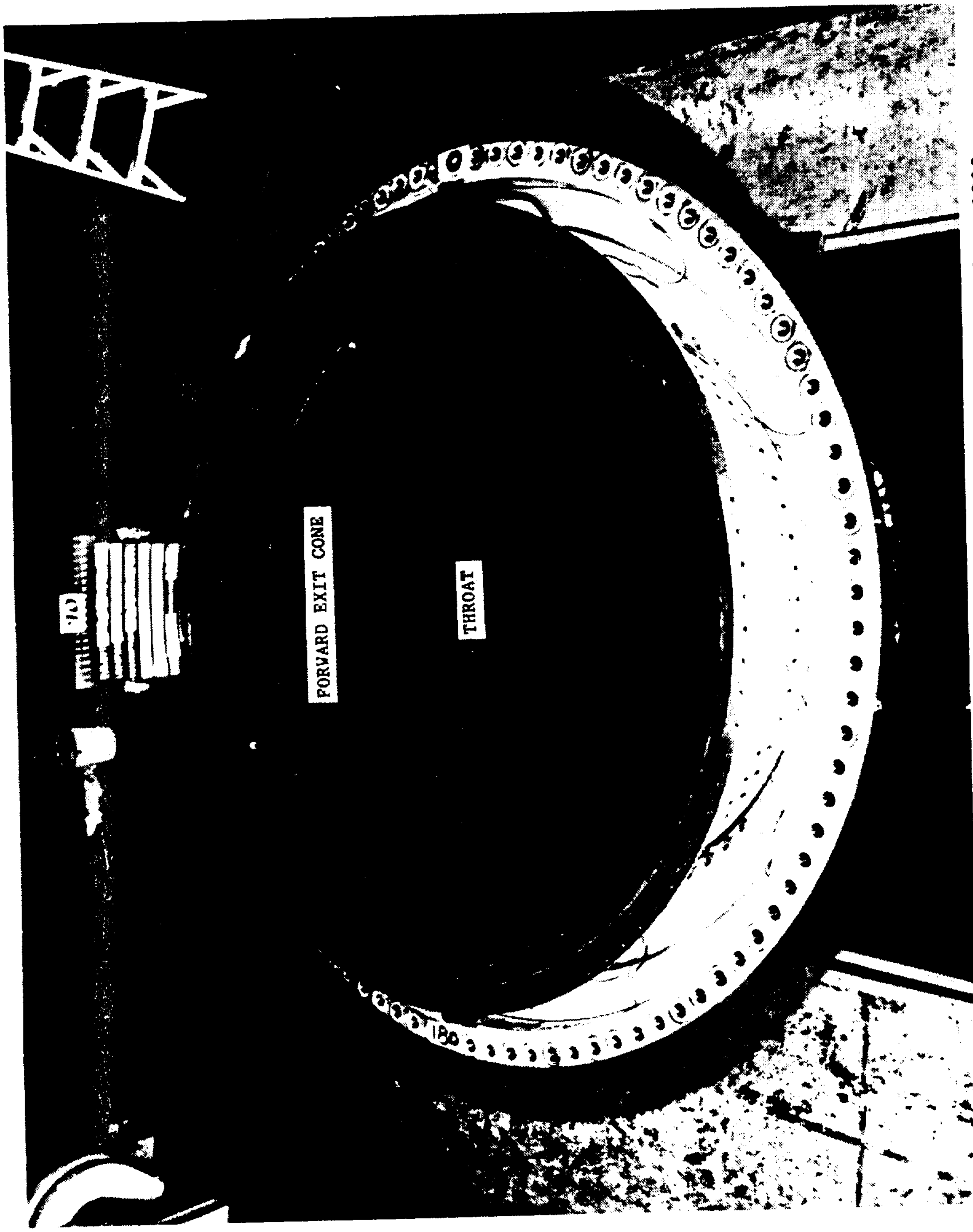

Figure 129 STS-26B Forward Nozzle Assembly (Internal) 0° to 90° to 180°

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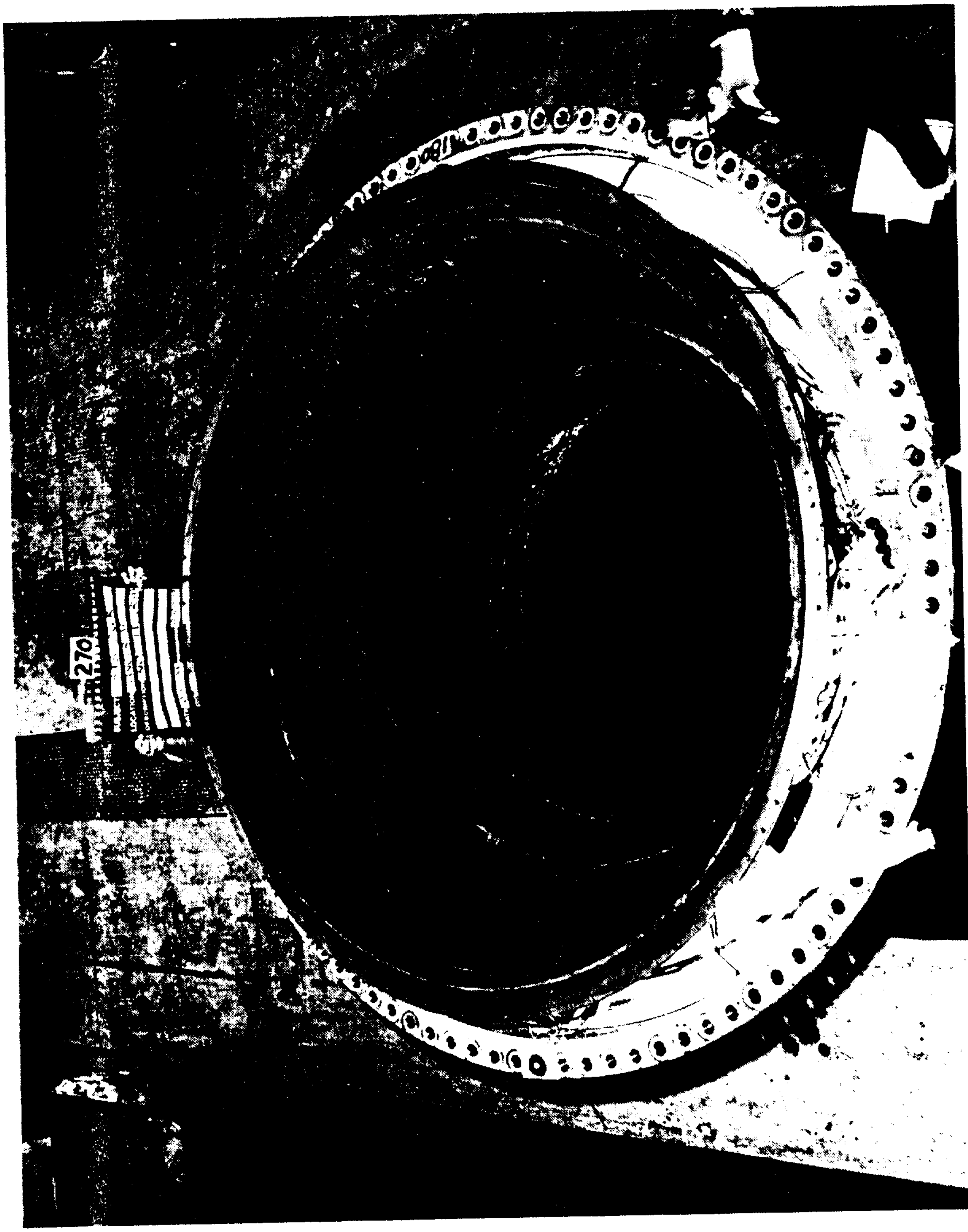

Figure 130 STS-26B Forward Nozzle Assembly (Internal) 180° to 270° to 0°

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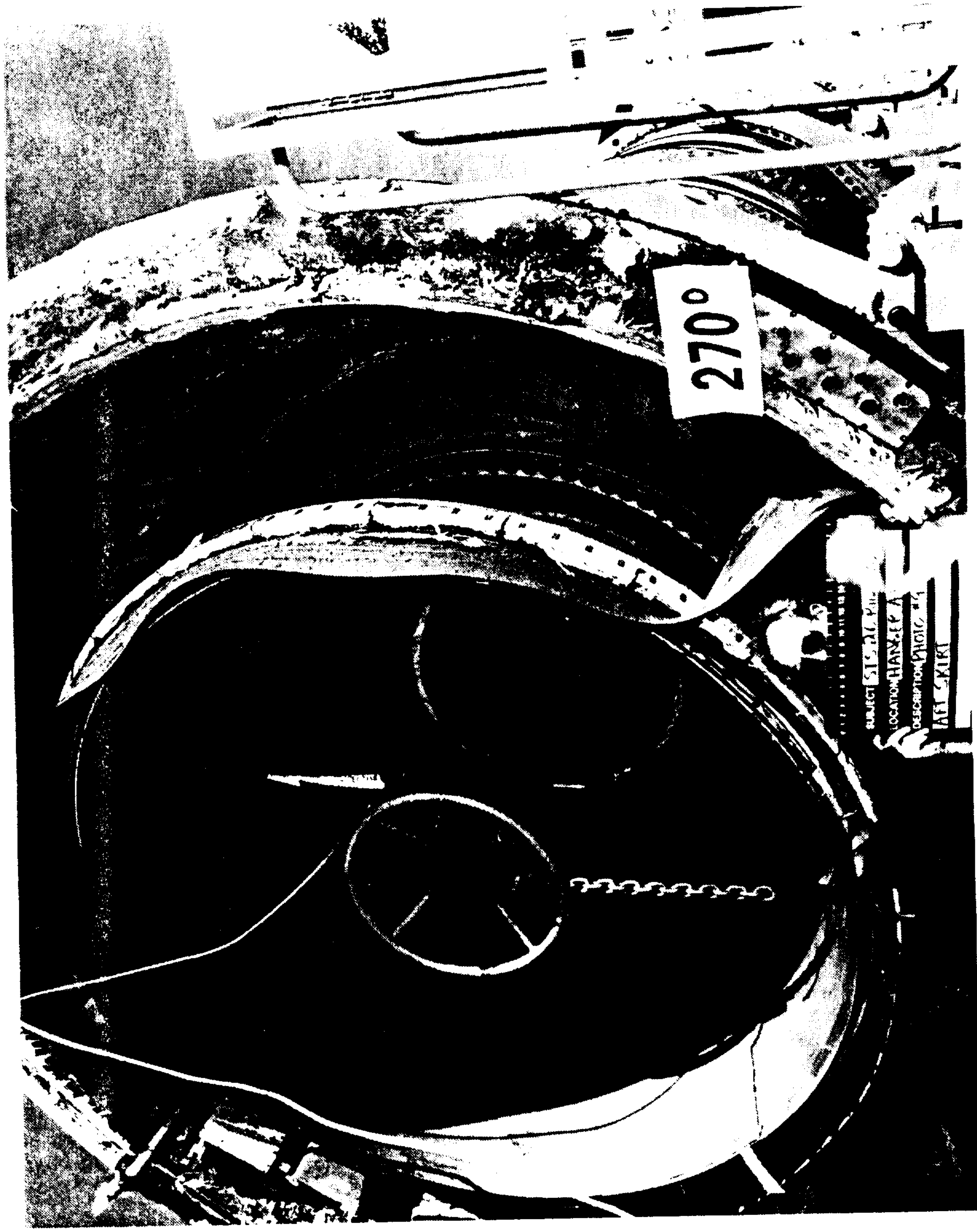
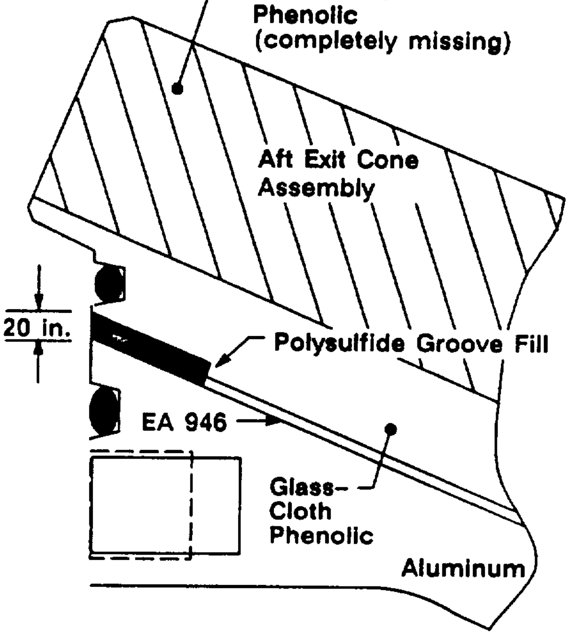


Figure 131 STS-26B Aft Exit Cone Fragment



Angular Location (deg)	Width (in.)
0	0.18
15	0.18
30	0.18
45	0.18
60	0.18
75	0.18
90	0.18
105	0.17
120	0.17
135	0.17
150	0.18
165	0.18
180	0.17
195	0.17
210	0.18
225	0.17
240	0.18
255	0.18
270	0.18
285	0.17
300	0.18
315	0.19
330	0.19
345	0.19

Table 9 STS-26B Aft Exit Cone Post-Flight Polysulfide Groove Radial Widths

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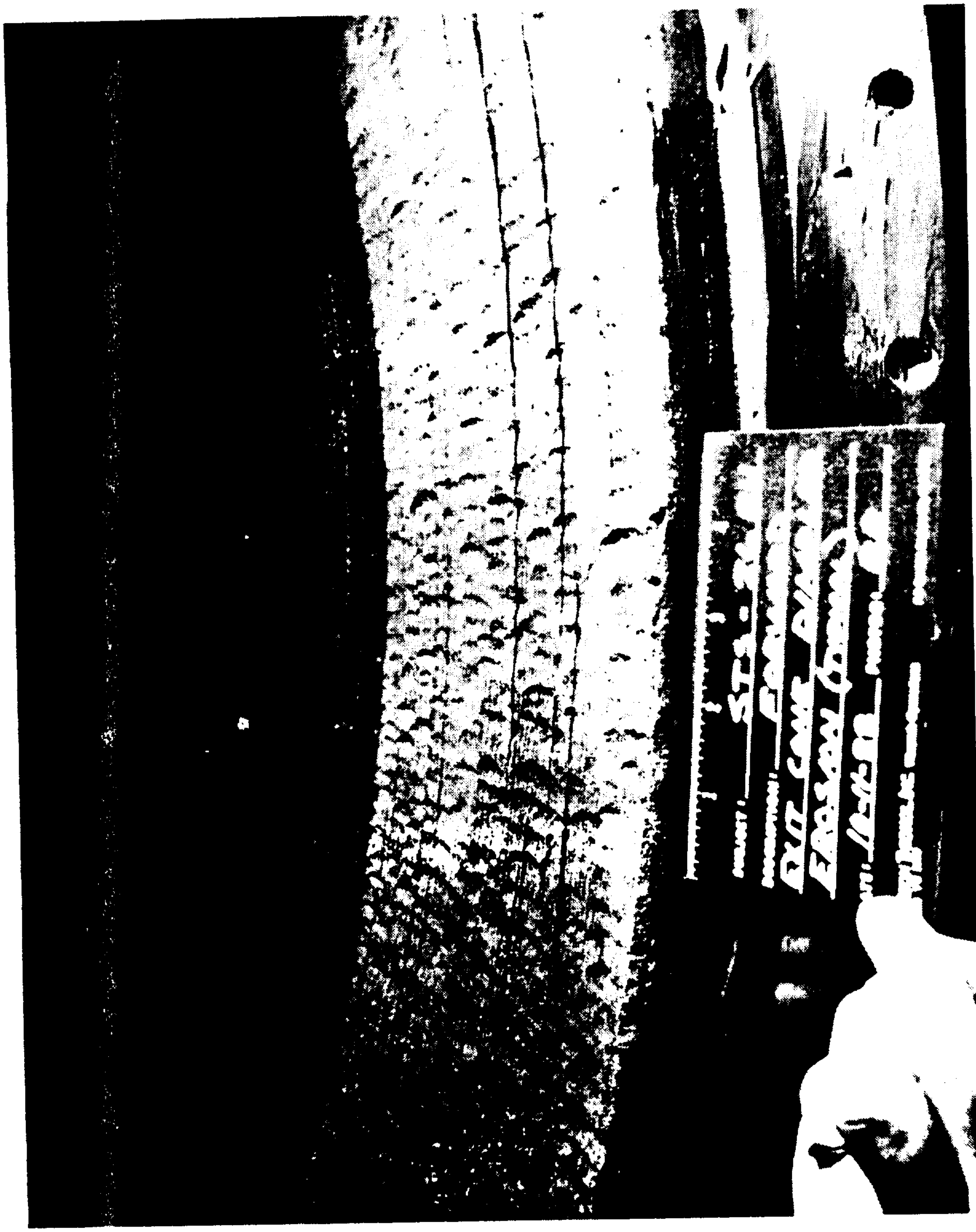
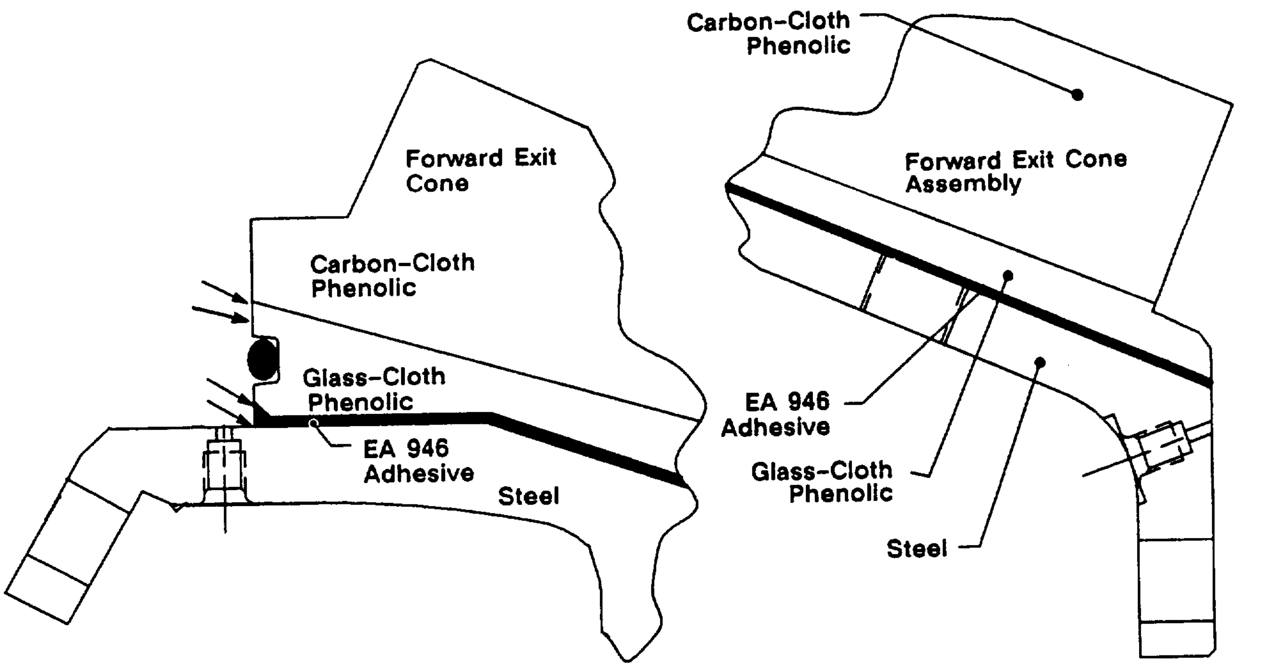


Figure 132 STS-26B Forward Exit Cone Dimpled Erosion



Forward End		
Location (deg)	Radial Separation (in.)	Separation Type
0	0.05	Metal/Adhesive
15	0.03	Metal/Adhesive
30	0.005	Metal/Adhesive
45	0.005	Metal/Adhesive
60	0.005	Metal/Adhesive
60	0.03	GCP
75	0.02	Metal/Adhesive
75	0.03	GCP
90	0.005	Metal/Adhesive
90	0.04	Cohesive
105	0.01	Metal/Adhesive
105	0.02	GCP/CCP
120	0.005	GCP
135	0.005	Metal/Adhesive
150	0.03	Metal/Adhesive
165	0.005	Metal/Adhesive
180	0.005	Metal/Adhesive
195	0.005	Metal/Adhesive
210	0.005	Metal/Adhesive
225	0.005	Metal/Adhesive
240	0.005	Metal/Adhesive
255	0.005	Metal/Adhesive
270	0.01	Metal/Adhesive
285	0.005	Metal/Adhesive
300	0.005	Metal/Adhesive
315	0.005	Metal/Adhesive
330	0.01	Metal/Adhesive
345	0.02	Metal/Adhesive

Figure 133 STS-26B Forward Exit Cone Bondline Separations

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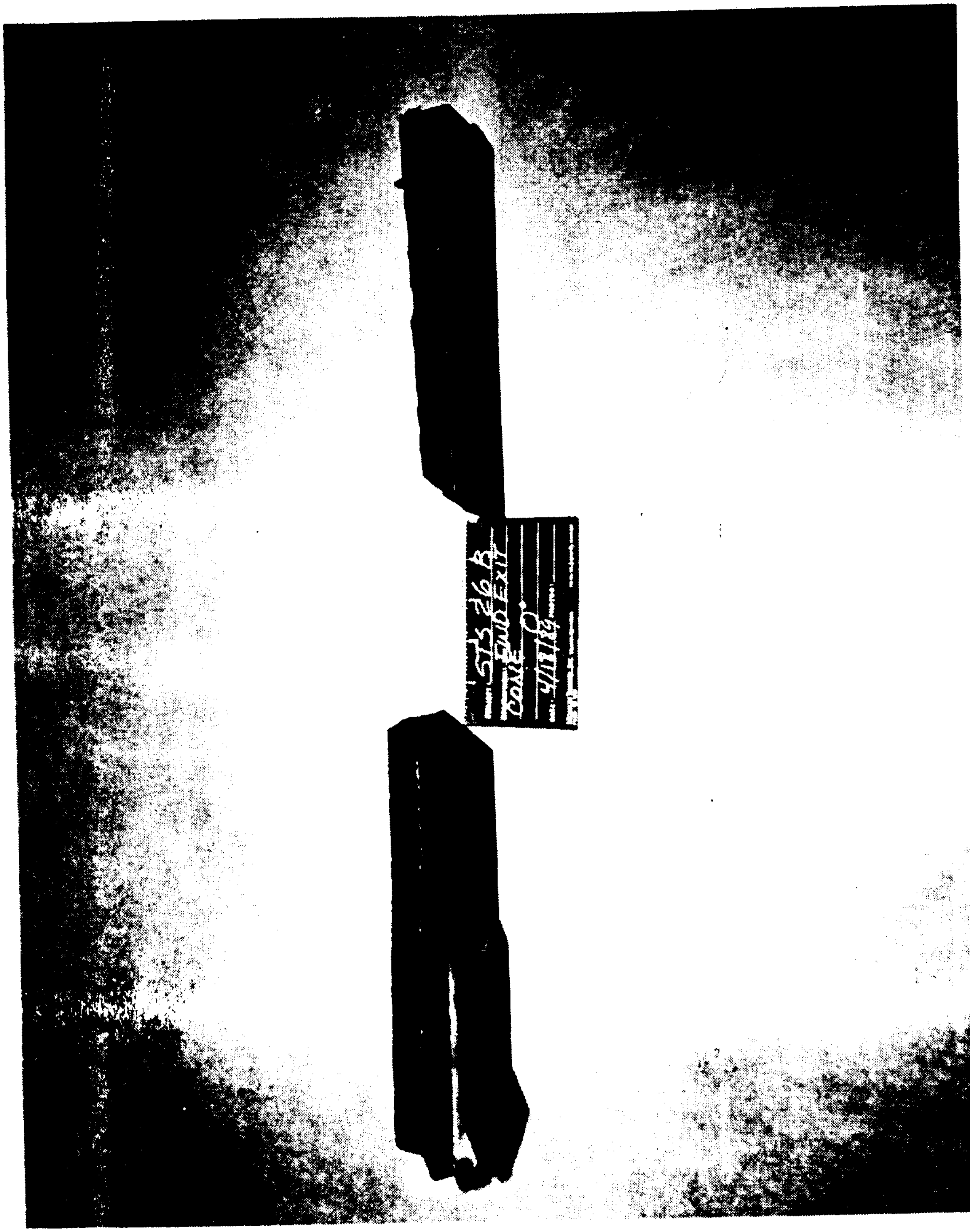

Figure 134 STS-26B Forward Exit Cone Liner Section (0 Degrees)

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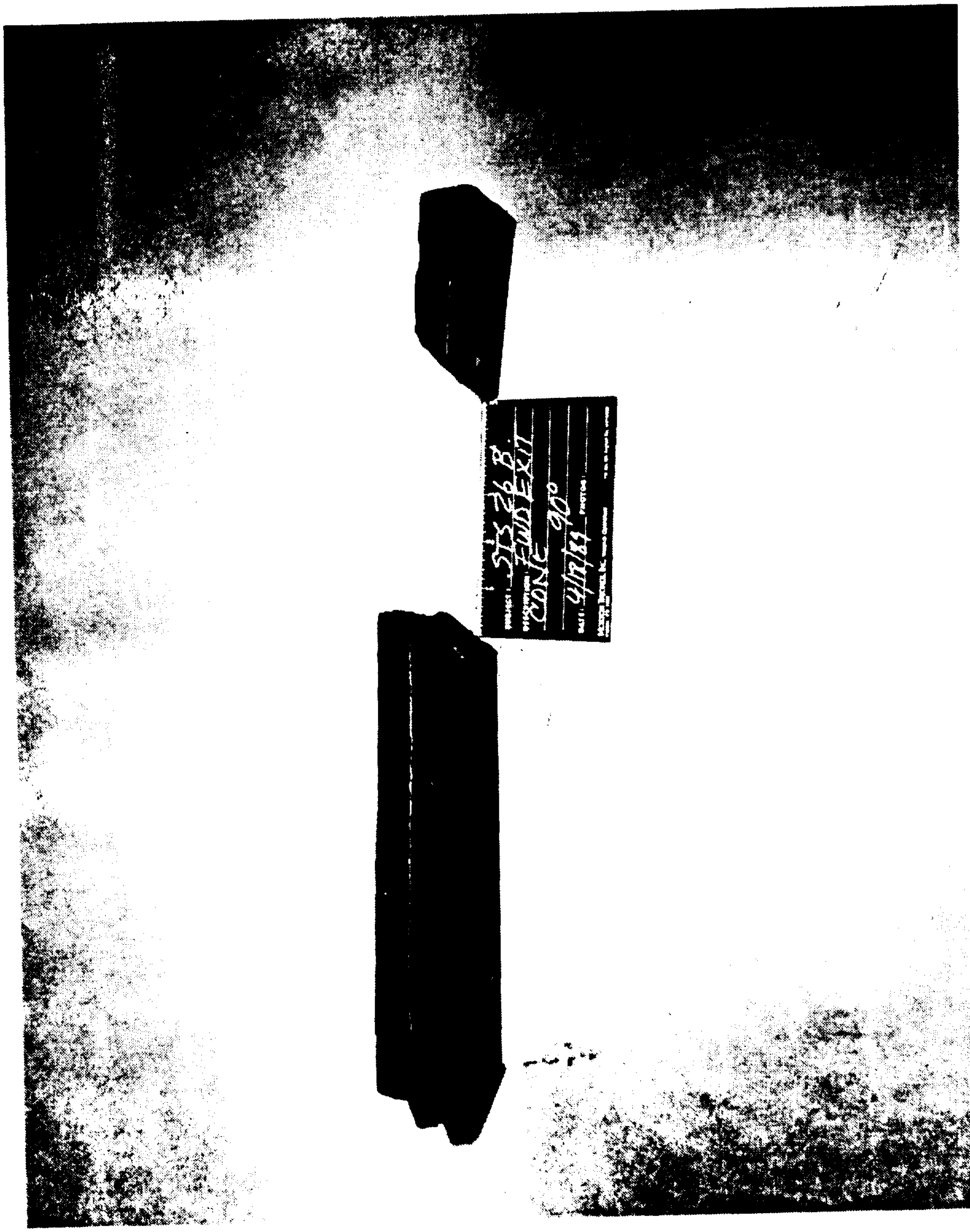

Figure 135 STS-26B Forward Exit Cone Liner Section (90 Degrees)

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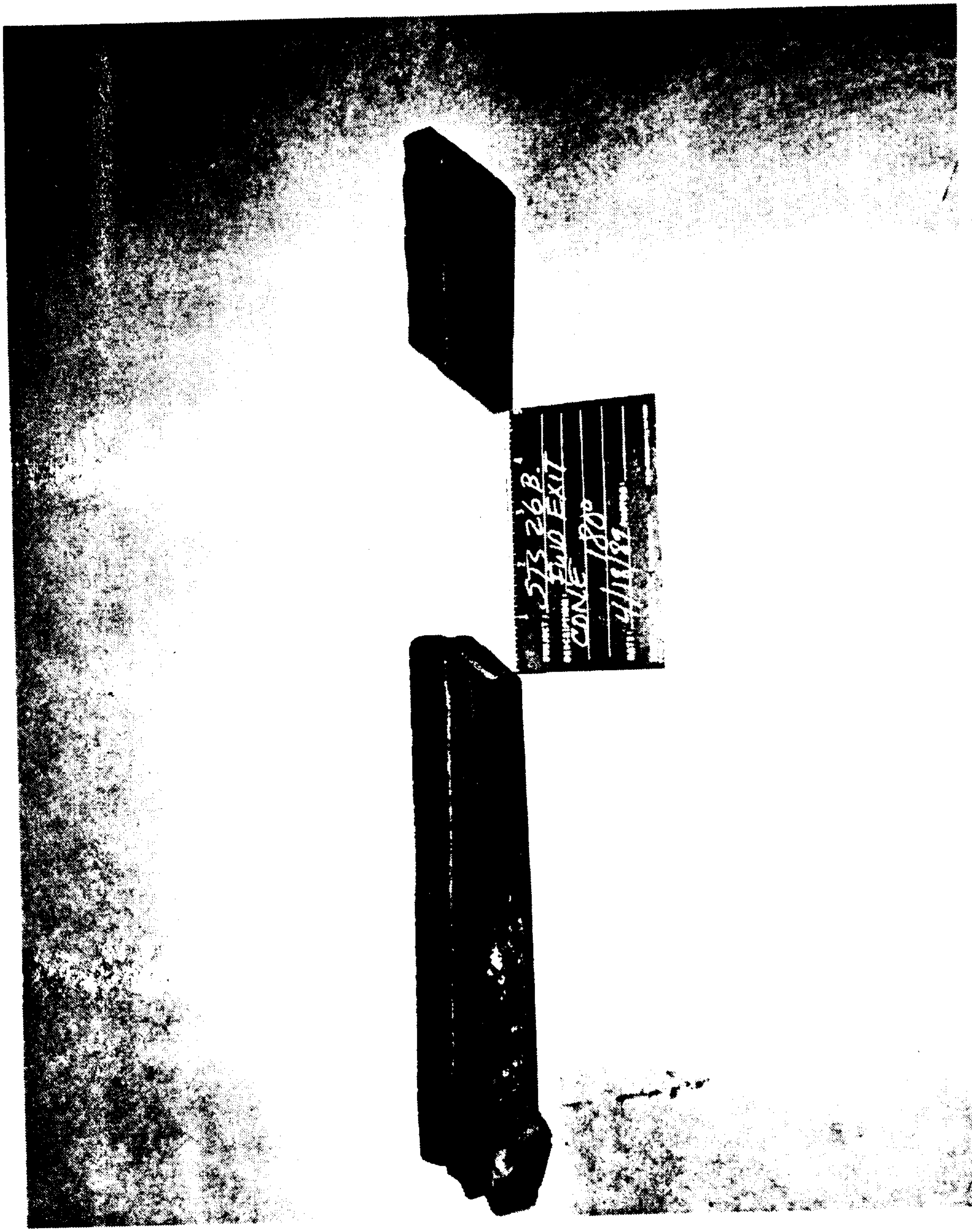

Figure 136 STS-26B Forward Exit Cone Liner Section (180 Degrees)

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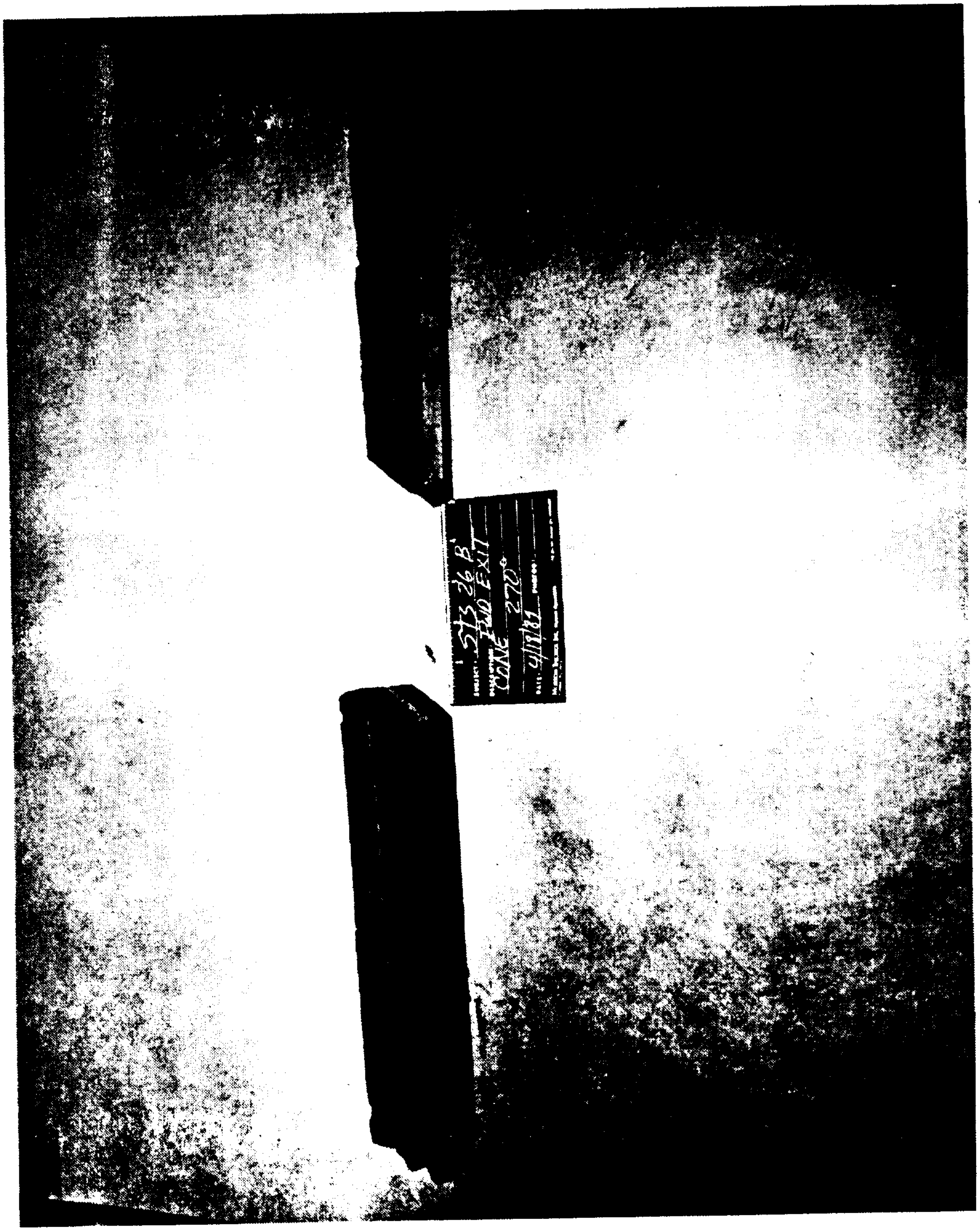

Figure 137 STS-26B Forward Exit Cone Liner Section (270 Degrees)

Table 10 STS-26B Forward Exit Cone Erosion and Char Data

Angular Location	Stations									
	1	4	8	12	16	20	24	28	32	34
0 degrees										
Measured Erosion	0.46	0.34	0.32	NA	NA	NA	NA	0.21	0.19	0.18
Measured Char	0.79	0.81	0.76	NA	NA	NA	NA	0.77	0.79	0.79
Adjusted Char*	0.63	0.65	0.61	NA	NA	NA	NA	0.62	0.63	0.63
2E + 1.25AC	1.71	1.49	1.40	NA	NA	NA	NA	1.19	1.17	1.15
RSRM Min Liner Thickness	1.789	1.714	1.614	1.510	1.414	1.345	1.314	1.321	1.366	1.404
Margin of Safety	0.05	0.15	0.15	NA	NA	NA	NA	0.11	0.17	0.22
90 degrees										
Measured Erosion	0.42	0.30	0.34	NA	NA	NA	NA	NA	0.19	0.19
Measured Char	0.82	0.82	0.74	NA	NA	NA	NA	NA	0.82	0.72
Adjusted Char*	0.66	0.66	0.59	NA	NA	NA	NA	NA	0.66	0.58
2E + 1.25AC	1.66	1.42	1.42	NA	NA	NA	NA	NA	1.20	1.10
RSRM Min Liner Thickness	1.789	1.714	1.614	1.510	1.414	1.345	1.314	1.321	1.366	1.404
Margin of Safety	0.08	0.21	0.14	NA	NA	NA	NA	NA	0.14	0.28
180 degrees										
Measured Erosion	0.45	0.35	0.32	NA	NA	NA	NA	NA	0.21	0.25
Measured Char	0.80	0.77	0.77	NA	NA	NA	NA	NA	0.77	0.77
Adjusted Char*	0.64	0.62	0.62	NA	NA	NA	NA	NA	0.62	0.62
2E + 1.25AC	1.70	1.47	1.41	NA	NA	NA	NA	NA	1.19	1.27
RSRM Min Liner Thickness	1.789	1.714	1.614	1.510	1.414	1.345	1.314	1.321	1.366	1.404
Margin of Safety	0.05	0.17	0.14	NA	NA	NA	NA	NA	0.15	0.11
270 degrees										
Measured Erosion	0.47	0.36	0.35	NA	NA	NA	NA	0.20	0.17	0.16
Measured Char	0.75	0.81	0.83	NA	NA	NA	NA	0.80	0.77	0.78
Adjusted Char*	0.60	0.65	0.66	NA	NA	NA	NA	0.64	0.62	0.62
2E + 1.25AC	1.69	1.53	1.53	NA	NA	NA	NA	1.20	1.11	1.10
RSRM Min Liner Thickness	1.789	1.714	1.614	1.510	1.414	1.345	1.314	1.321	1.366	1.404
Margin of Safety	0.06	0.12	0.05	NA	NA	NA	NA	0.10	0.23	0.28

* Measured Char Adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

Refer to Figure 18 for Station Locations

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Figure 138 STS-26B Forward Exit Cone Corrosion (0 Degrees)

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Figure 139 STS-26B Forward Exit Cone Corrosion (80 Degrees)

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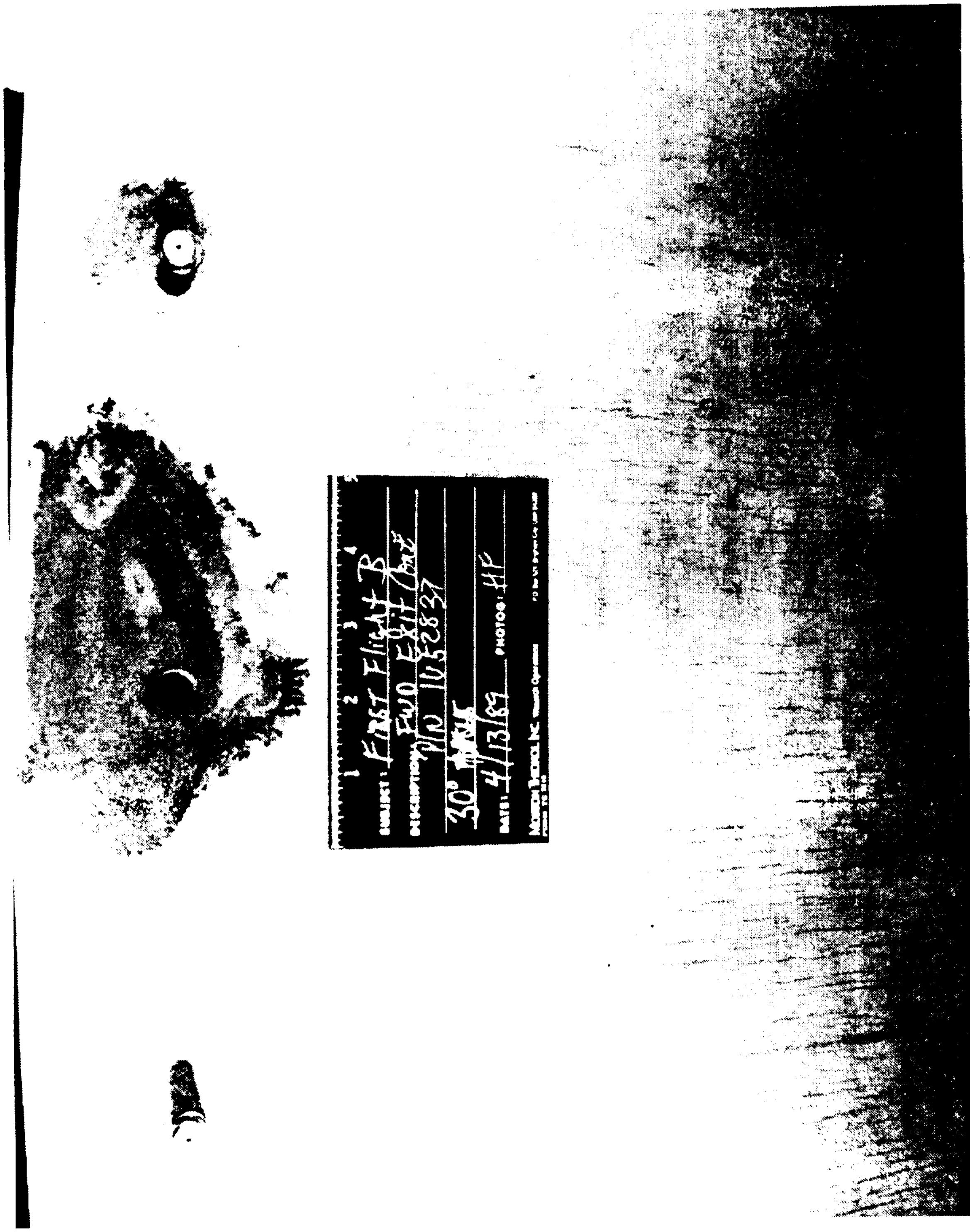

Figure 140 STS-26B Forward Exit Cone Corrosion (30 Degrees)

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Figure 141 STS-26B Forward Exit Cone Corrosion (60 Degrees)

MORTON THIOKOL, INC.
Aerospace Group

Space Operations

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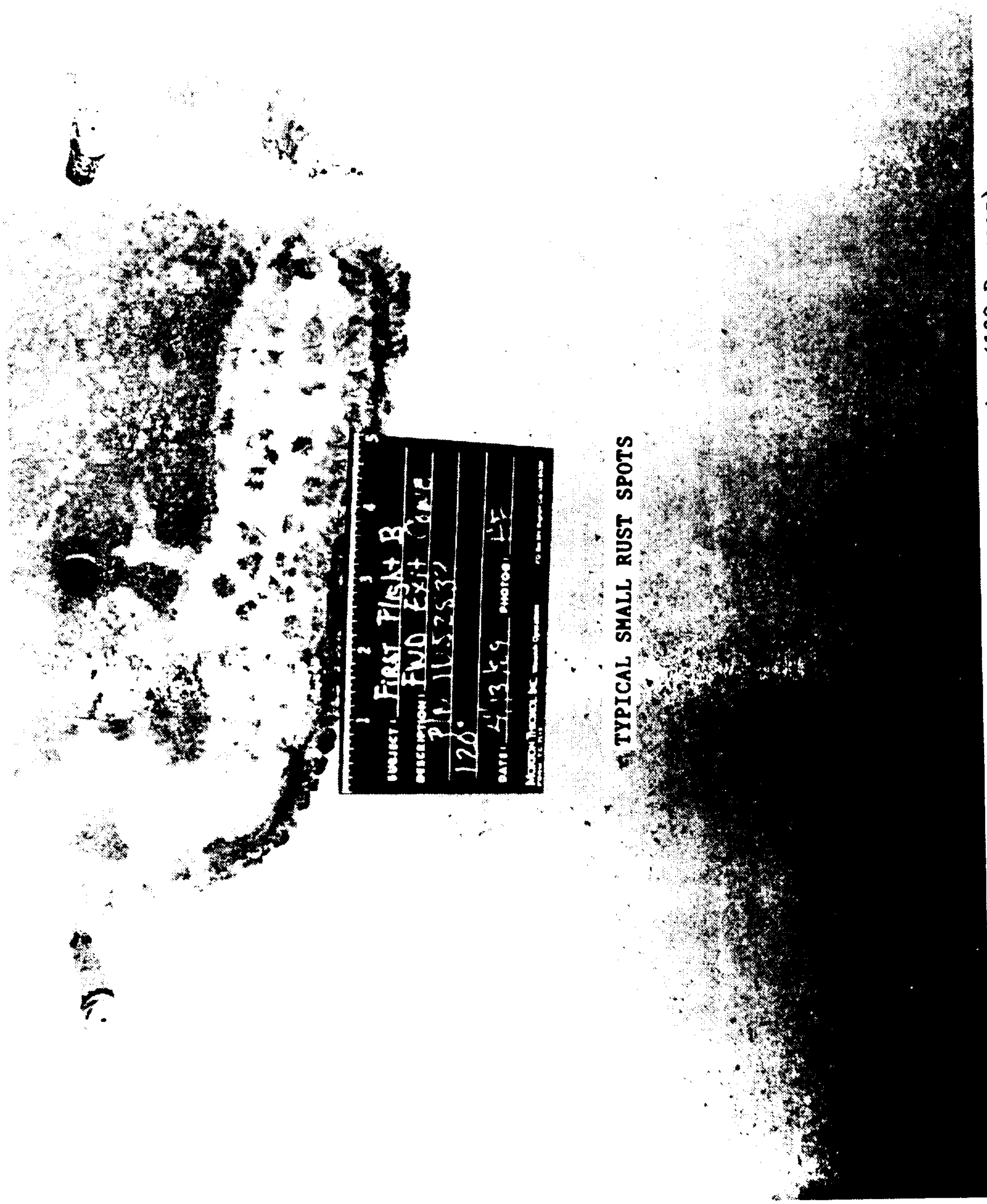

Figure 142 STS-26B Forward Exit Cone Corrosion (120 Degrees)

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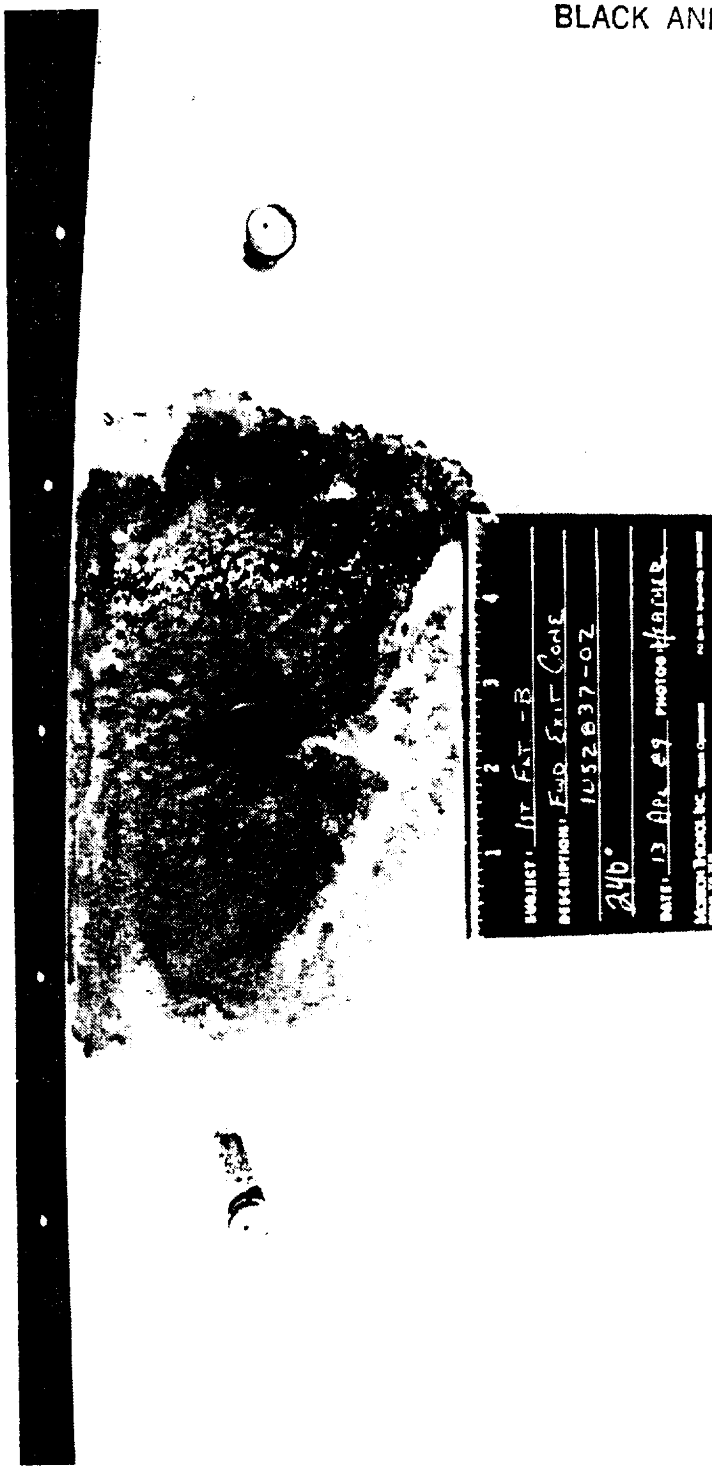

Figure 143 STS-26B Forward Exit Cone Corrosion (240 Degrees)

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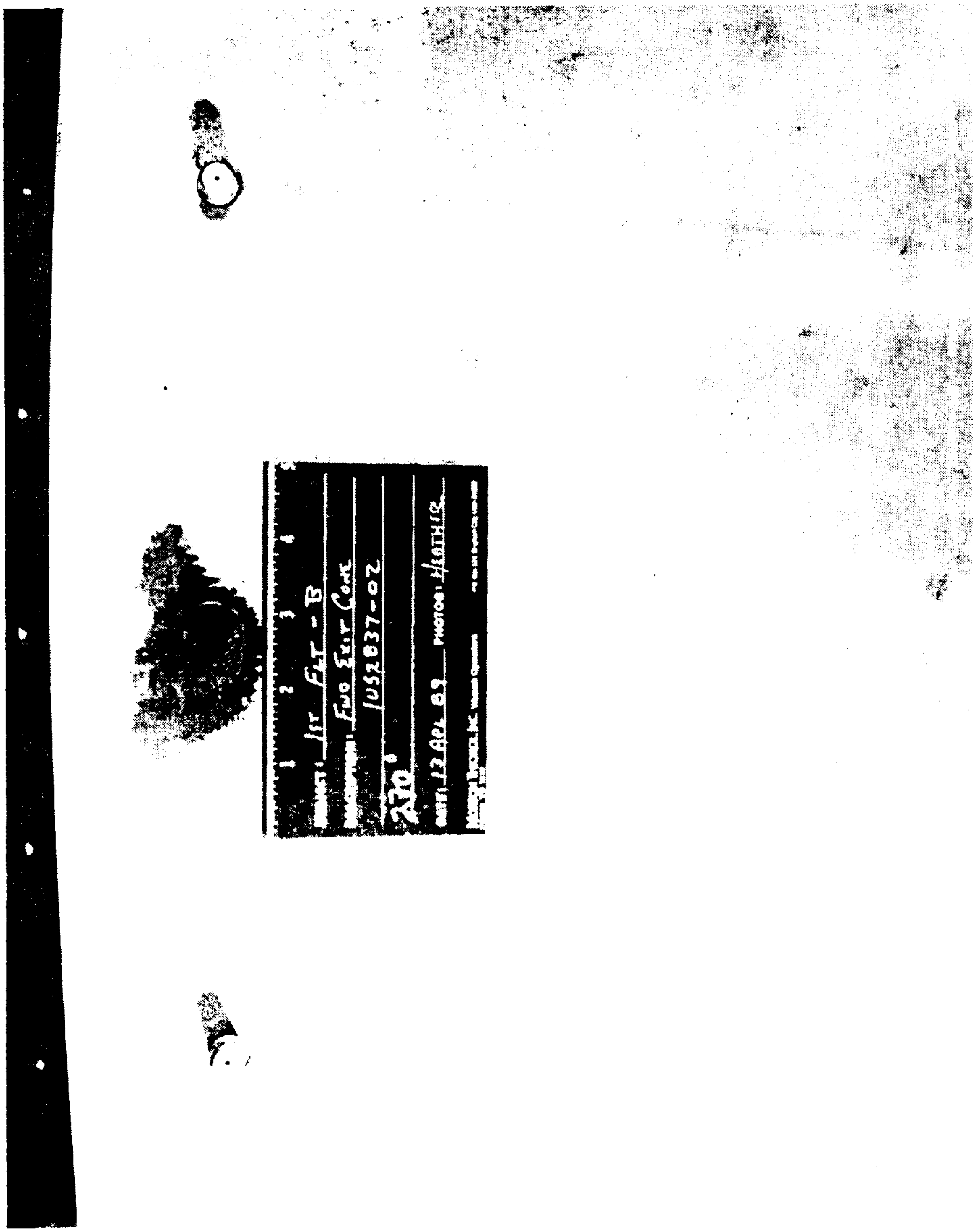

Figure 144 STS-26B Forward Exit Cone Corrosion (270 Degrees)

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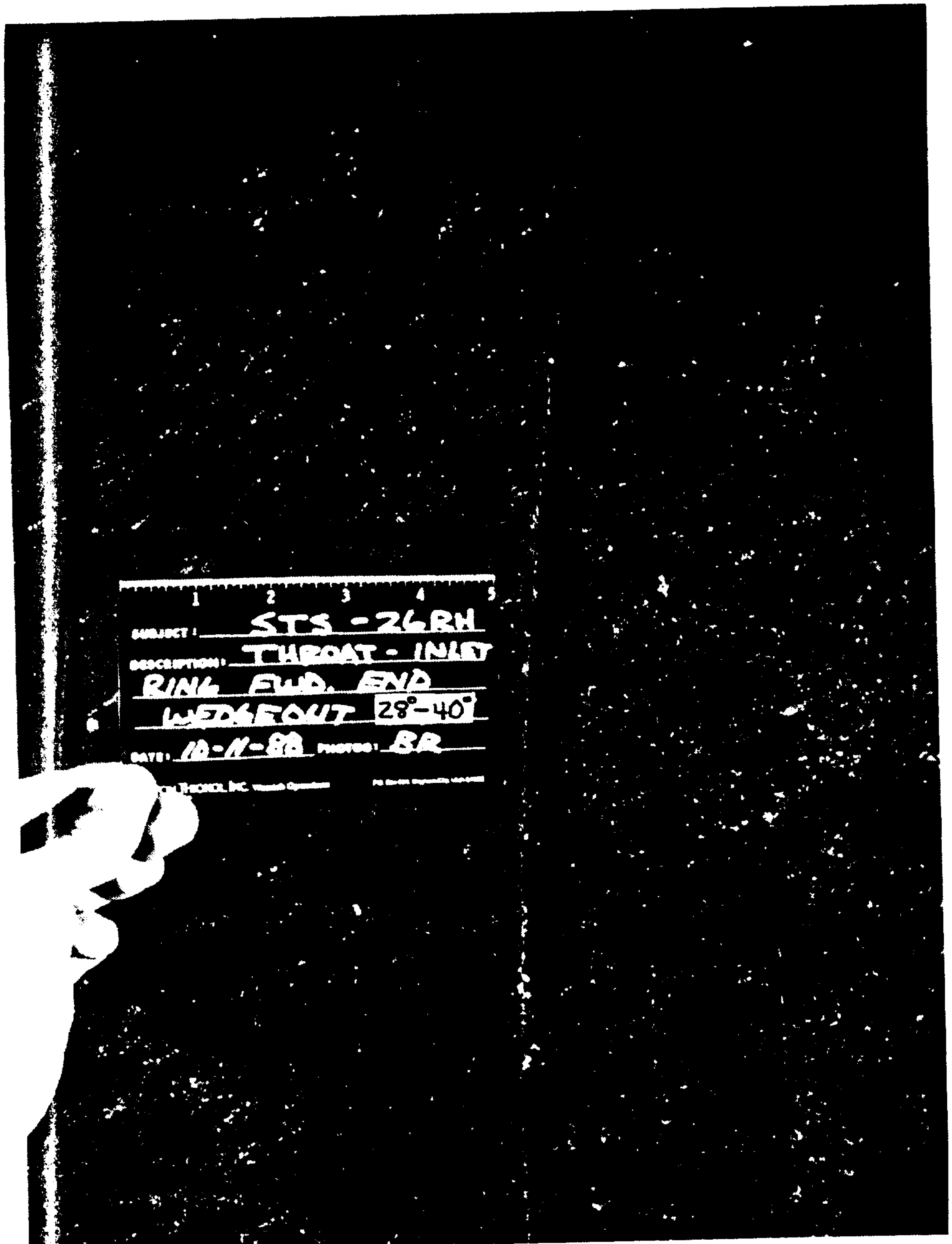
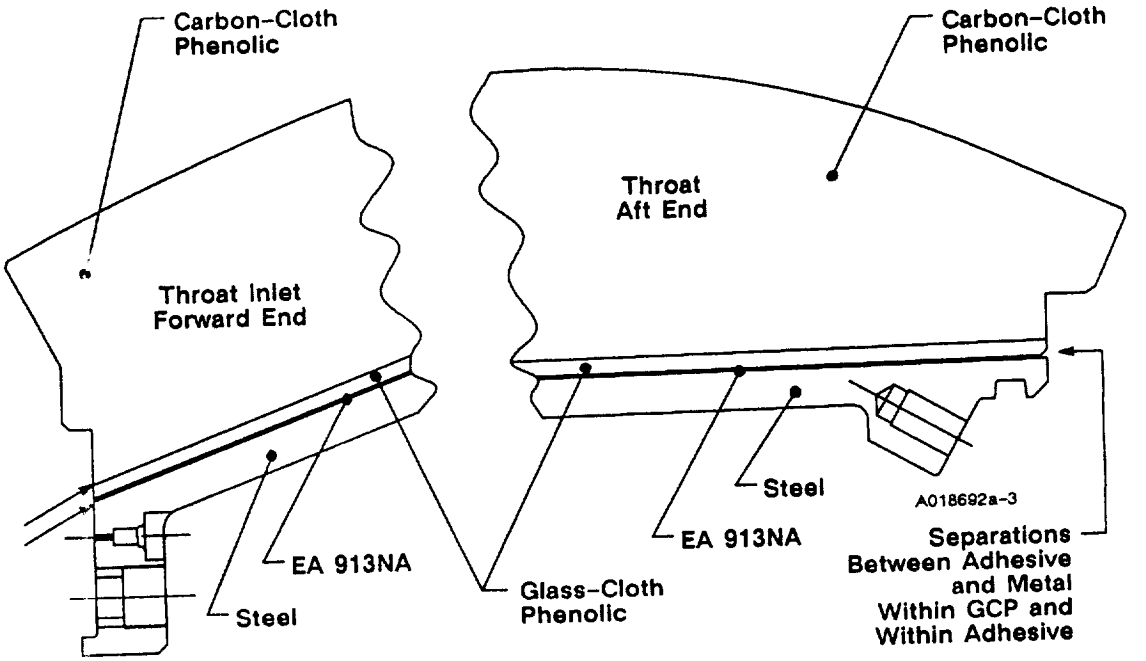


Figure 145 STS-26B Throat Inlet Ring Wedgeout (28 - 40 Degrees)



Fwd End Bondline Separations

Location (deg)	Radial Separation (in.)	Separation Type
0	0.030	Metal/Adhesive
15	0.030	Metal/Adhesive
30	0.030	Metal/Adhesive
45	0.030	Metal/Adhesive
60	0.030	Metal/Adhesive
75	0.020	Metal/Adhesive
90	0.030	Metal/Adhesive
105	0.030	Metal/Adhesive
120	0.030	Metal/Adhesive
135	0.020	Metal/Adhesive
150	0.030	Metal/Adhesive
165	0.030	Metal/Adhesive
180	0.020	Metal/Adhesive
195	0.020	Metal/Adhesive
210	0.020	Metal/Adhesive
225	0.030	Metal/Adhesive
240	0.020	GCP/CCP
240	0.020	Metal/Adhesive
255	0.020	GCP/CCP
250	0.020	GCP/CCP

Aft End Bondline Separations

Location (deg)	Radial Separation (in.)	Separation Type
0	0.030	Metal/Adhesive
15	0.030	GCP
30	0.020	Metal/Adhesive
45	0.040	Within Adhesive
60	0.040	Metal/Adhesive
75	0.040	Metal/Adhesive
90	0.030	Metal/Adhesive
105	0.040	Within Adhesive
120	0.040	Metal/Adhesive
135	0.050	Metal/Adhesive
150	0.050	Metal/ADhesive
165	0.050	Metal/Adhesive
180	0.040	Metal/Adhesive
195	0.020	Metal/Adhesive
210	0.020	Metal/Adhesive
225	0.010	Metal/Adhesive
240	0.030	Metal/Adhesive
255	0.010	Metal/Adhesive
270	0.020	Metal/Adhesive
285	0.010	Metal/Adhesive
300	0.030	Metal/Adhesive
315	0.030	Metal/Adhesive
330	0.030	Metal/Adhesive
345	0.010	Metal/Adhesive
345	0.010	Adhesive/GCP

Figure 146 STS-26B Throat Assembly Bondline Separations

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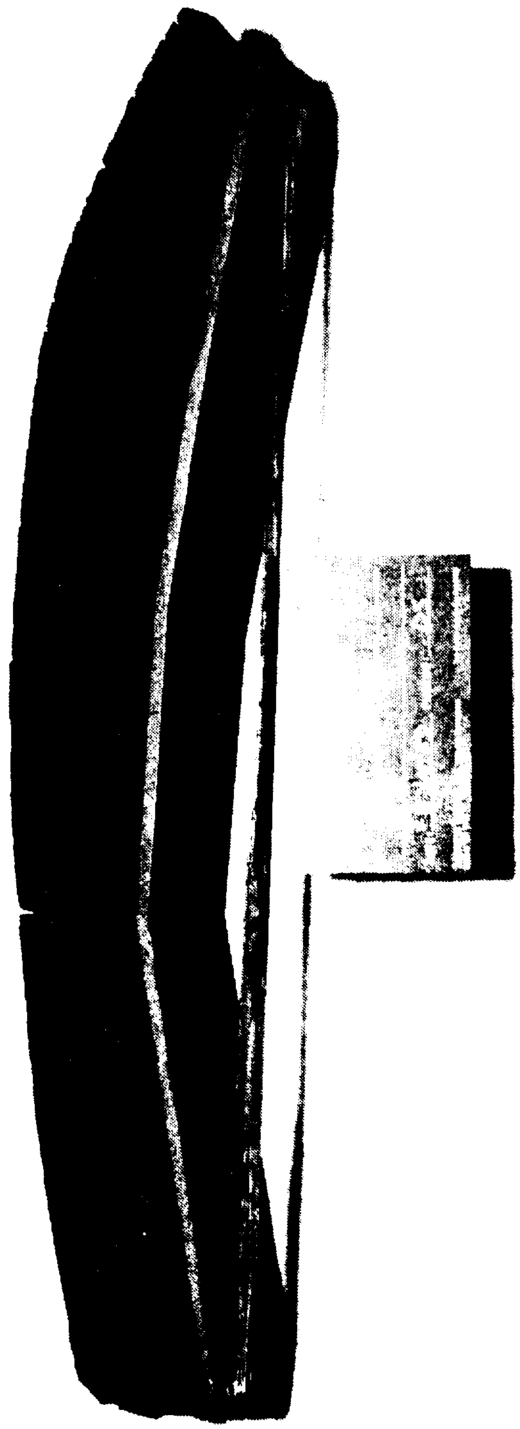

Figure 147 STS-26B Throat/Throat Inlet Section (0 Degrees)

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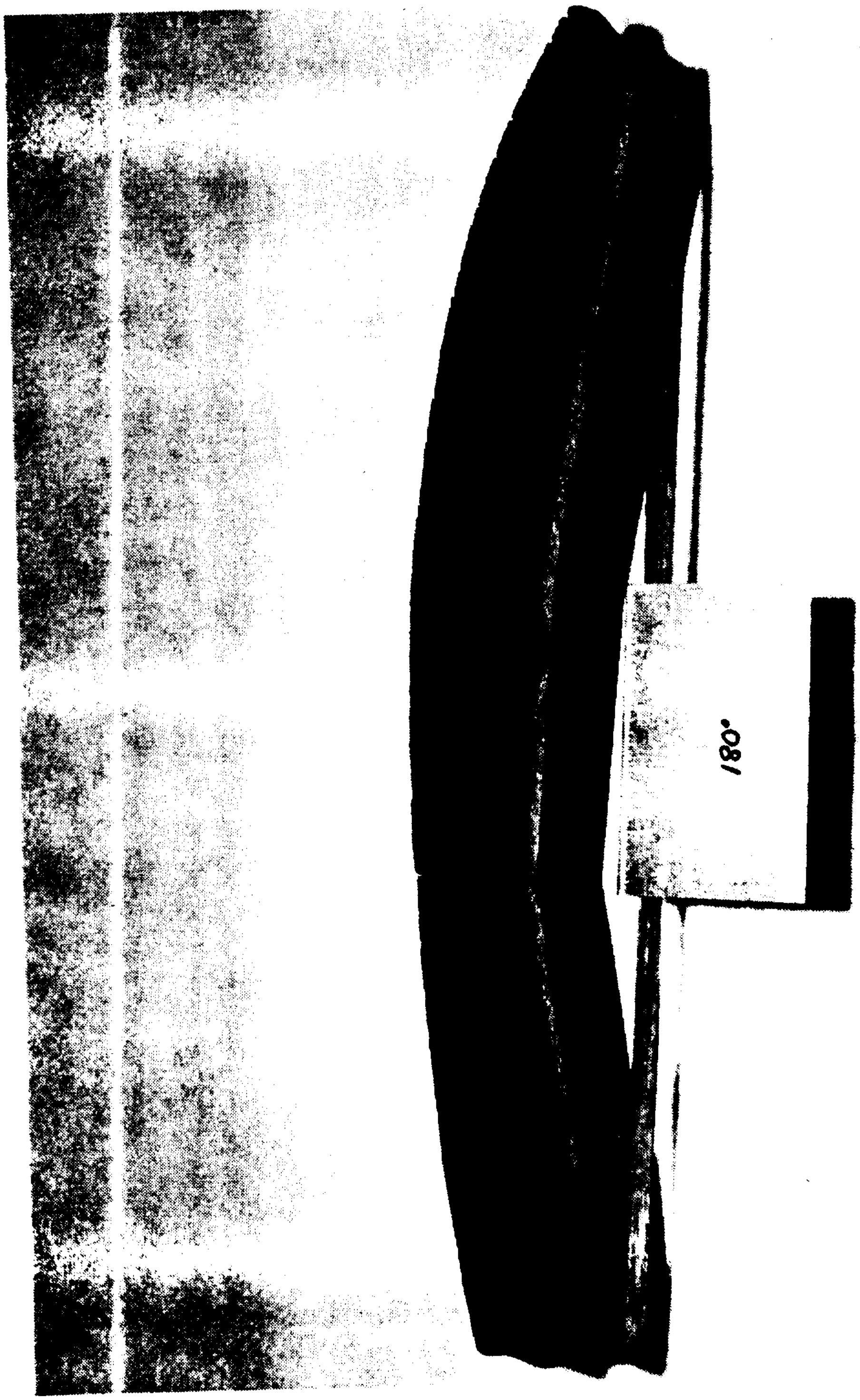

Figure 148 STS-26B Throat/Throat Inlet Section (180 Degrees)

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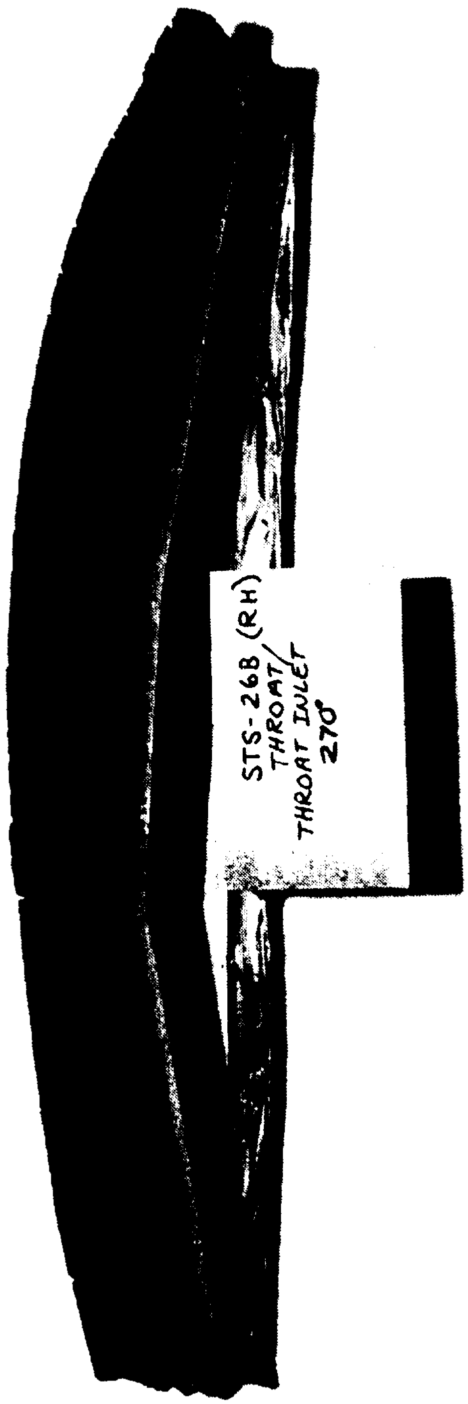

Figure 149 STS-26B Throat/Throat Inlet Section (270 Degrees)

Table 11 STS-26B Throat Assembly Erosion and Char Data

Angular Location	Stations 1	2	4	6	8	10	12	14	16	18	20	22	23
0 degrees													
Measured Erosion	0.98	1.03	1.03	1.15	1.18	1.10	1.06	1.06	1.05	0.88	0.71	0.49	0.43
Measured Char	0.61	0.62	0.64	0.64	0.60	0.54	0.64	0.66	0.66	0.70	0.67	0.79	0.86
Adjusted Char *	0.46	0.47	0.48	0.48	0.45	0.41	0.48	0.50	0.50	0.53	0.50	0.59	0.65
2E + 1.25AC	2.53	2.64	2.66	2.90	2.92	2.71	2.72	2.74	2.72	2.42	2.05	1.72	1.67
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.189	3.397	3.517	3.626	3.710	3.586	3.232	2.583	2.110
Margin of Safety	0.25	0.23	0.25	0.13	0.09	0.26	0.29	0.32	0.36	0.48	0.58	0.50	0.27
90 degrees													
Measured Erosion	1.06	1.10	1.13	1.20	1.14	1.09	1.09	1.02	1.02	0.83	0.64	0.43	0.41
Measured Char	0.56	0.54	0.65	0.60	0.62	0.59	0.57	0.60	0.59	0.67	0.76	0.79	0.81
Adjusted Char *	0.42	0.41	0.49	0.45	0.47	0.44	0.43	0.45	0.44	0.50	0.57	0.59	0.61
2E + 1.25AC	2.65	2.71	2.87	2.96	2.86	2.73	2.71	2.60	2.59	2.29	1.99	1.60	1.58
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.189	3.397	3.517	3.626	3.710	3.586	3.232	2.583	2.110
Margin of Safety	0.20	0.20	0.15	0.11	0.11	0.24	0.30	0.39	0.43	0.57	0.62	0.61	0.34
180 degrees													
Measured Erosion	1.08	1.11	1.18	1.19	1.21	1.14	1.10	1.10	1.06	0.94	0.70	0.53	0.45
Measured Char	0.58	0.55	0.56	0.58	0.60	0.58	0.56	0.50	0.50	0.61	0.75	0.74	0.79
Adjusted Char *	0.44	0.41	0.42	0.44	0.45	0.44	0.42	0.38	0.38	0.46	0.56	0.56	0.59
2E + 1.25AC	2.70	2.74	2.89	2.92	2.98	2.82	2.73	2.67	2.59	2.45	2.10	1.75	1.64
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.189	3.397	3.517	3.626	3.710	3.586	3.232	2.583	2.110
Margin of Safety	0.17	0.19	0.15	0.12	0.07	0.20	0.29	0.36	0.43	0.46	0.54	0.47	0.29
270 degrees													
Measured Erosion	1.06	1.10	1.15	1.17	1.14	1.12	1.07	1.07	1.03	0.92	0.68	0.50	0.44
Measured Char	0.50	0.53	0.58	0.59	0.60	0.53	0.55	0.57	0.59	0.65	0.67	0.76	0.78
Adjusted Char *	0.38	0.40	0.44	0.44	0.45	0.40	0.41	0.43	0.44	0.49	0.50	0.57	0.59
2E + 1.25AC	2.59	2.70	2.84	2.89	2.84	2.74	2.66	2.67	2.61	2.45	1.99	1.71	1.61
RSRM Min Liner Thickness	3.174	3.247	3.314	3.280	3.189	3.397	3.517	3.626	3.710	3.586	3.232	2.583	2.110
Margin of Safety	0.23	0.20	0.17	0.13	0.12	0.24	0.32	0.36	0.42	0.46	0.63	0.51	0.31

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

Refer to Figure 25 for Station Locations

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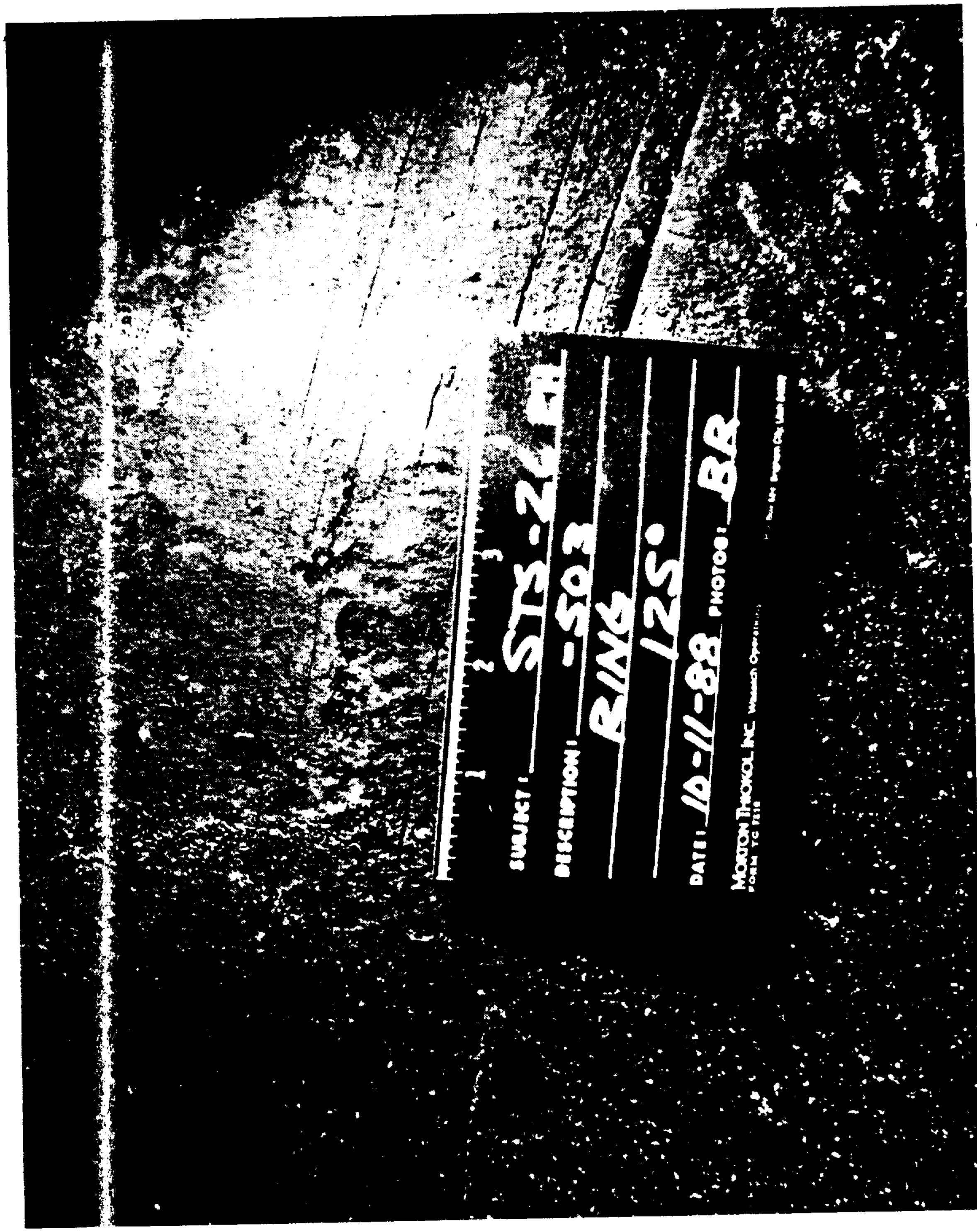

Figure 150 STS-26B (-503) Ring Impact Marks (125 Degrees)

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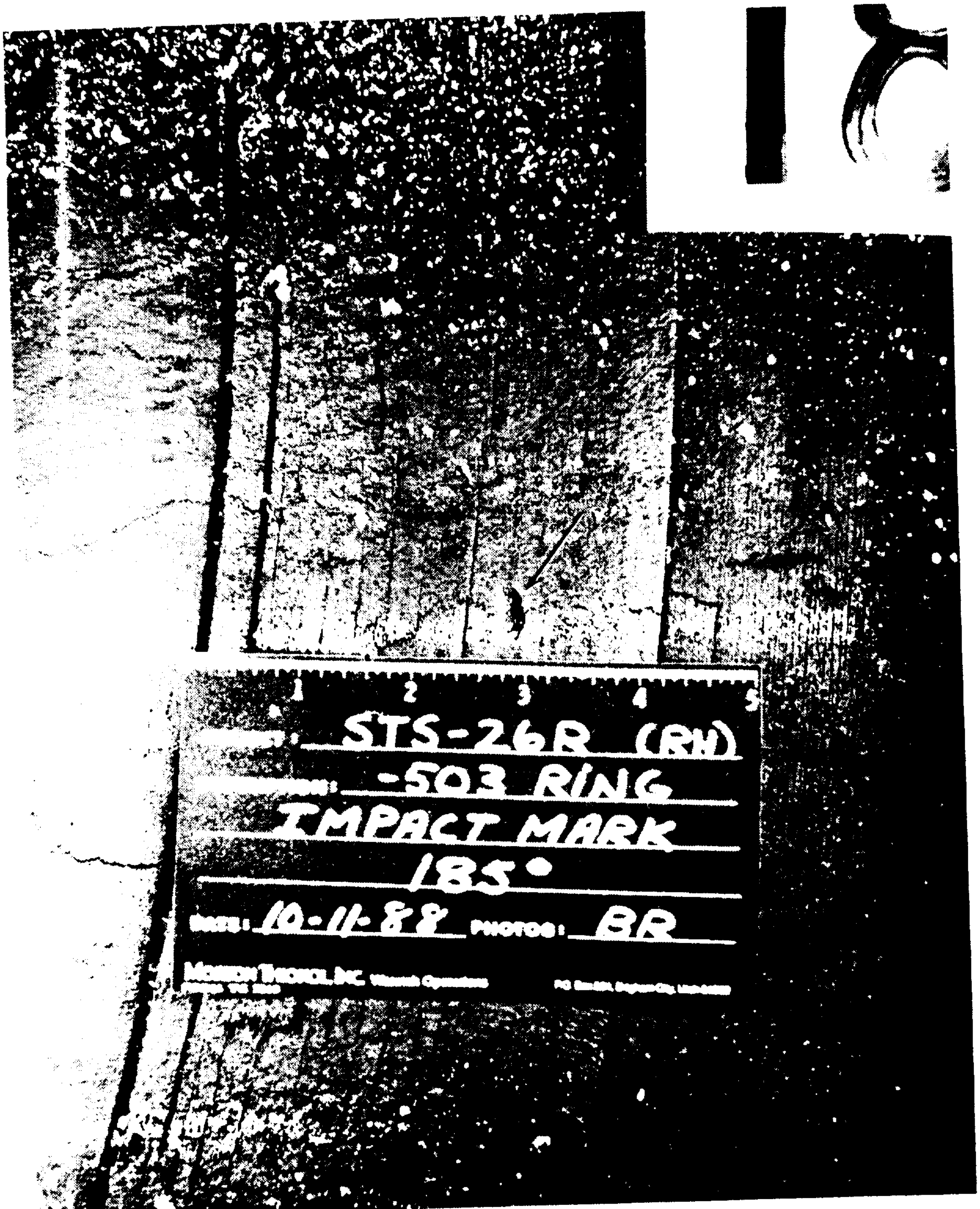

Figure 151 STS-26B (-503) Ring Impact Marks (185 Degrees)

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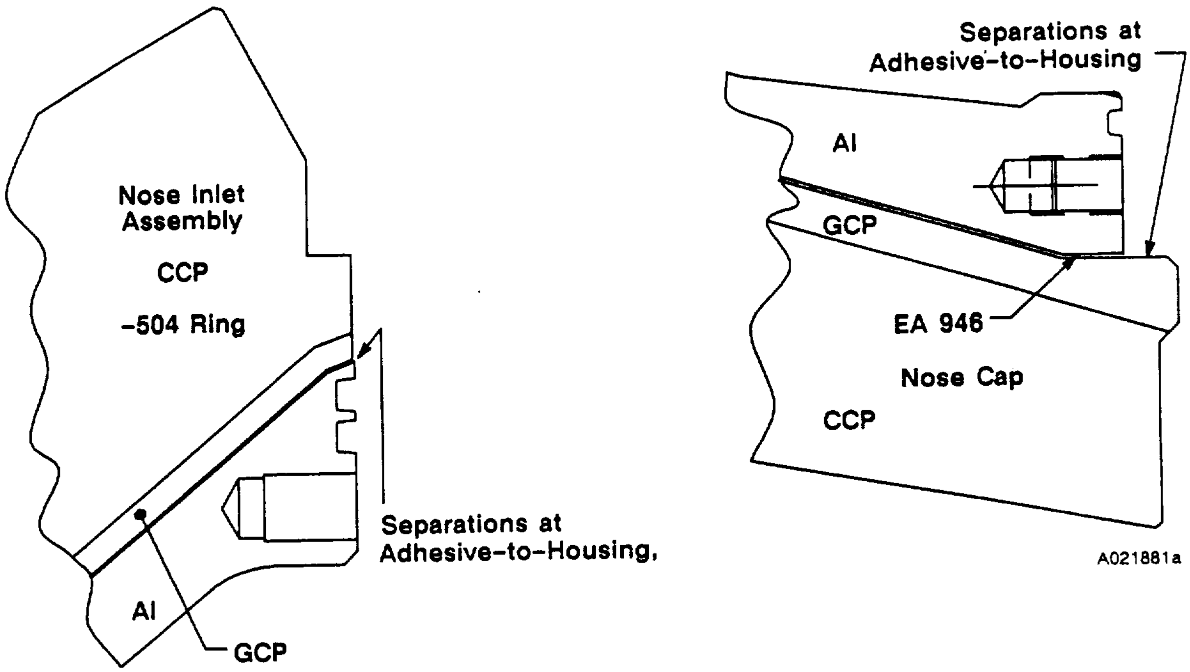
Figure 152 STS-26B Typical Nose Cap Aft End Wedgeout (Post-Burn) (170 Degrees)



Location (deg)	Radial Separation (in.)	Separation Type*
238-245	0.020	Metal/Adhesive
250	0.020	Metal/Adhesive

Location (deg)	Radial Separation (in.)	Separation Type*
105	0.005	Metal/Adhesive
135	0.005	Metal/Adhesive
150	0.005	Metal/Adhesive
165	0.005	Metal/Adhesive
180	0.005	Metal/Adhesive
195	0.005	Metal/Adhesive
210	0.005	Metal/Adhesive
225	0.005	Metal/Adhesive
240	0.005	Metal/Adhesive
255	0.005	Metal/Adhesive
285	0.005	Metal/Adhesive
300	0.005	Metal/Adhesive
315	0.005	Metal/Adhesive
345	0.005	Metal/Adhesive

Figure 153 STS-26B Nose Inlet Assembly Bondline Separations

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Figure 154 STS-26B Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section (0 Degrees)

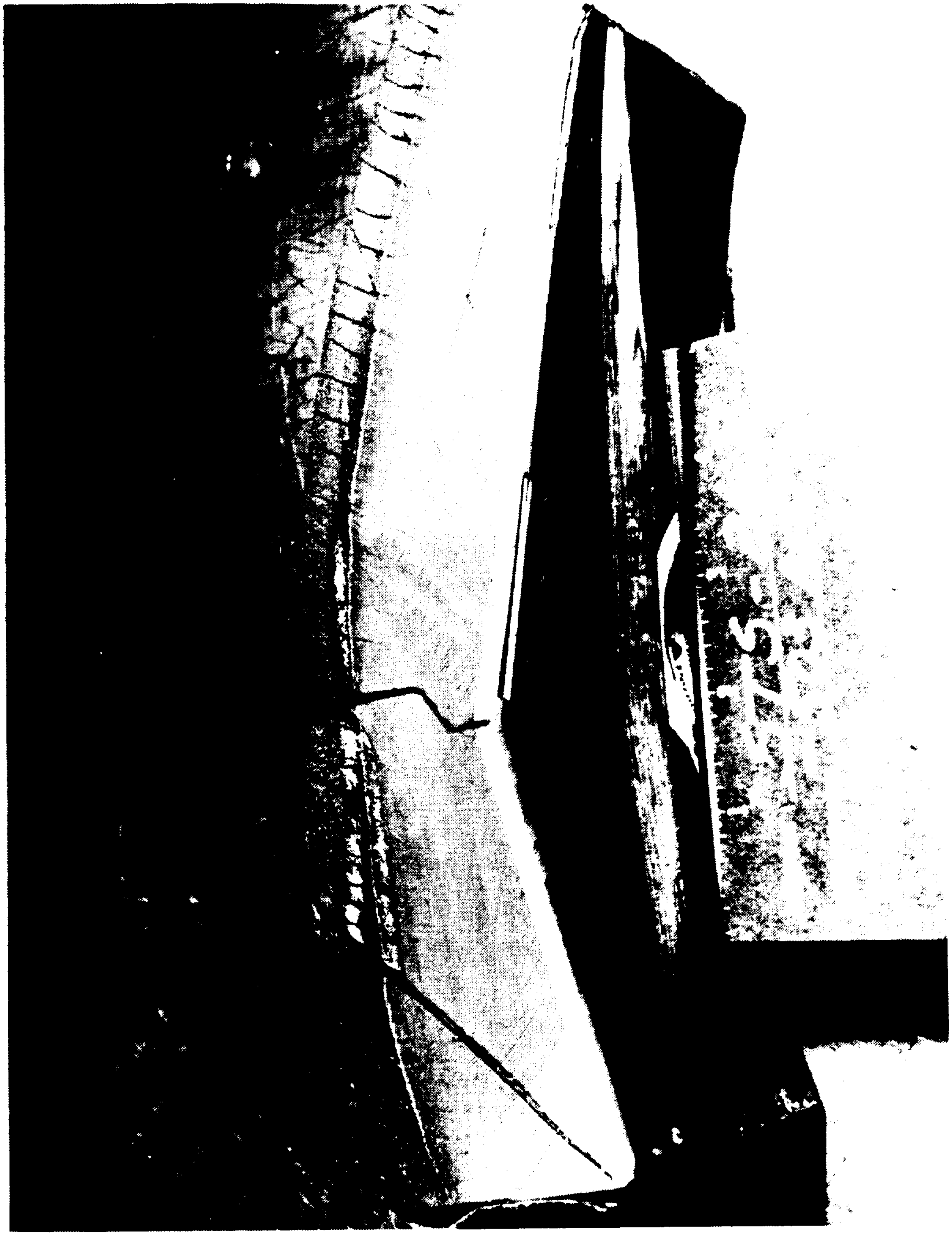

Figure 155 STS-26B Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section (90 Degrees)

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Figure 156 STS-26B Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section (180 Degrees)

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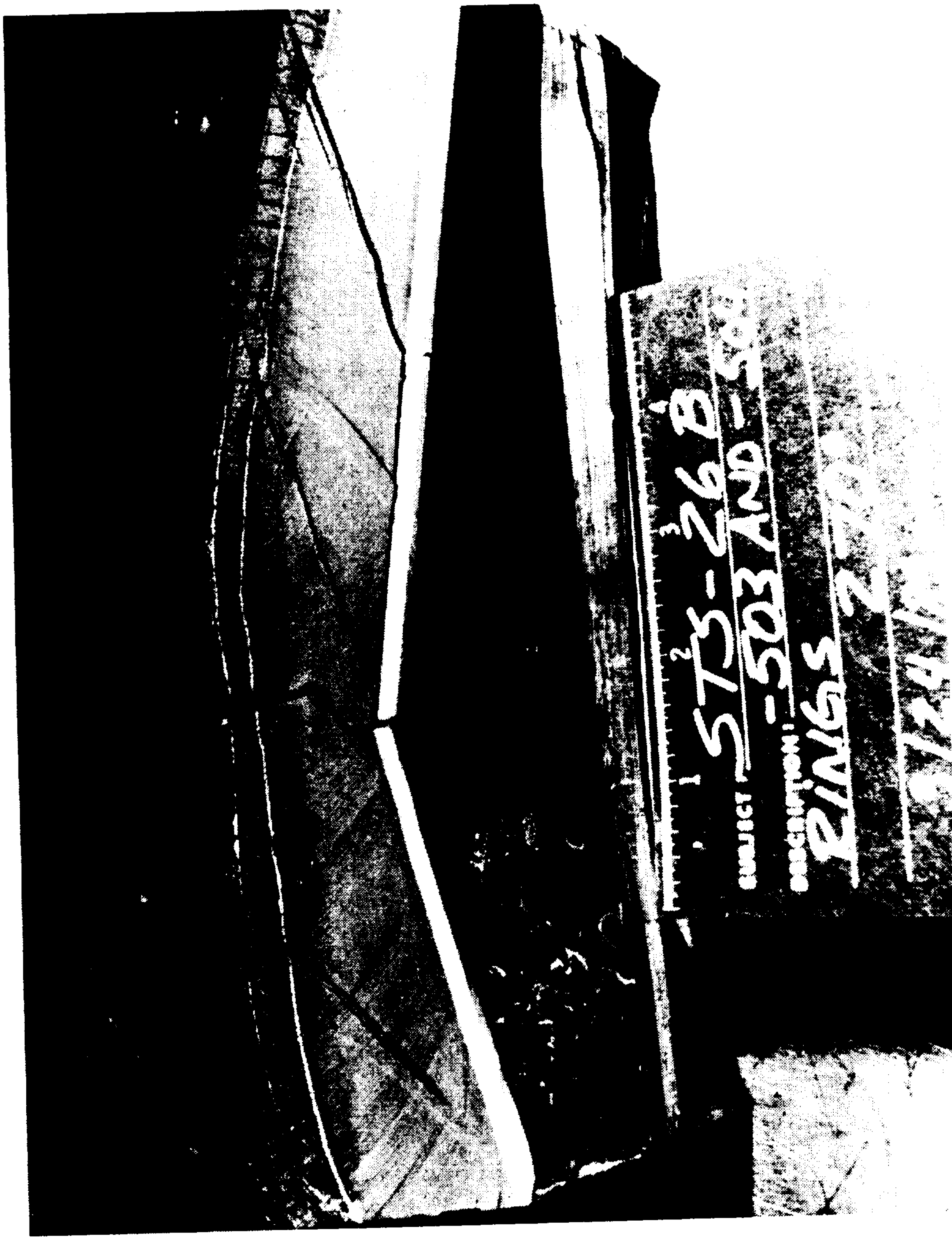

Figure 157 STS-26B Forward Nose Ring and Aft Inlet Ring (-503 and -504) Section (270 Degrees)

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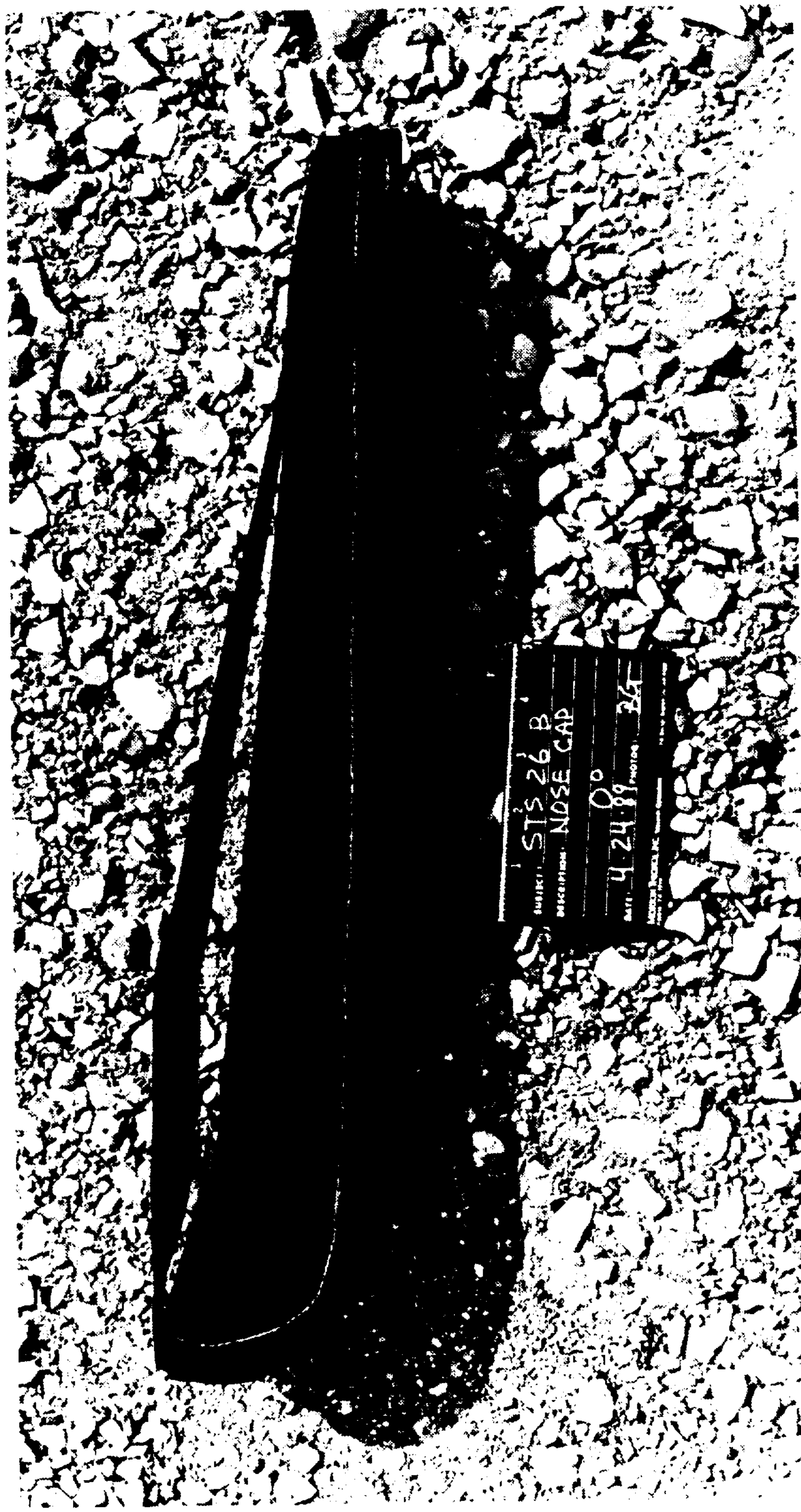

Figure 158 STS-26B Nose Cap Section (0 Degrees)

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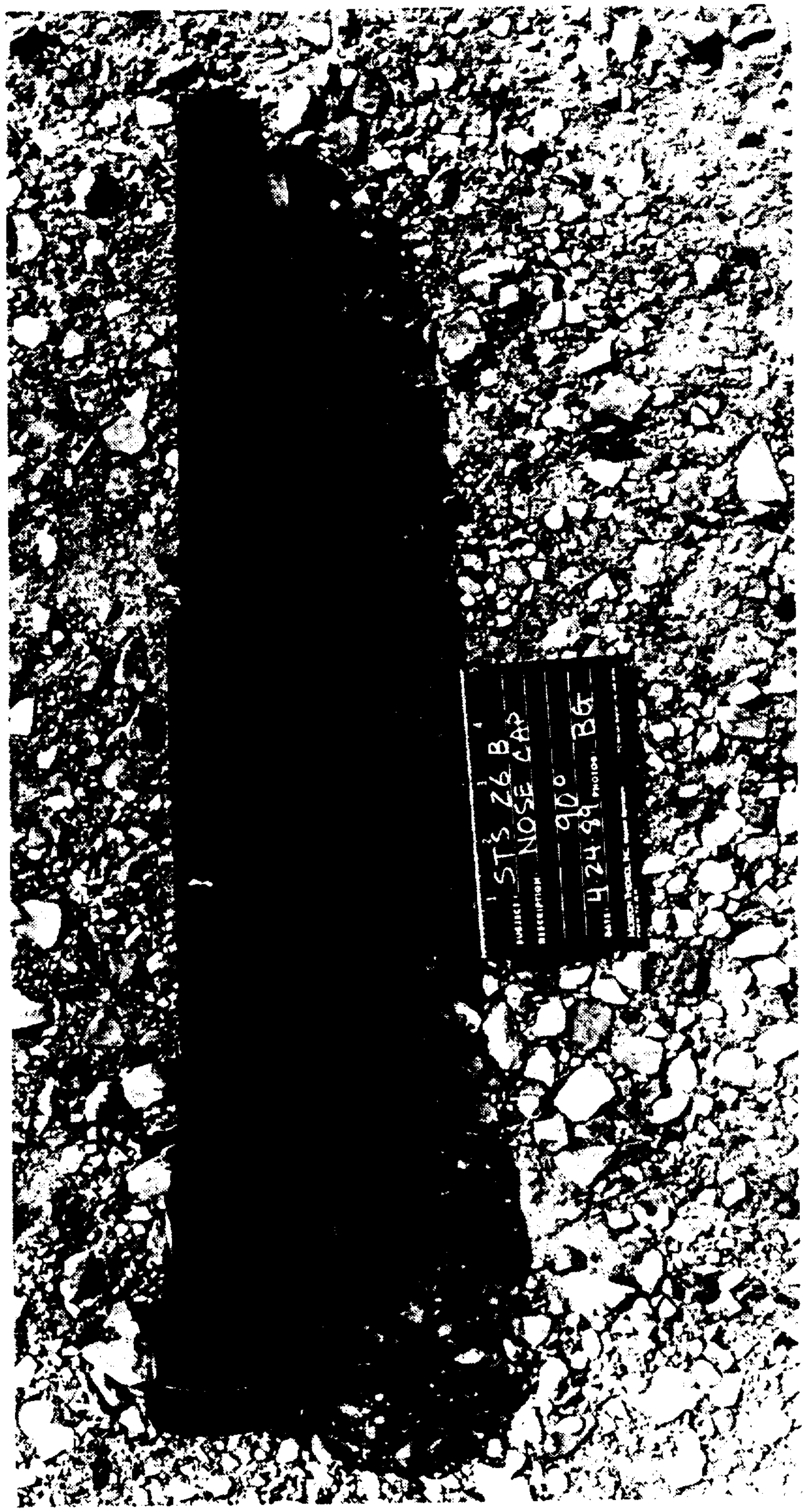

Figure 159 STS-26B Nose Cap Section (90 Degrees)

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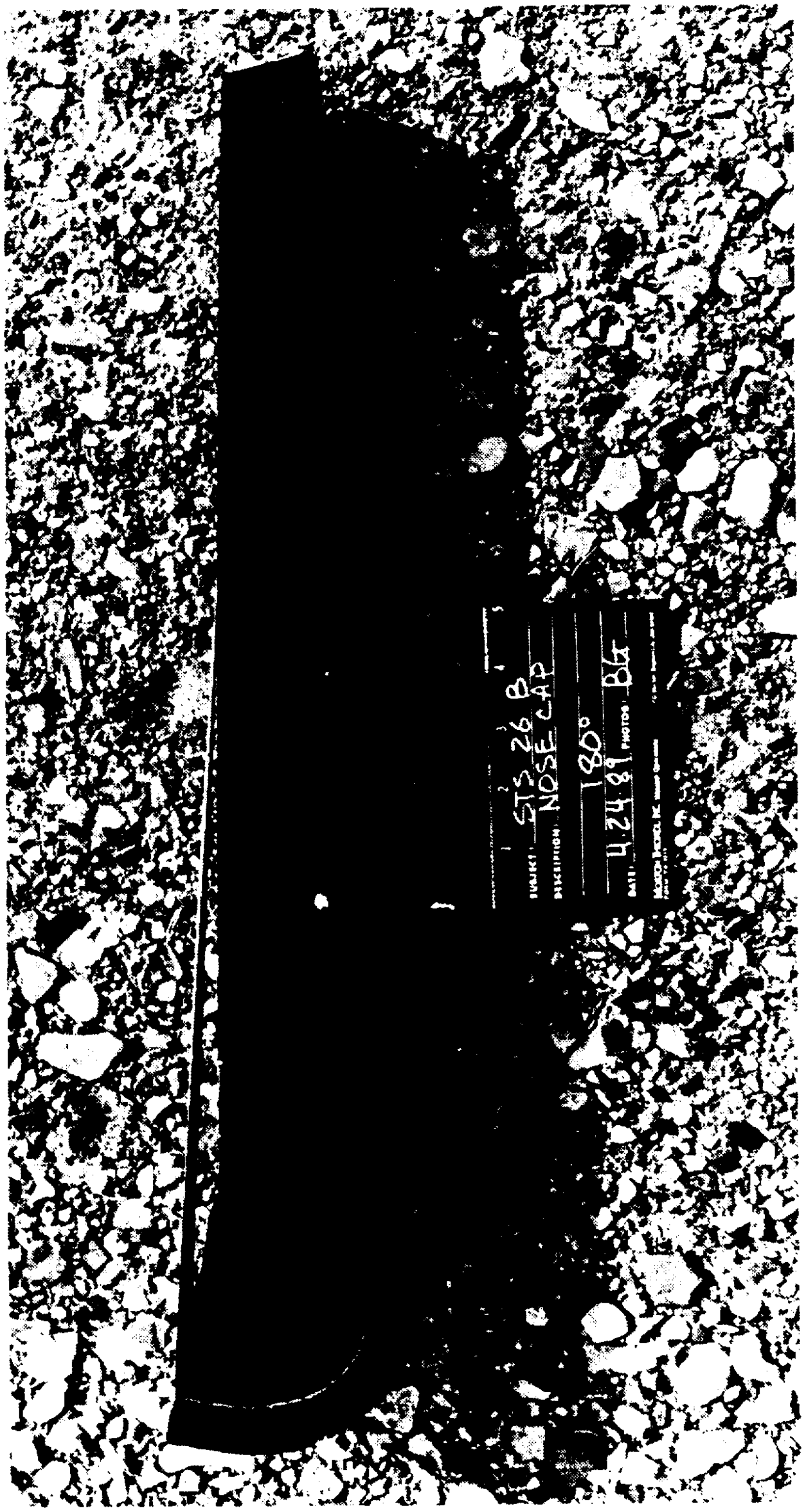

Figure 160 STS-26B Nose Cap Section (180 Degrees)

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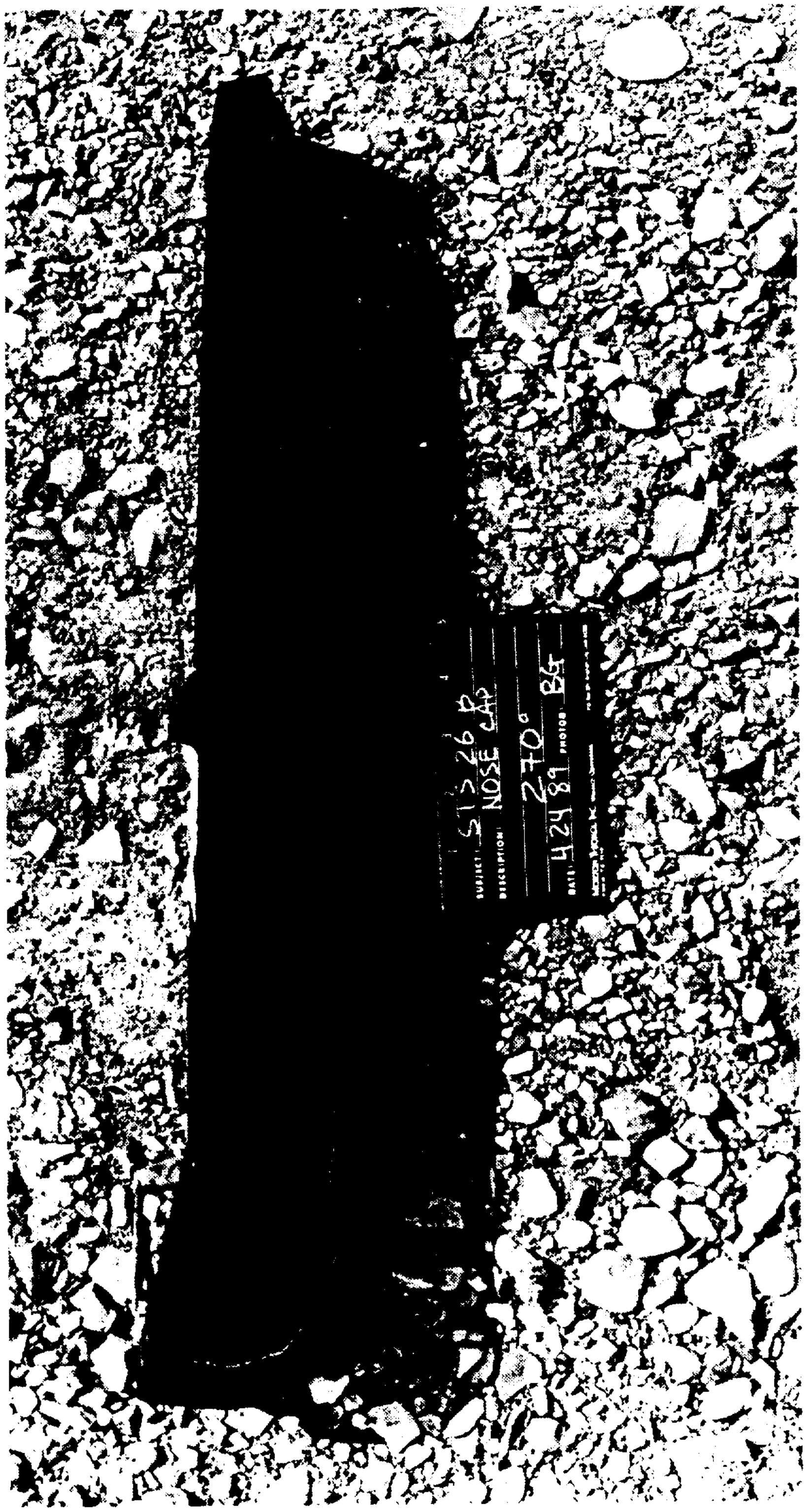

Figure 161 STS-26B Nose Cap Section (270 Degrees)

Table 12 STS-26B Nose Inlet Rings (-503,-504) Erosion and Char Data

Angular Location	Stations 28	30	32	34	36	38	39.5
0 degrees							
Measured Erosion	0.97	0.81	0.88	0.80	0.88	0.92	0.95
Measured Char	0.95	0.77	0.73	0.64	0.62	0.72	0.68
Adjusted Char*	0.71	0.58	0.55	0.48	0.47	0.54	0.51
2E + 1.25AC	2.83	2.34	2.44	2.20	2.34	2.52	2.54
RSRM Min Liner Thickness	3.508	3.252	2.950	3.182	3.200	3.026	2.981
Margin of Safety	0.24	0.39	0.21	0.45	0.37	0.20	0.17
90 degrees							
Measured Erosion	1.12	0.84	0.87	0.86	0.90	0.97	NA
Measured Char	0.72	0.76	0.76	0.68	0.70	0.65	NA
Adjusted Char*	0.54	0.57	0.57	0.51	0.53	0.49	NA
2E + 1.25AC	2.92	2.39	2.45	2.36	2.46	2.55	NA
RSRM Min Liner Thickness	3.508	3.252	2.950	3.182	3.200	3.026	2.981
Margin of Safety	0.20	0.36	0.20	0.35	0.30	0.19	NA
180 degrees							
Measured Erosion	1.38	0.85	1.28	0.86	0.87	0.92	1.02
Measured Char	0.53	0.76	0.37	0.66	0.58	0.63	0.49
Adjusted Char*	0.40	0.57	0.28	0.50	0.44	0.47	0.37
2E + 1.25AC	3.26	2.41	2.91	2.34	2.28	2.43	2.50
RSRM Min Liner Thickness	3.508	3.252	2.950	3.182	3.200	3.026	2.981
Margin of Safety	0.08	0.35	0.01	0.36	0.40	0.24	0.19
270 degrees							
Measured Erosion	1.07	0.83	0.95	0.82	0.84	0.95	1.19
Measured Char	0.77	0.78	0.67	0.60	0.63	0.60	0.54
Adjusted Char*	0.58	0.59	0.50	0.45	0.47	0.45	0.41
2E + 1.25AC	2.86	2.39	2.53	2.20	2.27	2.46	2.89
RSRM Min Liner Thickness	3.508	3.252	2.950	3.182	3.200	3.026	2.981
Margin of Safety	0.23	0.36	0.17	0.44	0.41	0.23	0.03

* Measured Char Adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \text{ X erosion} + 1.25 \text{ X Adj char*}} - 1$$

Refer to Figure 38 for Station Locations

Table 13 STS-26B Nose Cap Assembly Erosion and Char Data

Angular Location	Stations 1.5	4	6	8	10	12	14	16	18	20	22	24	26
0 degrees													
Measured Erosion	0.31	0.35	0.39	0.45	0.48	0.56	0.66	0.76	0.90	1.15	1.73	1.70	1.32
Measured Char	0.68	0.67	0.61	0.63	0.58	0.58	0.56	0.50	0.50	0.52	0.61	0.75	0.70
Adjusted Char *	0.54	0.54	0.49	0.50	0.46	0.46	0.45	0.40	0.40	0.42	0.49	0.60	0.53
2E + 1.25AC	1.30	1.37	1.39	1.53	1.54	1.70	1.88	2.02	2.30	2.82	4.07	4.15	3.30
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	0.37	0.49	0.62	0.61	0.73	0.69	0.64	0.63	0.52	0.44	0.16	0.13	0.17
45 degrees													
Measured Erosion	NA	0.25	0.32	0.38	0.40	0.51	0.49	0.63	0.66	0.86	1.43	1.63	1.22
Measured Char	NA	0.63	0.53	0.54	0.56	0.48	0.52	0.43	0.45	0.48	0.57	0.80	0.75
Adjusted Char *	NA	0.50	0.42	0.43	0.45	0.38	0.42	0.34	0.36	0.38	0.46	0.64	0.56
2E + 1.25AC	NA	1.13	1.17	1.30	1.36	1.50	1.50	1.69	1.77	2.20	3.43	4.06	3.14
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4,055	4.713	4.691	3.863
Margin of Safety	NA	0.80	0.92	0.89	0.96	0.92	1.06	0.95	0.98	0.84	0.37	0.16	0.23
90 degrees													
Measured Erosion	NA	0.36	0.37	0.44	0.43	0.46	0.53	0.71	0.87	1.10	1.66	1.86	1.35
Measured Char	NA	0.58	0.59	0.58	0.58	0.55	0.54	0.41	0.44	0.48	0.67	0.71	0.72
Adjusted Char *	NA	0.46	0.47	0.46	0.46	0.44	0.43	0.33	0.35	0.38	0.54	0.57	0.54
2E + 1.25AC	NA	1.30	1.33	1.46	1.44	1.47	1.60	1.83	2.18	2.68	3.99	4.43	3.38
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.57	0.69	0.68	0.85	0.96	0.93	0.80	0.61	0.51	0.18	0.06	0.14
135 degrees													
Measured Erosion	NA	0.30	0.40	0.44	0.50	0.57	0.64	0.76	0.86	1.10	1.70	1.95	1.40
Measured Char	NA	0.71	0.61	0.65	0.60	0.55	0.49	0.46	0.54	0.59	0.76	0.70	0.67
Adjusted Char *	NA	0.57	0.49	0.52	0.48	0.44	0.39	0.37	0.43	0.47	0.61	0.56	0.50
2E + 1.25AC	NA	1.31	1.41	1.53	1.60	1.69	1.77	1.98	2.26	2.79	4.16	4.60	3.43
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.56	0.59	0.61	0.67	0.70	0.74	0.67	0.55	0.45	0.13	0.02	0.13

* measured char adjusted to end of action time

$$\text{margin of safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char}^*} - 1$$

Refer to Figure 38 for Station Locations

Table 13 STS-26B Nose Cap Assembly Erosion and Char Data (continued)

Angular Location	Stations 1.5	4	6	8	10	12	14	16	18	20	22	24	26
180 degrees													
Measured Erosion	0.23	0.28	0.30	0.32	0.33	0.49	0.52	0.56	0.66	0.93	1.37	1.50	1.02
Measured Char	0.57	0.56	0.59	0.56	0.53	0.38	0.41	0.39	0.44	0.49	0.65	0.78	0.84
Adjusted Char *	0.46	0.45	0.47	0.45	0.42	0.30	0.33	0.31	0.35	0.39	0.52	0.62	0.63
2E + 1.25AC	1.03	1.12	1.19	1.20	1.19	1.36	1.45	1.51	1.76	2.35	3.39	3.78	2.83
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	0.72	0.82	0.89	1.05	1.24	1.12	1.13	1.18	0.99	0.73	0.39	0.24	0.37
225 degrees													
Measured Erosion	NA	0.15	0.22	0.30	0.37	0.43	0.48	0.50	0.67	0.90	1.65	1.99	1.43
Measured Char	NA	0.70	0.63	0.54	0.54	0.51	0.43	0.49	0.53	0.62	0.78	0.67	0.65
Adjusted Char *	NA	0.56	0.50	0.43	0.43	0.41	0.34	0.39	0.42	0.50	0.62	0.54	0.49
2E + 1.25AC	NA	1.00	1.07	1.14	1.28	1.37	1.39	1.49	1.87	2.42	4.08	4.65	3.47
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	1.04	1.10	1.16	1.08	1.10	1.22	1.21	0.88	0.68	0.16	0.01	0.11
270 degrees													
Measured Erosion	NA	0.33	0.37	0.45	0.47	0.51	0.62	0.71	0.81	1.06	1.50	1.68	1.21
Measured Char	NA	0.69	0.60	0.61	0.60	0.55	0.57	0.48	0.48	0.45	0.50	0.75	0.78
Adjusted Char *	NA	0.55	0.48	0.49	0.48	0.44	0.46	0.38	0.38	0.36	0.40	0.60	0.59
2E + 1.25AC	NA	1.35	1.34	1.51	1.54	1.57	1.81	1.90	2.10	2.57	3.50	4.11	3.15
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.51	0.68	0.63	0.73	0.83	0.71	0.74	0.67	0.58	0.35	0.14	0.23
315 degrees													
Measured Erosion	NA	0.24	0.30	0.29	0.32	0.37	0.43	0.54	0.64	0.82	1.25	1.43	0.98
Measured Char	NA	0.59	0.53	0.58	0.53	0.51	0.56	0.51	0.55	0.57	0.68	0.75	0.79
Adjusted Char *	NA	0.47	0.42	0.46	0.42	0.41	0.45	0.41	0.44	0.46	0.54	0.60	0.59
2E + 1.25AC	NA	1.07	1.13	1.16	1.17	1.25	1.42	1.59	1.83	2.21	3.18	3.61	2.70
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.90	0.99	1.12	1.28	1.30	1.17	1.07	0.92	0.83	0.48	0.30	0.43
15 degrees													
Measured Erosion	NA	0.30	0.39	0.35	0.37	0.41	0.42	0.53	0.67	0.89	1.31	1.57	1.09
Measured Char	NA	0.50	0.44	0.51	0.56	0.57	0.57	0.51	0.40	0.40	0.78	0.70	0.60
Adjusted Char *	NA	0.40	0.35	0.41	0.45	0.46	0.46	0.41	0.32	0.32	0.62	0.56	0.45
2E + 1.25AC	NA	1.10	1.22	1.21	1.30	1.39	1.41	1.57	1.74	2.18	3.40	3.84	2.74
RSRM Min Liner Thickness	1.776	2.038	2.248	2.458	2.668	2.878	3.088	3.298	3.507	4.055	4.713	4.691	3.863
Margin of Safety	NA	0.85	0.84	1.03	1.05	1.07	1.19	1.10	1.02	0.86	0.39	0.22	0.41

* measured char adjusted to end of action time

$$\text{margin of safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

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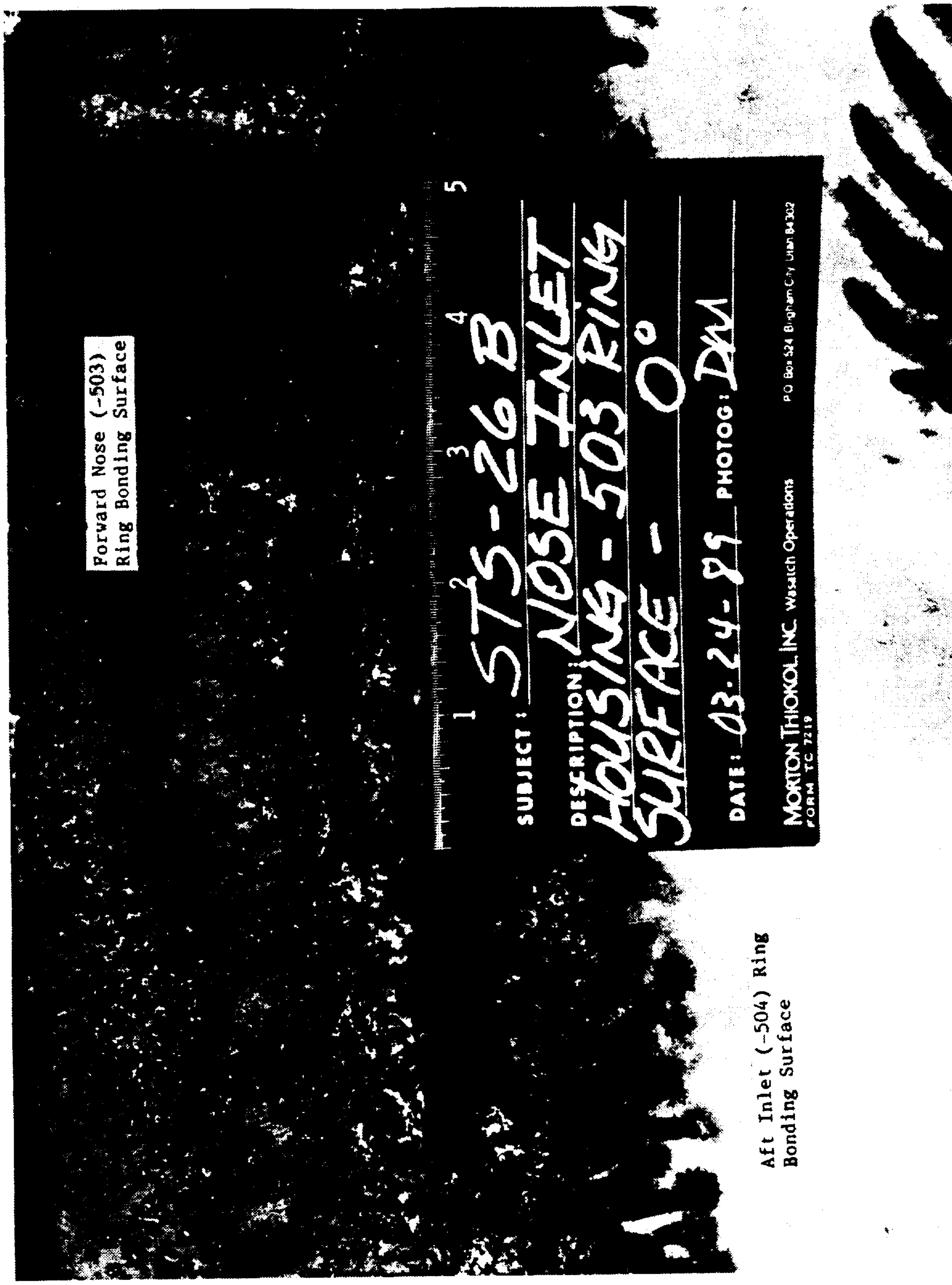

Figure 162 STS-26B Nose Inlet Housing Bonding Surfaces (0 Degrees)

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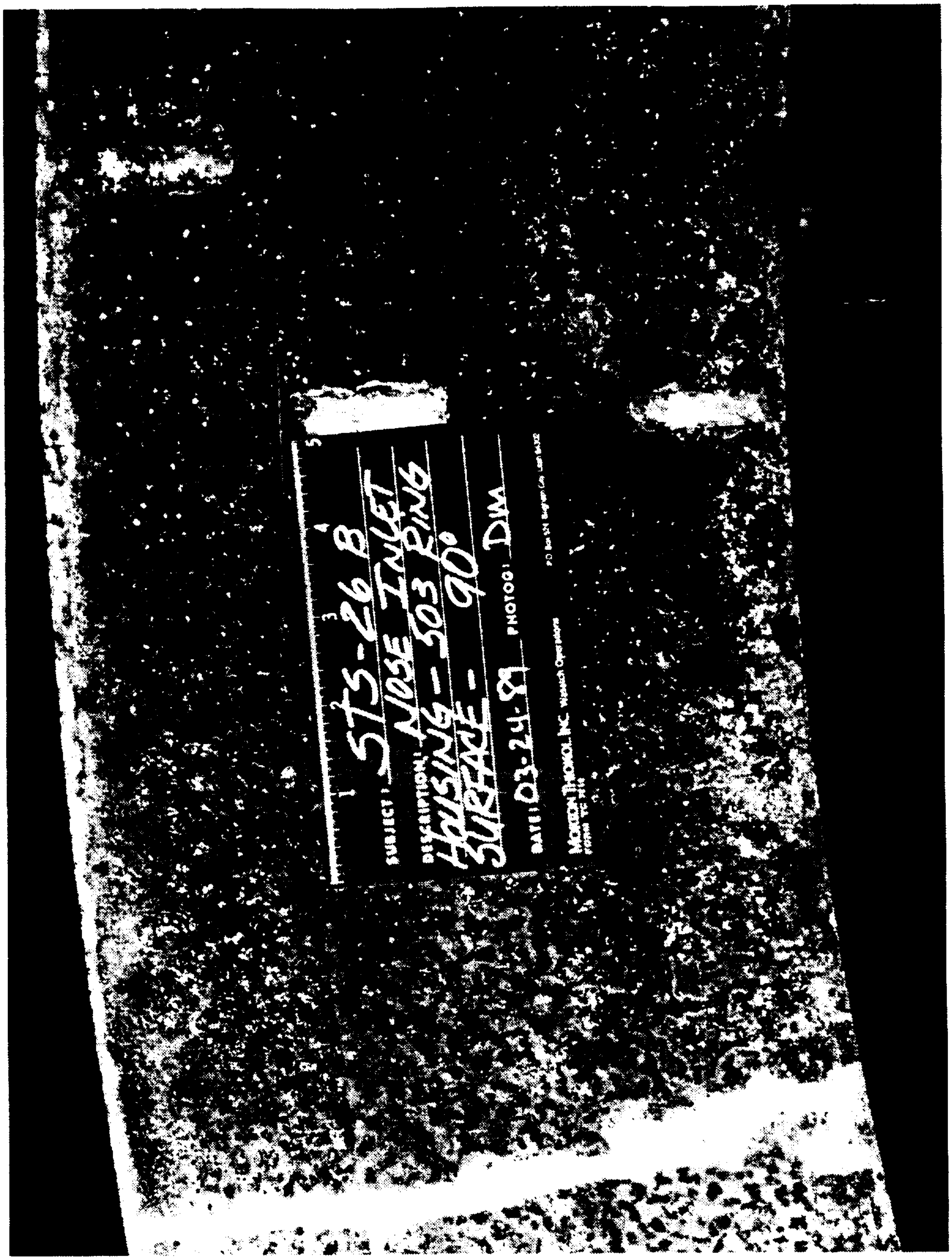

Figure 163 STS-26B Nose Inlet Housing Bonding Surfaces (90 Degrees)

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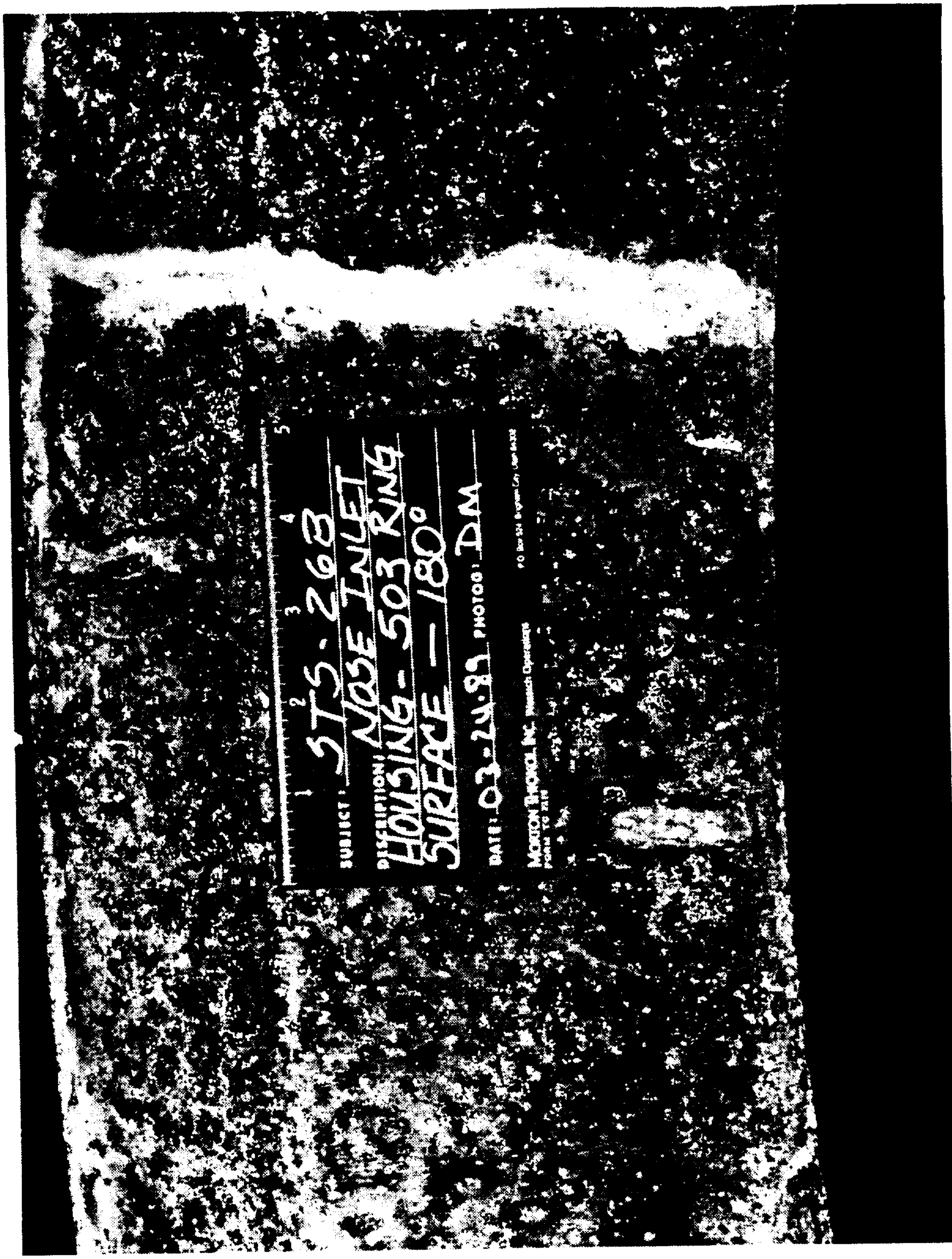

Figure 164 STS-26B Nose Inlet Housing Bonding Surfaces (180 Degrees)

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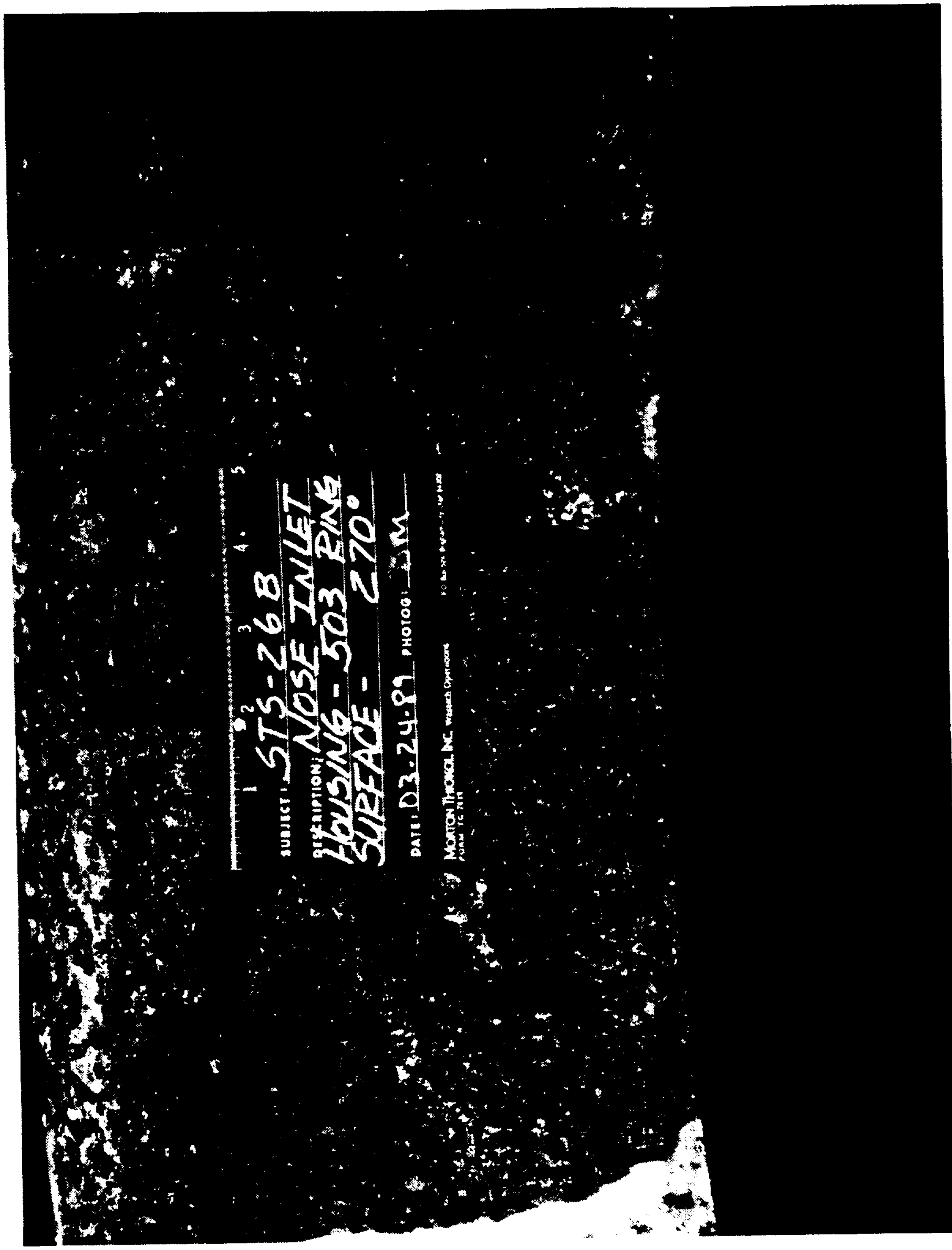

Figure 165 STS-26B Nose Inlet Housing Bonding Surfaces (270 Degrees)

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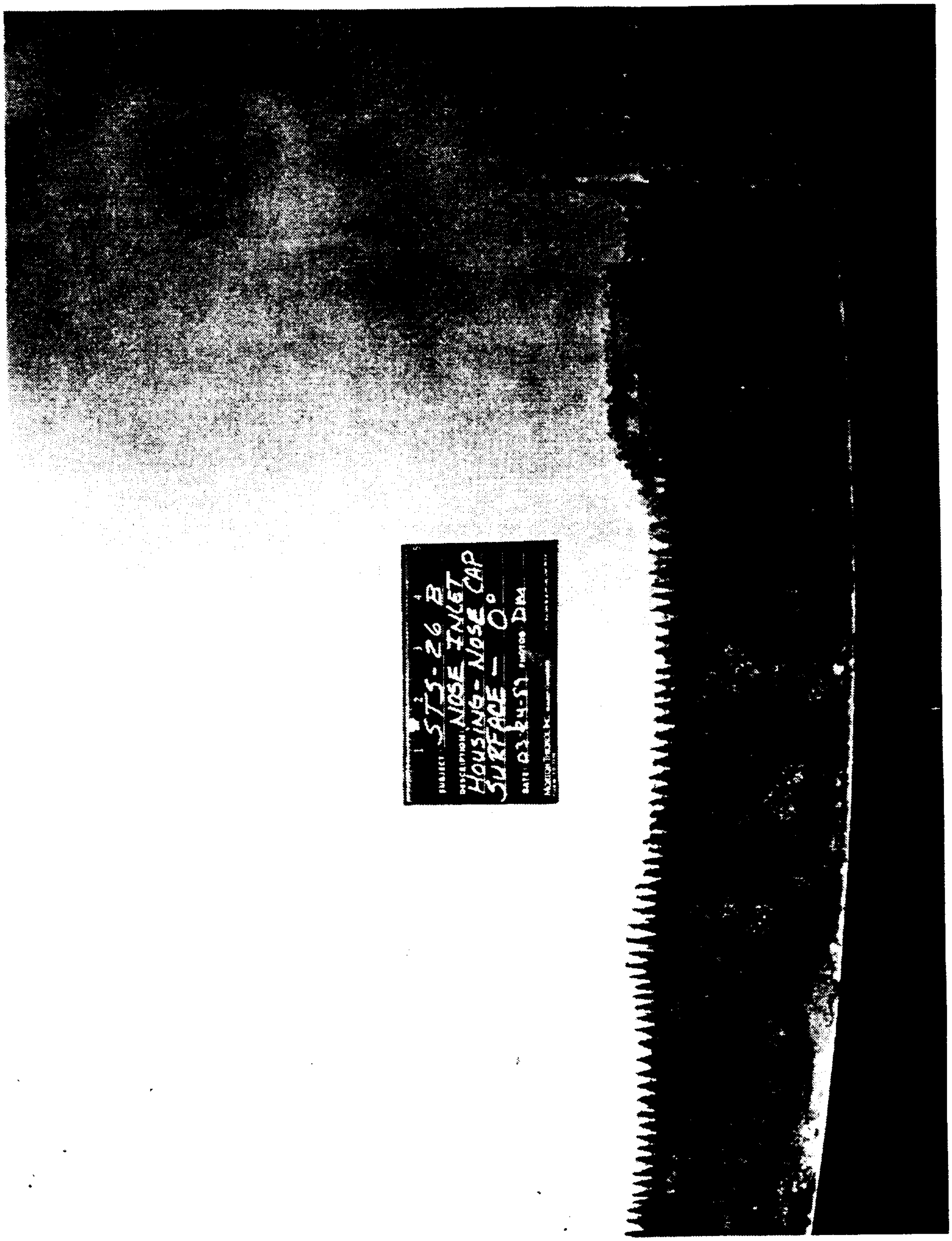

Figure 166 STS-26B Nose Cap Bonding Surface (0 Degrees)

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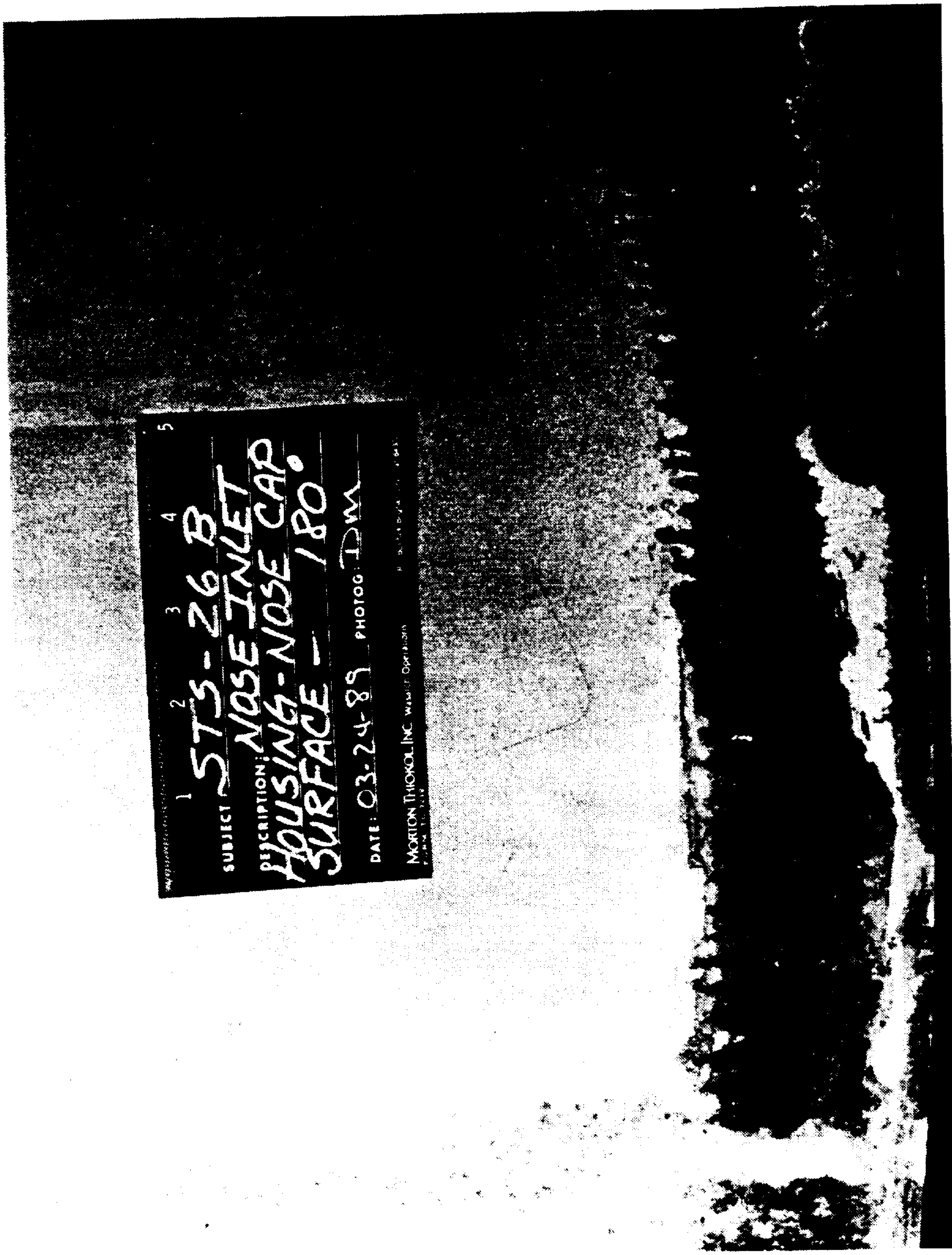

Figure 167 STS-26B Nose Cap Bonding Surface (180 Degrees)

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Figure 168 STS-26B Nose Inlet Housing Pitting (180 Degrees)

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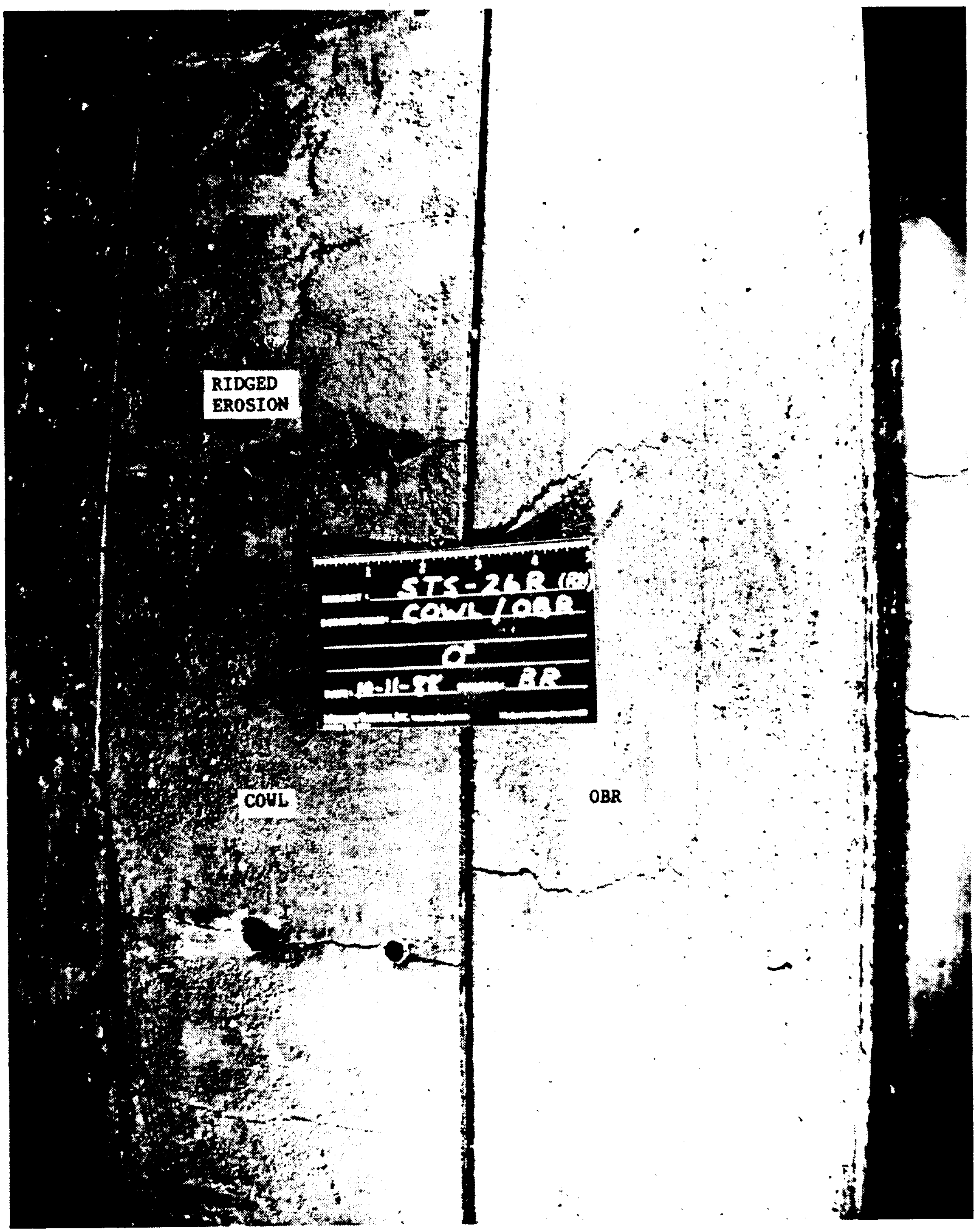

Figure 169 STS-26B Cowl/OBR Closeup (0 Degrees)

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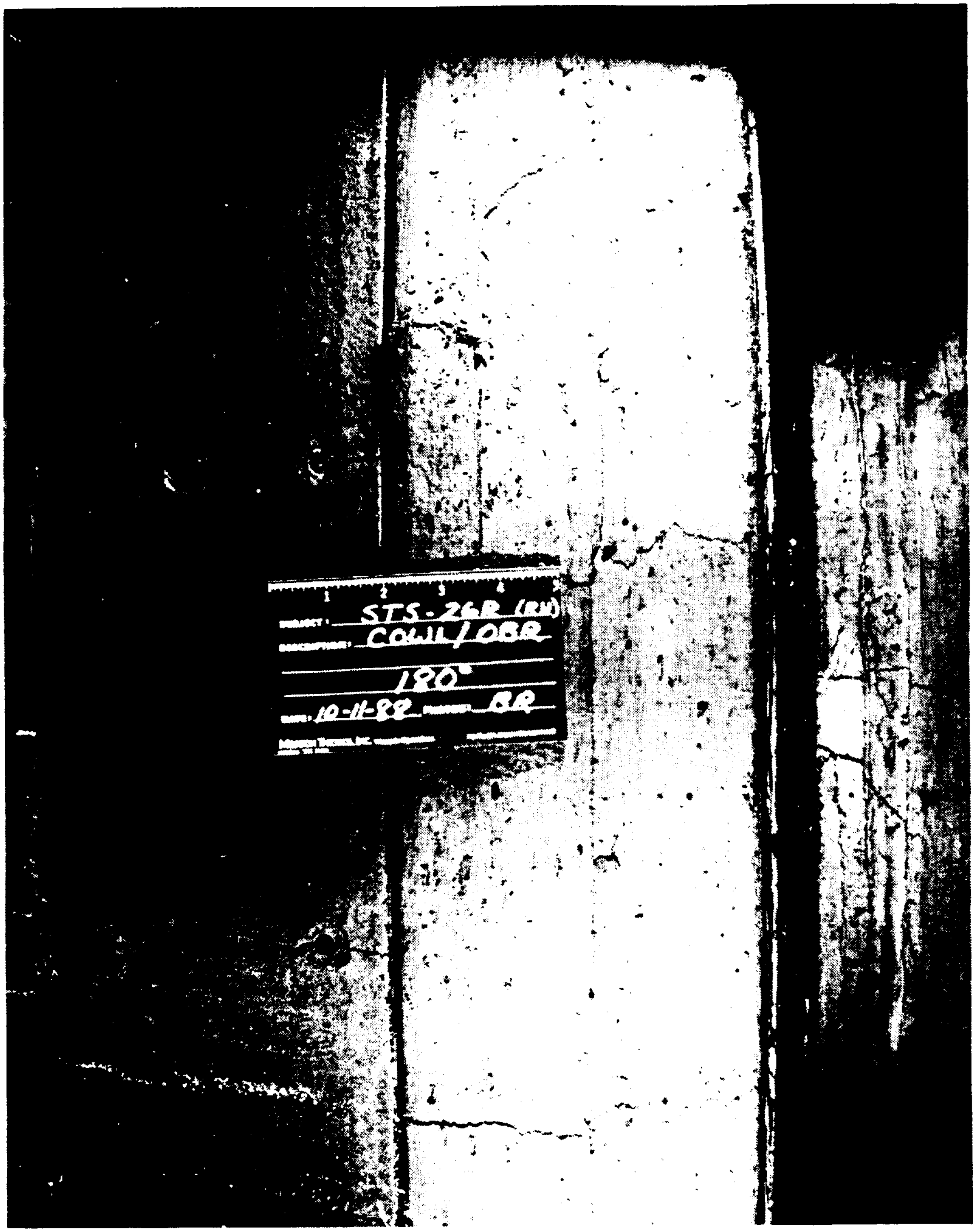

Figure 170 STS-26B Cowl/OBR Closeup (180 Degrees)

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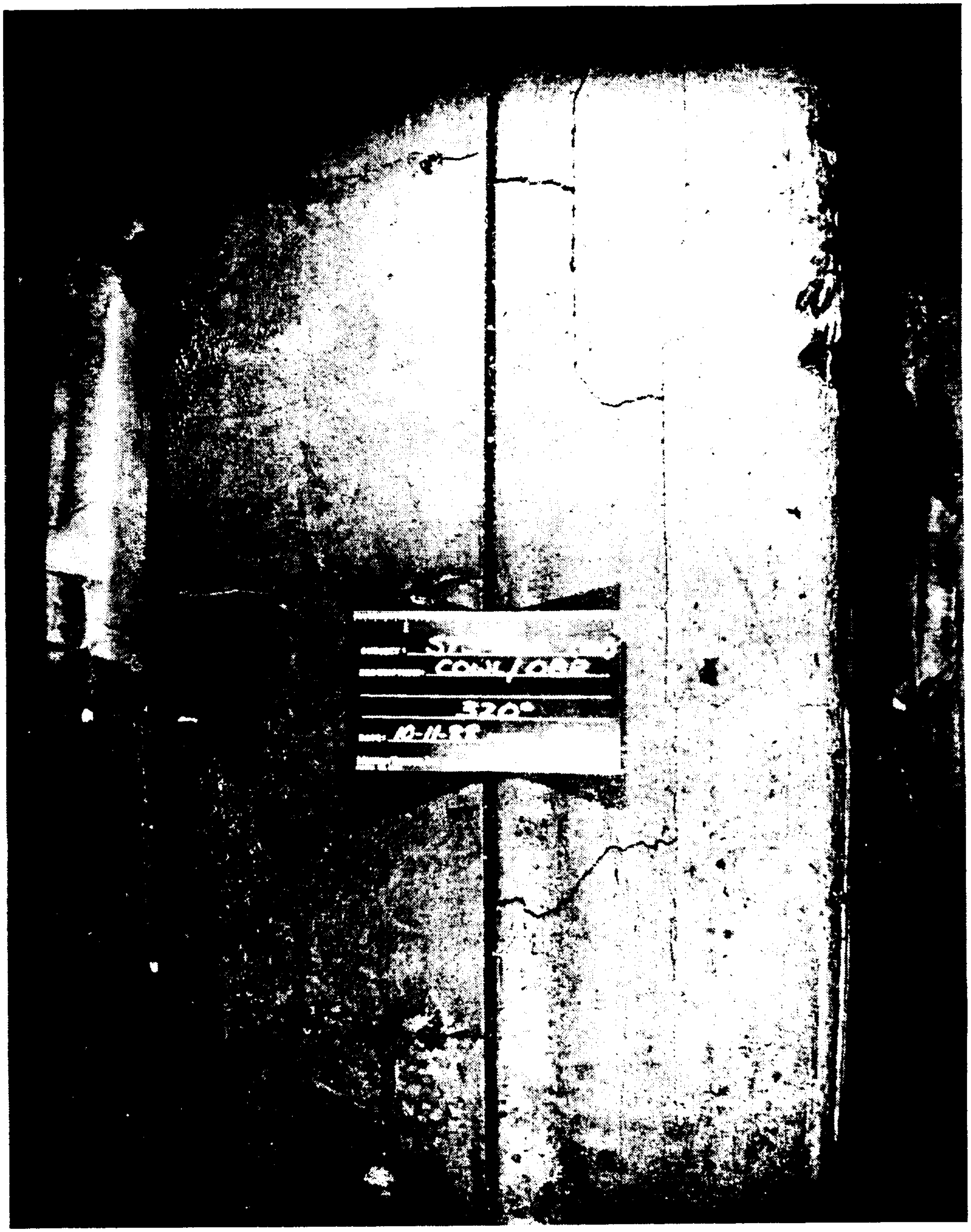

Figure 171 STS-26B Cowl/OBR Closeup (320 Degrees)

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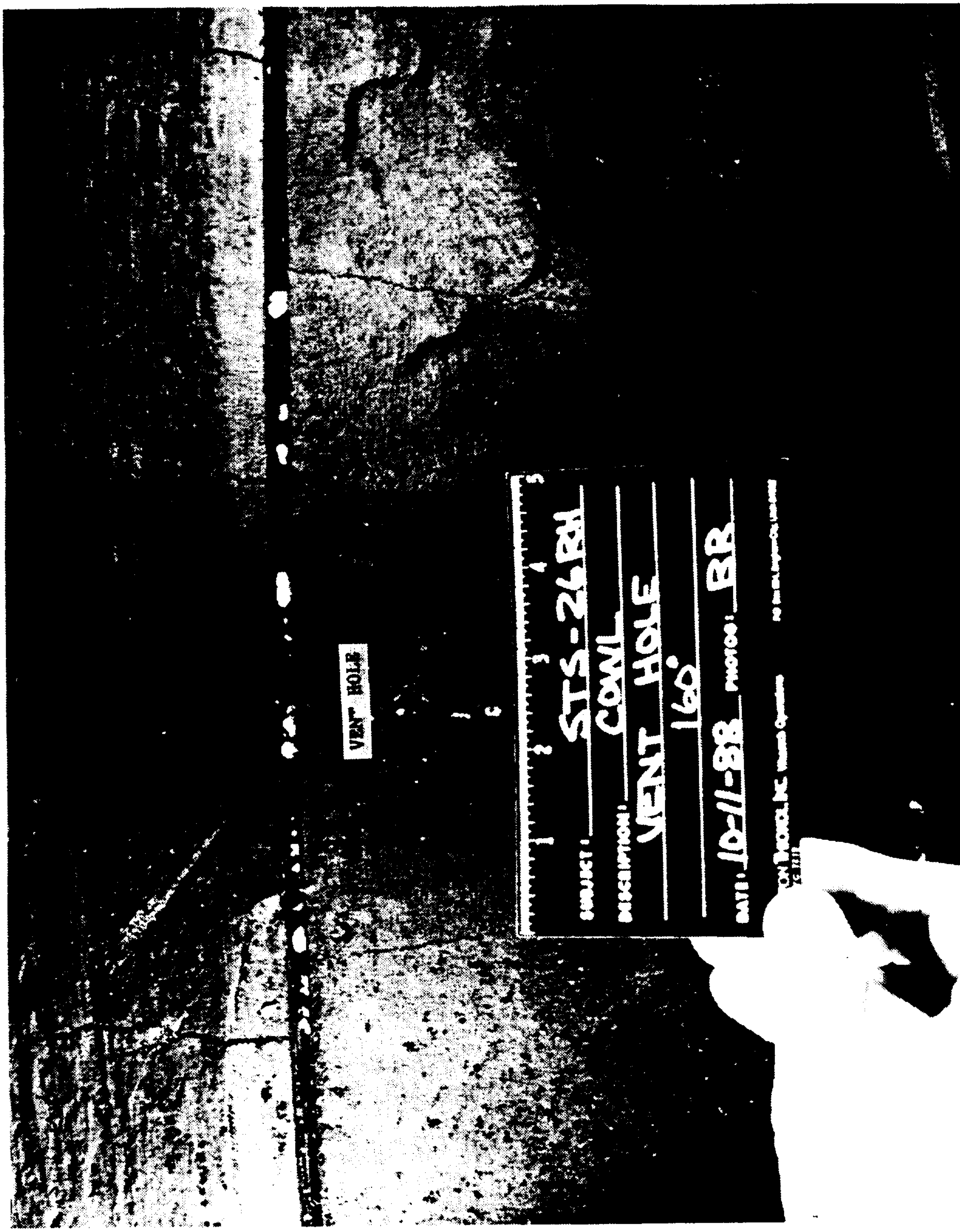

Figure 172 STS-26B Cowl Vent Hole Plugged with Slag (160 Degrees)

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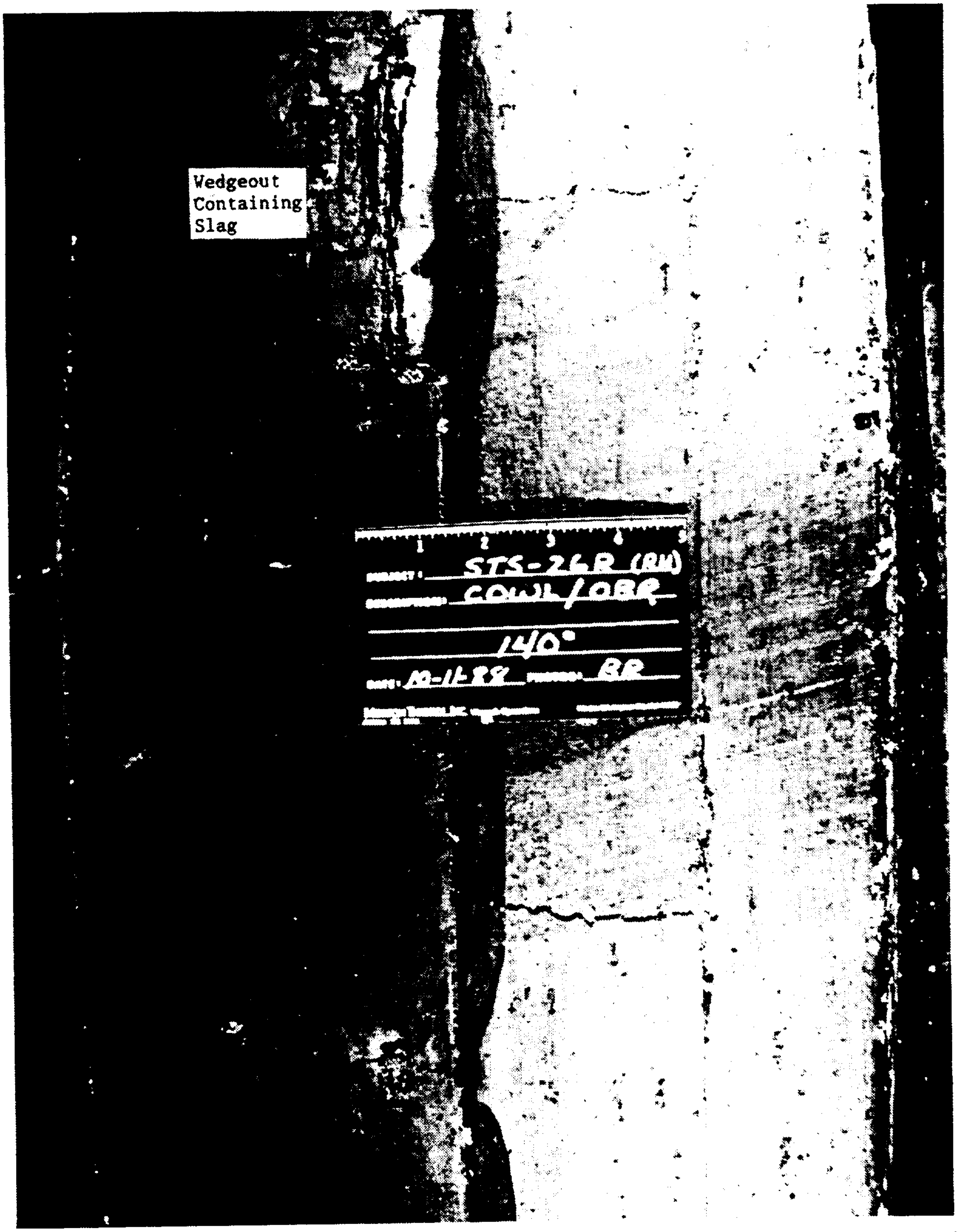

Figure 173 STS-26B Cowl Ring Wedgeout Containing Slag (120 - 137 Degrees)

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Figure 174 STS-26B Cowl Ring Section (0 Degrees)

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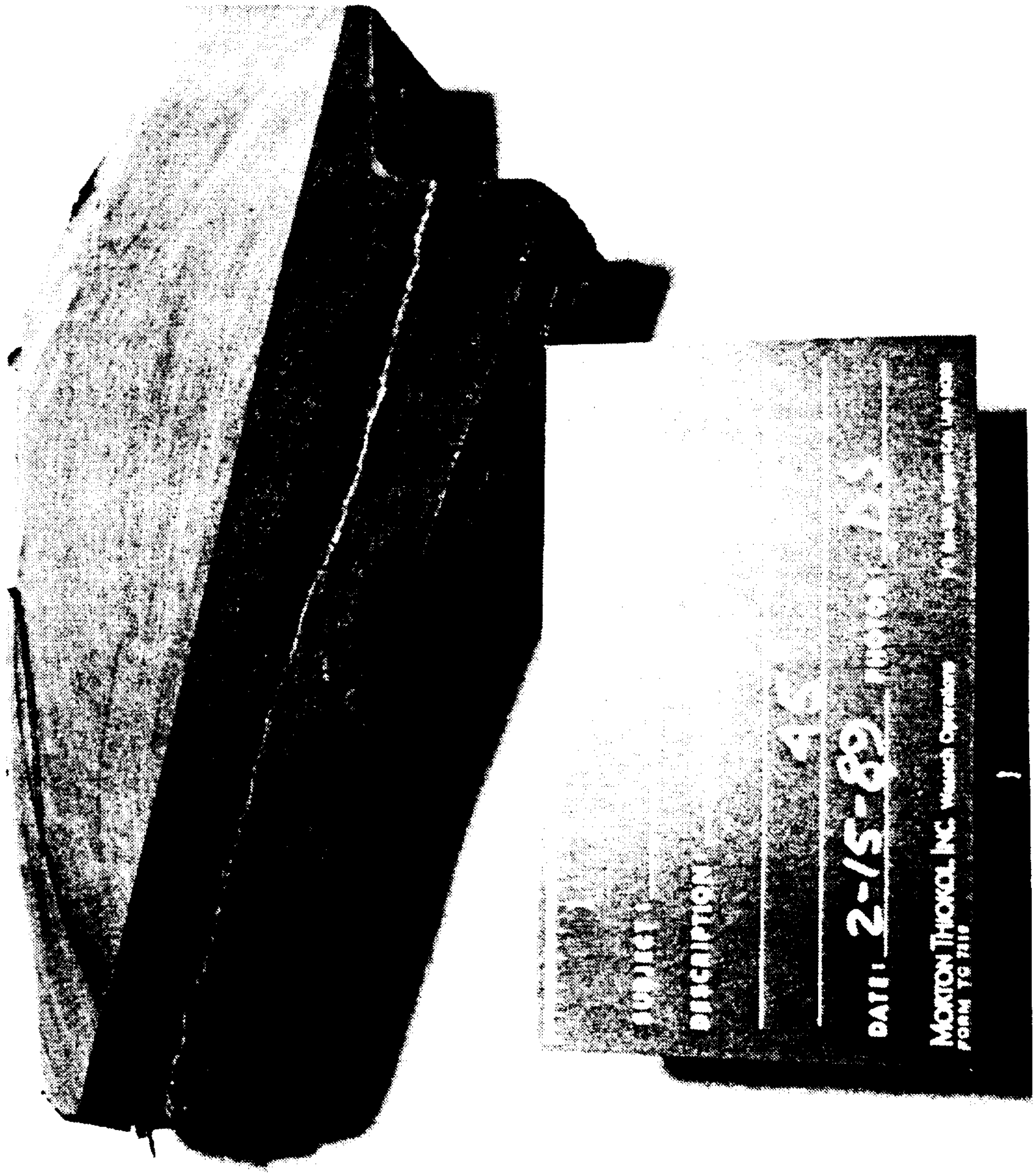

Figure 175 STS-26B Cowl Ring Section (45 Degrees)

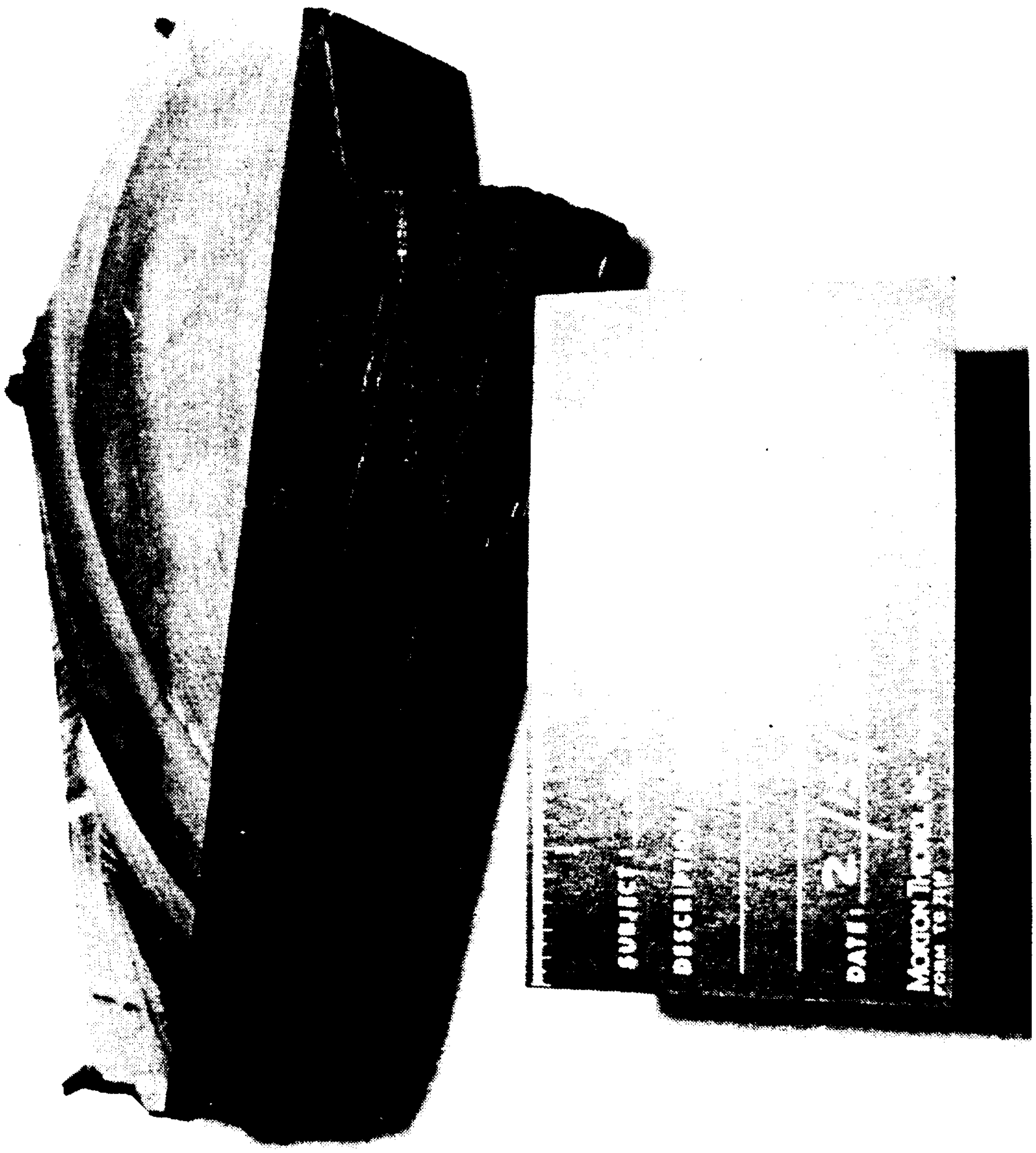

Figure 176 STS-26B Cowl Ring Section (180 Degrees)

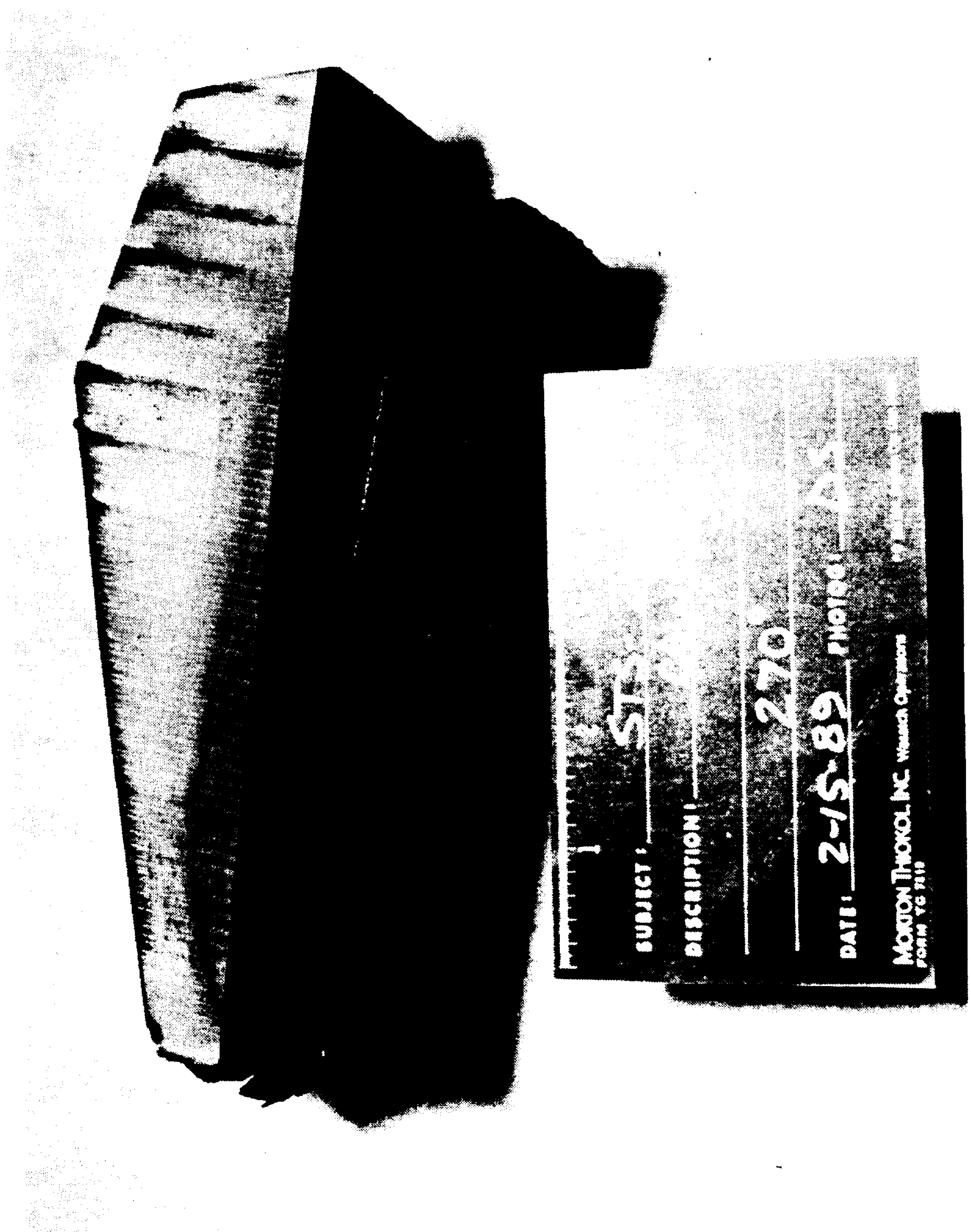

Figure 177 STS-26B Cowl Ring Section (270 Degrees)

Table 14 STS-26B Cowl/OBR Erosion and Char Data

Angular Location	Stations											
	0	1	2	3	4	5	6	7	8	9	10	11.3
0 degrees												
Measured Erosion	0.21	0.21	0.30	0.29	0.26	0.19	0.13	0.11	NA	0.10	0.08	0.06
Measured Char	0.62	0.61	0.55	0.56	0.61	0.69	0.77	0.90	NA	0.85	0.90	0.85
Adjusted Char *	0.50	0.49	0.44	0.45	0.49	0.55	0.62	0.72	NA	0.68	0.72	0.68
2E + 1.25AC	1.04	1.03	1.15	1.14	1.13	1.07	1.03	1.12	NA	1.05	1.06	0.97
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.36	0.46	0.37	0.45	0.53	0.69	0.83	0.76	NA	0.60	0.59	0.75
20 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.06	0.05
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.87	0.90
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.70	0.72
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.99	1.00
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.70	0.70
40 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.05	0.00
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.83	0.91
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.66	0.73
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.93	0.91
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.81	0.87
45 degrees												
Measured Erosion	0.58	0.25	0.26	0.27	0.24	0.22	0.19	0.18	NA	NA	NA	NA
Measured Char	0.21	0.61	0.66	0.75	0.70	0.68	0.80	0.81	NA	NA	NA	NA
Adjusted Char *	0.17	0.49	0.53	0.60	0.56	0.54	0.64	0.65	NA	NA	NA	NA
2E + 1.25AC	1.37	1.11	1.18	1.29	1.18	1.12	1.18	1.17	NA	NA	NA	NA
RSRM Min Liner Thickness	1.417	1.499	1.577	'.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.04	0.35	0.34	0.28	0.47	0.62	0.60	0.68	NA	NA	NA	NA
60 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.06	0.05
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.88	0.92
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.70	0.74
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.00	1.02
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.69	0.67

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

Refer to Figure 55 for Station Locations

Table 14 STS-26B Cowl/OBR Erosion and Char Data (continued)

Angular Location	Stations											
	0	1	2	3	4	5	6	7	8	9	10	11.3
80 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.00	0.00
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.92	0.90	0.94
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.74	0.72	0.75
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.92	0.90	0.94
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.82	0.87	0.81
90 degrees												
Measured Erosion	NA	0.27	0.22	0.18	0.20	0.18	0.16	0.16	NA	NA	0.00	0
Measured Char	NA	NA	0.74	0.77	0.74	0.72	0.77	0.89	NA	NA	0.83	0.83
Adjusted Char *	NA	NA	0.59	0.62	0.59	0.58	0.62	0.71	NA	NA	0.66	0.66
2E + 1.25AC	NA	NA	1.18	1.13	1.14	1.08	1.09	1.21	NA	NA	0.83	0.83
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	0.34	0.46	0.52	0.68	0.73	0.63	NA	NA	1.03	1.05
120 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.00
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.88	0.92
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.70	0.74
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.88	0.92
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.92	0.85
125 degrees												
Measured Erosion	0.16	0.20	0.27	0.28	0.41	0.62	0.79	NA	NA	NA	NA	NA
Measured Char	0.70	0.80	0.70	0.68	0.53	0.36	0.19	NA	NA	NA	NA	NA
Adjusted Char *	0.56	0.64	0.56	0.54	0.42	0.29	0.15	NA	NA	NA	NA	NA
2E + 1.25AC	1.02	1.20	1.24	1.24	1.35	1.60	1.77	NA	NA	NA	NA	NA
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.39	0.25	0.27	0.33	0.28	0.13	0.07	NA	NA	NA	NA	NA
140 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.02	0.00
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.74	0.76	0.89
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.59	0.61	0.71
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.74	0.80	0.89
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.26	1.11	0.91

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

Table 14 STS-26B Cowl/OBR Erosion and Char Data (continued)

Angular Location	Stations											
160 degrees	0	1	2	3	4	5	6	7	8	9	10	11.3
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.04	0.02	0.03
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.77	0.79	0.82
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.62	0.63	0.66
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.85	0.83	0.88
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.97	1.03	0.93
180 degrees												
Measured Erosion	0.28	0.18	0.21	0.21	0.24	0.22	0.18	0.22	NA	NA	NA	NA
Measured Char	0.58	0.70	0.71	0.98	0.73	0.74	0.76	0.86	NA	NA	NA	NA
Adjusted Char *	0.46	0.56	0.57	0.78	0.58	0.59	0.61	0.69	NA	NA	NA	NA
2E + 1.25AC	1.14	1.06	1.13	1.40	1.21	1.18	1.12	1.30	NA	NA	NA	NA
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.25	0.41	0.40	0.18	0.43	0.53	0.69	0.51	NA	NA	NA	NA
220 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.02	0.02	0.00
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.78	0.77	0.85
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.62	0.62	0.68
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.82	0.81	0.85
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.04	1.08	1.00
225 degrees												
Measured Erosion	0.18	0.28	0.31	0.33	0.41	0.40	0.21	0.21	NA	NA	NA	NA
Measured Char	0.68	0.68	0.73	0.77	0.66	0.70	0.90	0.86	NA	NA	NA	NA
Adjusted Char *	0.54	0.54	0.58	0.62	0.53	0.56	0.72	0.69	NA	NA	NA	NA
2E + 1.25AC	1.04	1.24	1.35	1.43	1.48	1.50	1.32	1.28	NA	NA	NA	NA
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.37	0.21	0.17	0.16	0.17	0.21	0.43	0.54	NA	NA	NA	NA
240 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.04	0.04	0.02
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.80	0.82	0.88
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.64	0.66	0.70
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.88	0.90	0.92
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.90	0.87	0.85

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

Table 14 STS-26B Ccwl/OBR Erosion and Char Data (continued)

Angular Location	Stations 0	1	2	3	4	5	6	7	8	9	10	11.3
260 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.00	0.00
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.92	0.94	0.97
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.74	0.75	0.78
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.92	0.94	0.97
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.82	0.79	0.75
270 degrees												
Measured Erosion	0.13	0.19	0.28	0.30	0.24	0.23	0.20	0.18	NA	0.04	0.04	0.00
Measured Char	0.60	0.73	0.69	0.72	0.82	0.80	0.82	0.84	NA	0.90	0.89	0.93
Adjusted Char *	0.48	0.58	0.55	0.58	0.66	0.64	0.66	0.67	NA	0.72	0.71	0.74
2E + 1.25AC	0.86	1.11	1.25	1.32	1.30	1.26	1.22	1.20	NA	0.98	0.97	0.93
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.65	0.35	0.26	0.25	0.33	0.44	0.55	0.64	NA	0.71	0.74	0.83
280 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.00
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.86	0.86
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.69	0.69
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.86	0.86
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.96	0.98
300 degrees												
Measured Erosion	0.16	0.22	0.25	0.29	0.31	0.18	0.15	0.16	NA	0.07	0.04	0.05
Measured Char	0.60	0.65	0.67	0.63	0.64	0.77	0.78	0.82	NA	0.85	0.88	0.88
Adjusted Char *	0.48	0.52	0.54	0.50	0.51	0.62	0.62	0.66	NA	0.68	0.70	0.70
2E + 1.25AC	0.92	1.09	1.17	1.21	1.26	1.13	1.08	1.14	NA	0.99	0.96	0.98
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.54	0.38	0.35	0.37	0.38	0.60	0.75	0.73	NA	0.69	0.76	0.73
315 degrees												
Measured Erosion	0.20	0.18	0.21	0.21	0.24	0.22	0.18	0.20	NA	NA	NA	NA
Measured Char	0.66	0.67	0.69	0.67	0.68	0.70	0.76	0.83	NA	NA	NA	NA
Adjusted Char *	0.53	0.54	0.55	0.54	0.54	0.56	0.61	0.66	NA	NA	NA	NA
2E + 1.25AC	1.06	1.03	1.11	1.09	1.16	1.14	1.12	1.23	NA	NA	NA	NA
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	0.34	0.46	0.42	0.52	0.49	0.59	0.69	0.60	NA	NA	NA	NA

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

Table 14 STS-26B Cowl/OBR Erosion and Char Data (continued)

Angular Location	Stations											
320 degrees	0	1	2	3	4	5	6	7	8	9	10	11.3
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.03	0.03	0.04
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.83	0.83	0.83
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.66	0.66	0.66
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.89	0.89	0.91
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.88	0.90	0.87
340 degrees												
Measured Erosion	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.07	0.02
Measured Char	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.84	0.90
Adjusted Char *	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.67	0.72
2E + 1.25AC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.98	0.94
RSRM Min Liner Thickness	1.417	1.499	1.577	1.655	1.733	1.811	1.889	1.963	1.597	1.675	1.687	1.704
Margin of Safety	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.72	0.81

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{erosion} + 1.25 \times \text{adj char*}} - 1$$

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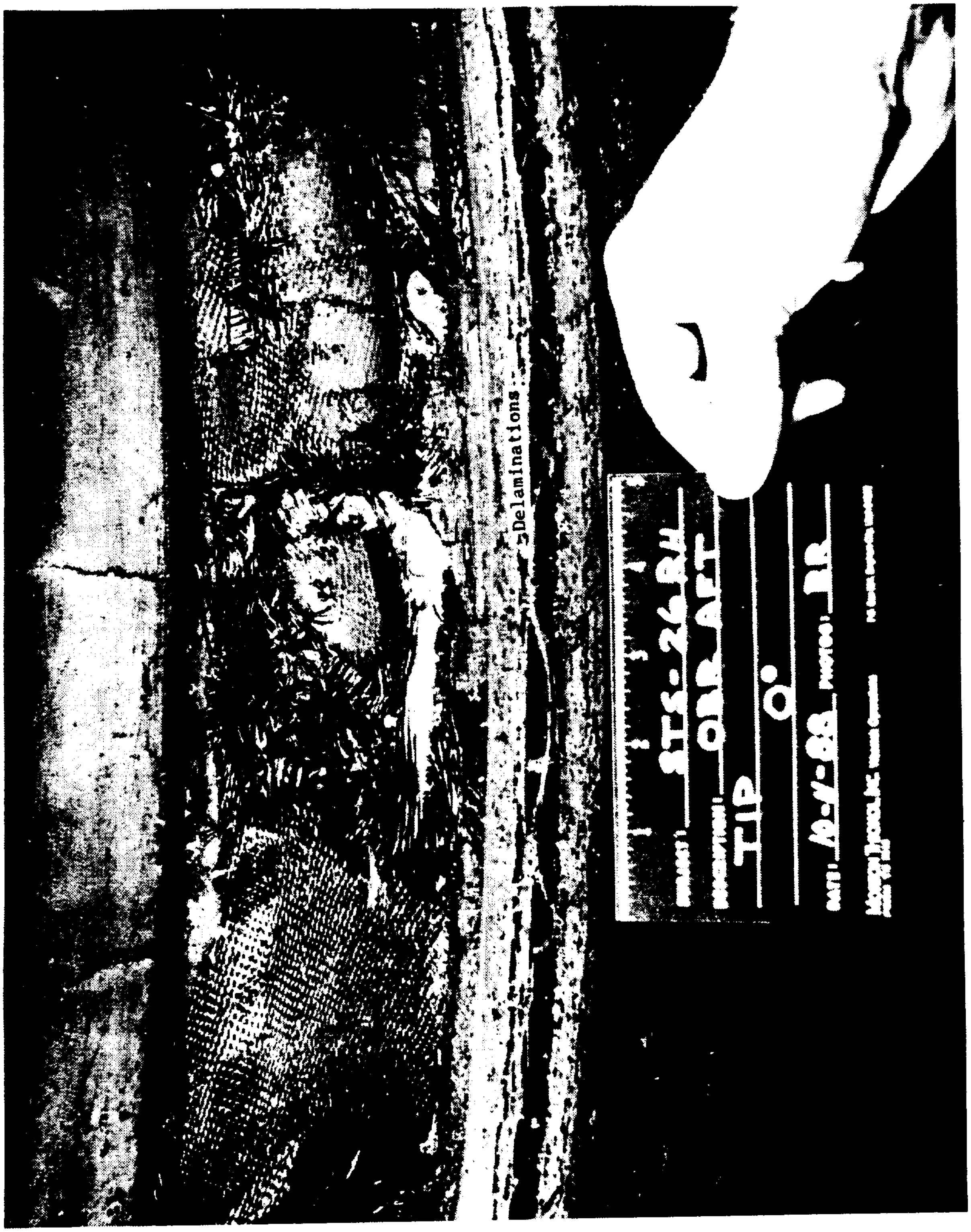

Figure 178 STS-26B Outer Boot Ring Aft Tip Delamination (0 Degrees)

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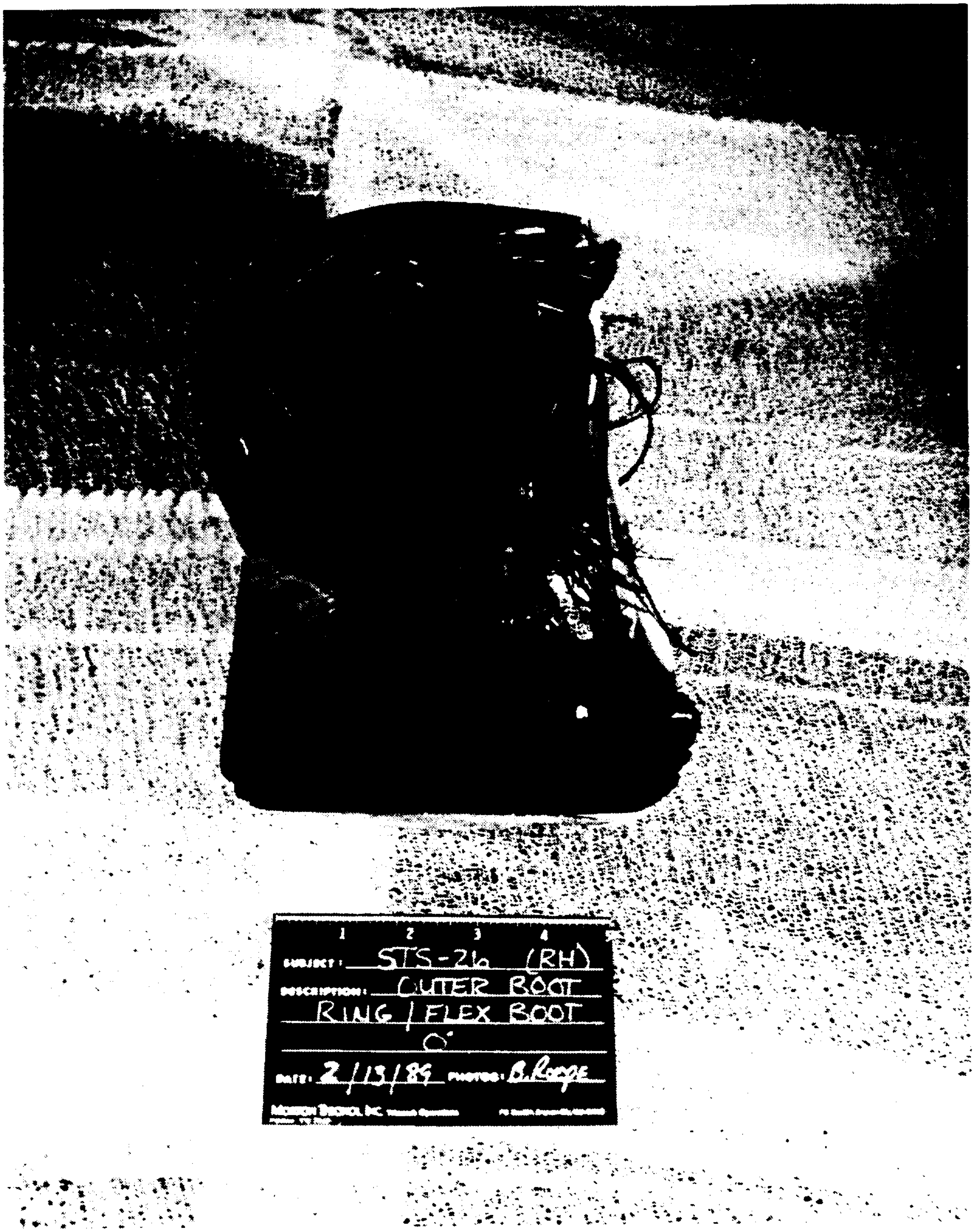

Figure 179 STS-26B Outer Boot Ring Section (0 Degrees)

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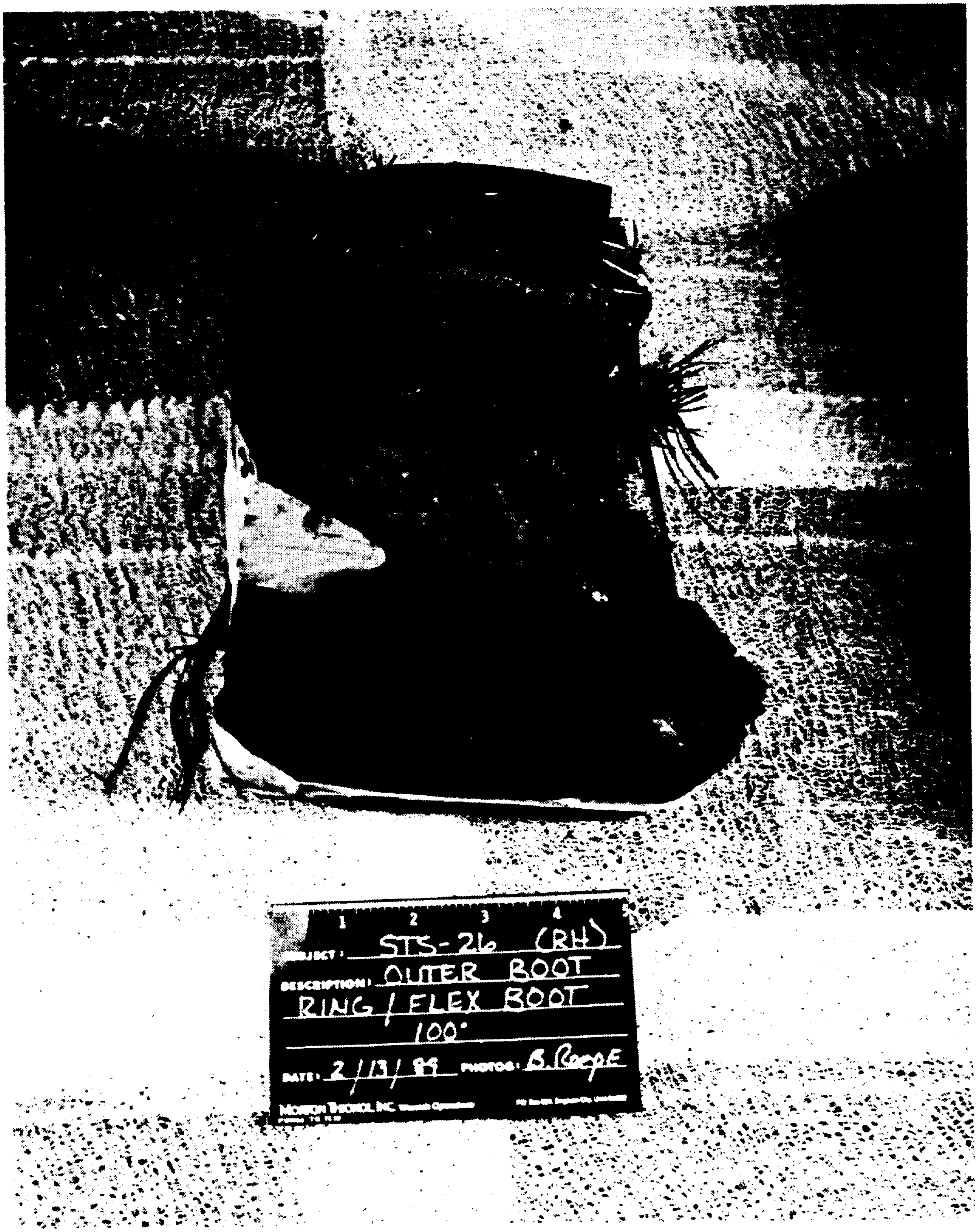

Figure 180 STS-26B Outer Boot Ring Section (100 Degrees)

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Figure 181 STS-26B Outer Boot Ring Section (160 Degrees)

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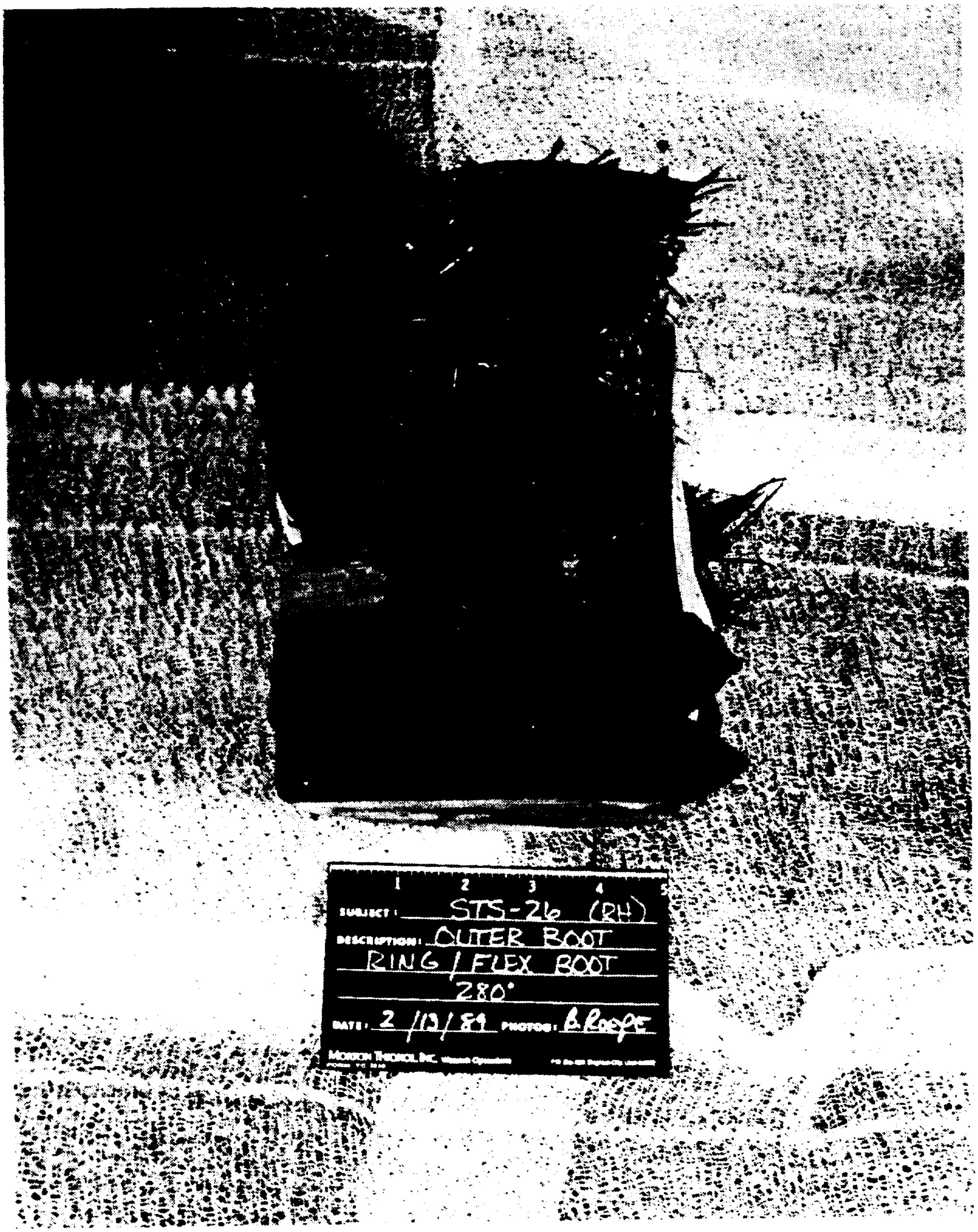

Figure 182 STS-26B Outer Boot Ring Section (280 Degrees)

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Figure 183 STS-26B Flex Boot (Cavity Side - 0 Degrees)

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Figure 184 STS-26B Flex Boot (Cavity Side - 120 Degrees)

Figure 185 STS-26B Flex Boot (Cavity Side - 240 Degrees)

Table 15 STS-26B Flex Boot Data Performance Margins of Safety

Degree Location	Remaining Plies	Max Material Affected Depth (in.)	Margin Of Safety*
0	3.9	1.11	0.50
20	3.9	1.11	0.50
40	3.9	1.11	0.50
60	3.5	1.24	0.34
80	3.7	1.17	0.42
100	3.9	1.11	0.50
120	3.9	1.11	0.50
140	3.9	1.11	0.50
160	3.8	1.14	0.46
220	3.9	1.11	0.50
240	3.8	1.14	0.46
260	3.7	1.17	0.42
280	3.0	1.40	0.19
300	3.2	1.34	0.24
320	3.7	1.17	0.42
340	3.9	1.11	0.50

$$* \text{ PMS} = \frac{\text{minimum overall thickness}}{(1.5 \times \text{max material affected depth})} - 1$$

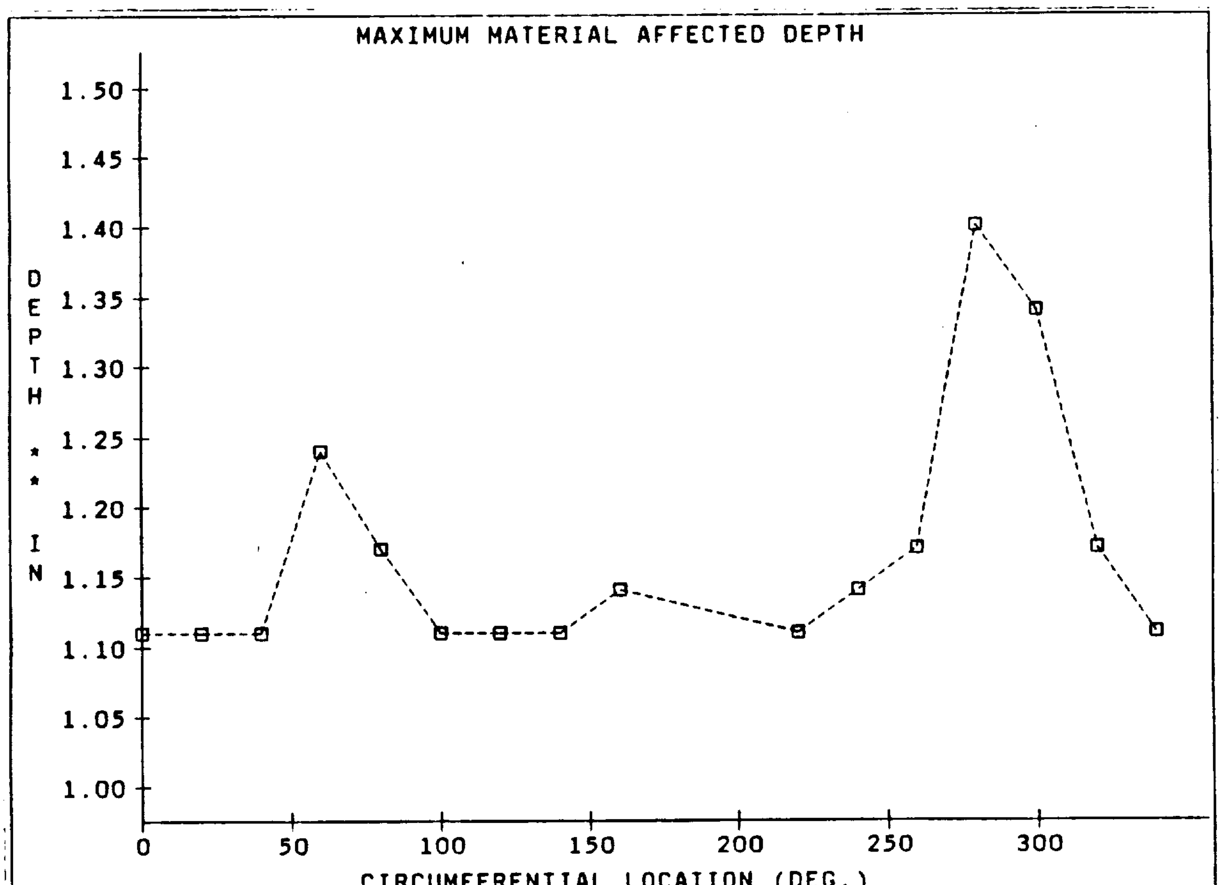

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Figure 186 STS-26B Fixed Housing Section (0 Degrees)

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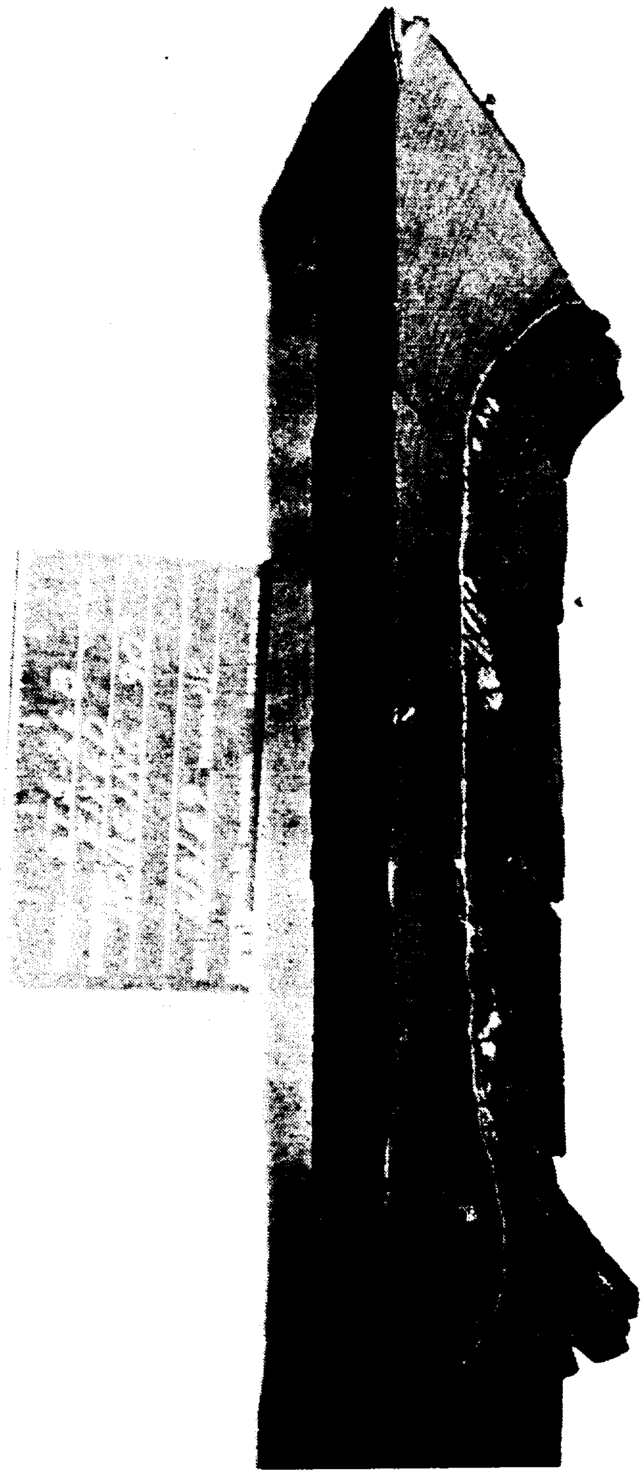

Figure 187 STS-26B Fixed Housing Section (90 Degrees)

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Figure 188 STS-26B Fixed Housing Section (180 Degrees)

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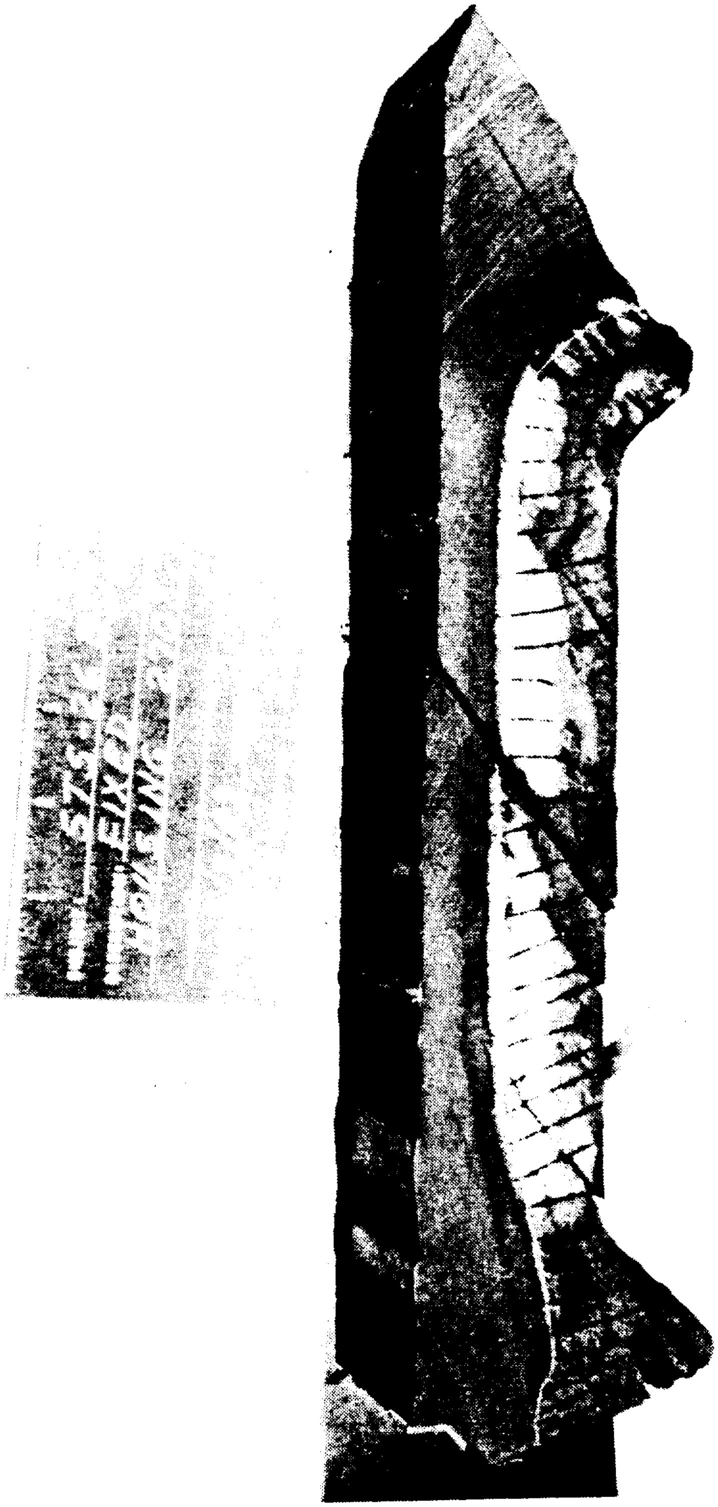

Figure 189 STS-26B Fixed Housing Section (270 Degrees)

Table 16 STS-26B Fixed Housing Insulation Erosion and Char Data

Angular Location	Stations 0	1	2	3	4	5	6	7	8	9	11
0 degrees											
Measured Erosion	0.04	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Measured Char	1.03	1.11	1.10	1.14	1.07	1.07	1.05	1.01	0.84	0.88	1.64
Adjusted Char*	0.82	0.89	0.88	0.91	0.86	0.86	0.84	0.81	0.67	0.70	1.31
2E + 1.25AC	1.11	1.19	1.12	1.14	1.07	1.07	1.05	1.01	0.84	0.88	1.64
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	2.43	0.75	0.63	0.60	0.71	0.71	0.74	0.82	1.19	1.76	0.86
90 degrees											
Measured Erosion	0.05	0.00	0.00	0.02	0.02	0.00	0.03	0.02	0.00	0.03	0.00
Measured Char	1.22	1.29	1.16	1.13	1.12	1.12	1.16	1.04	0.93	0.97	1.92
Adjusted Char*	0.98	1.03	0.93	0.90	0.90	0.90	0.93	0.83	0.74	0.78	1.54
2E + 1.25AC	1.32	1.29	1.16	1.17	1.16	1.12	1.22	1.08	0.93	1.03	1.92
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	1.88	0.61	0.57	0.56	0.58	0.63	0.50	0.70	0.97	1.36	0.59
180 degrees											
Measured Erosion	0.10	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Measured Char	1.26	1.15	1.01	0.98	0.94	0.99	0.99	0.90	0.82	0.89	1.95
Adjusted Char*	1.01	0.92	0.81	0.78	0.75	0.79	0.79	0.72	0.66	0.71	1.56
2E + 1.25AC	1.46	1.23	1.01	0.98	0.94	0.99	0.99	0.90	0.82	0.95	1.95
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	1.61	0.69	0.81	0.86	0.95	0.85	0.85	1.04	1.24	1.55	0.56
270 degrees											
Measured Erosion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.03	0.00
Measured Char	1.07	1.19	1.12	1.19	1.16	1.17	1.08	1.03	0.91	0.91	1.73
Adjusted Char*	0.86	0.95	0.90	0.95	0.93	0.94	0.86	0.82	0.73	0.73	1.38
2E + 1.25AC	1.07	1.19	1.12	1.19	1.16	1.17	1.08	1.07	0.91	0.97	1.73
RSRM min Liner Thickness	3.807	2.081	1.825	1.827	1.829	1.831	1.832	1.834	1.836	2.426	3.048
Margin of Safety	2.56	0.75	0.63	0.54	0.58	0.56	0.70	0.71	1.02	1.50	0.76

* Measured char adjusted to end of action time

$$\text{Margin of Safety} = \frac{\text{minimum liner thickness}}{2 \times \text{Erosion} + 1.25 \times \text{Adj Char*}} - 1$$

Refer to Figure 70 for Station Locations

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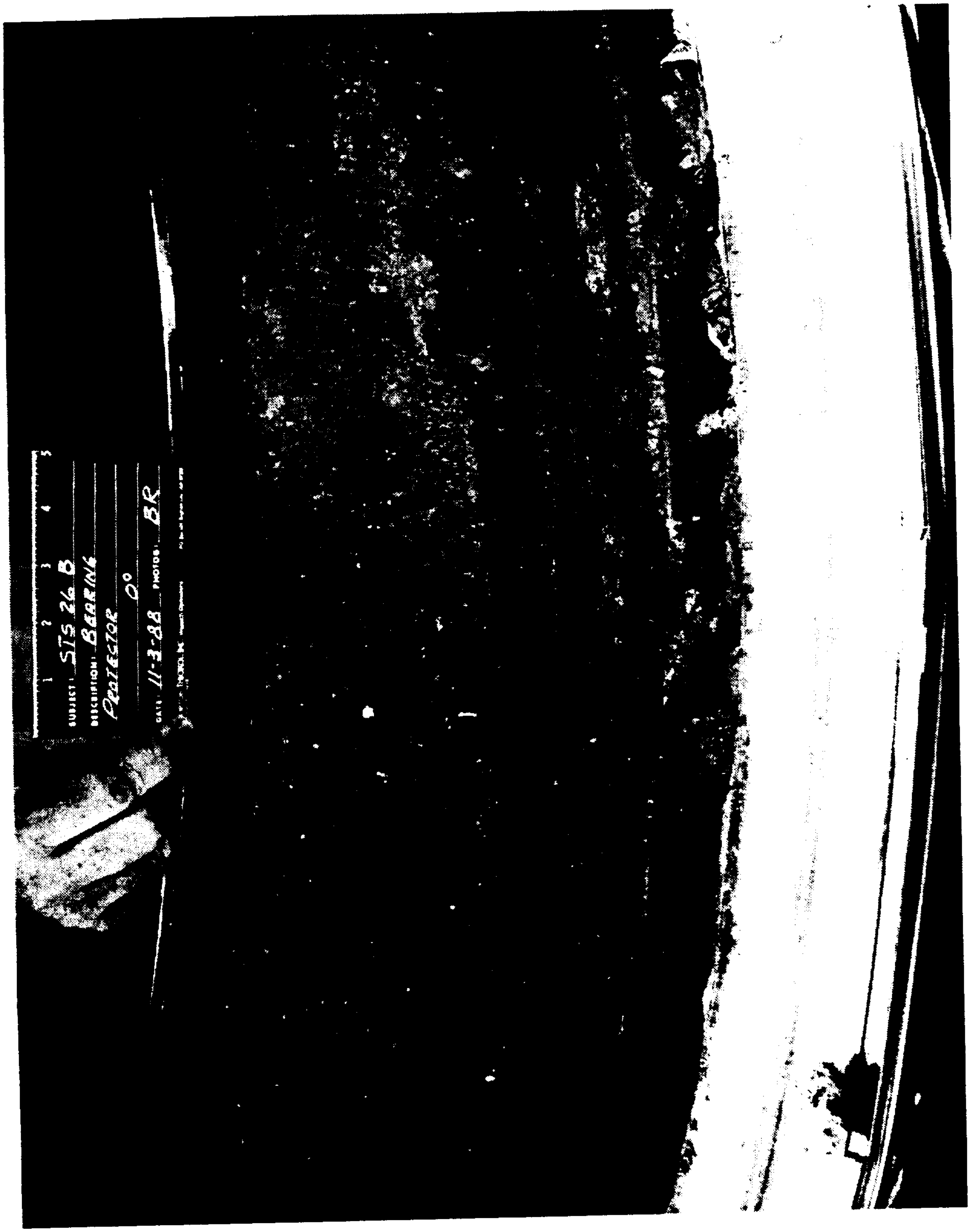

Figure 190 STS-26B Bearing Protector (0 Degrees)

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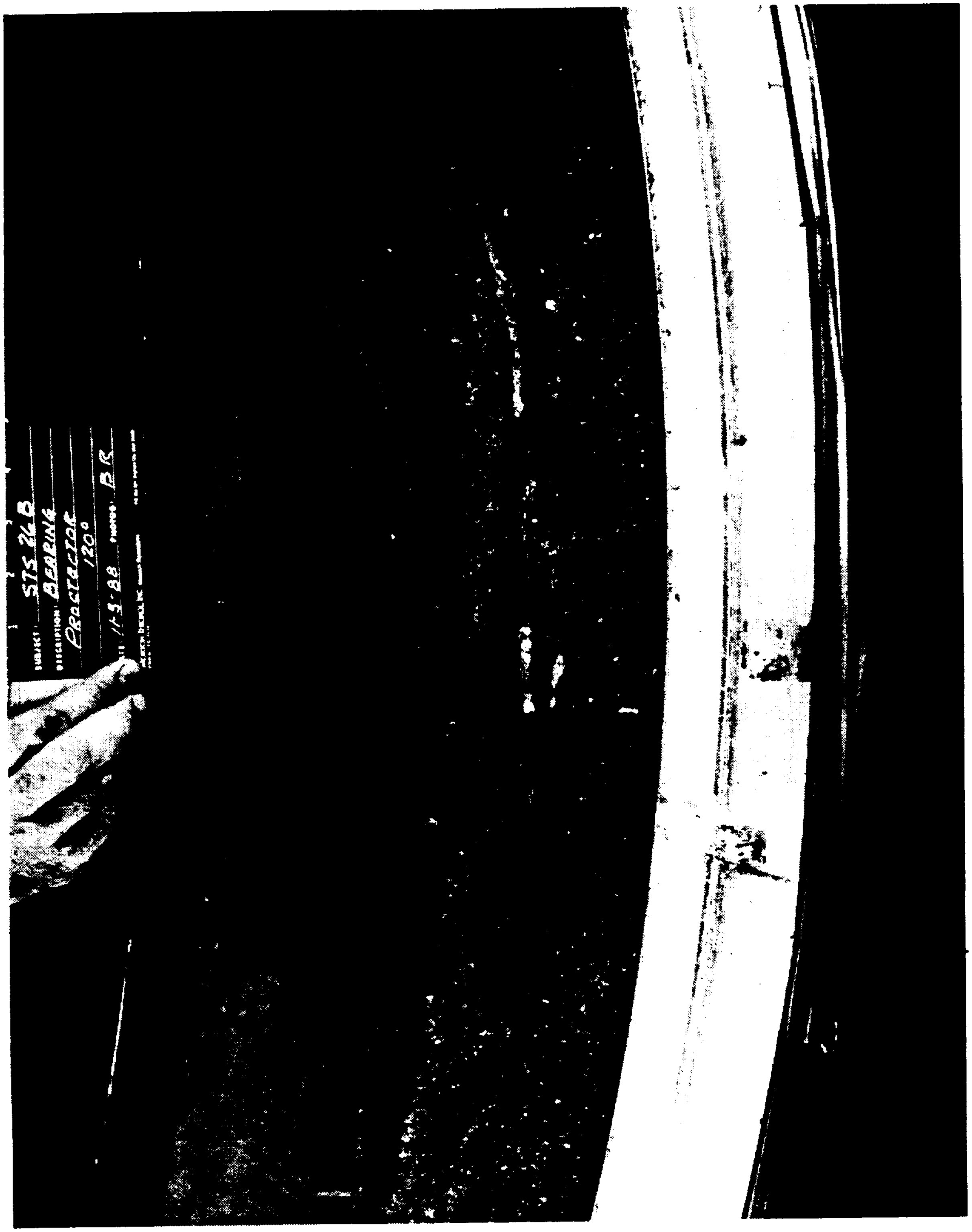

Figure 191 STS-26B Bearing Protector (120 Degrees)

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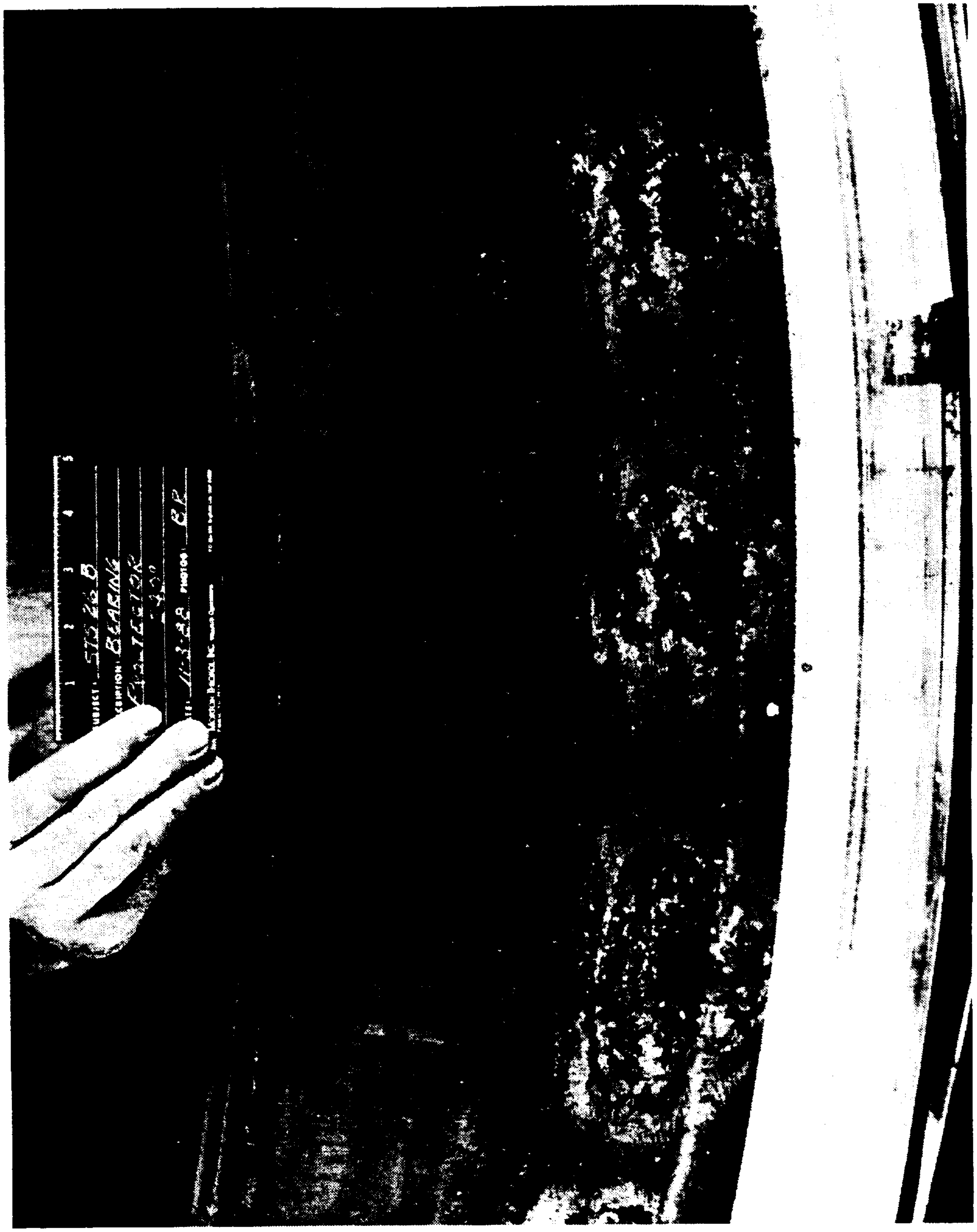
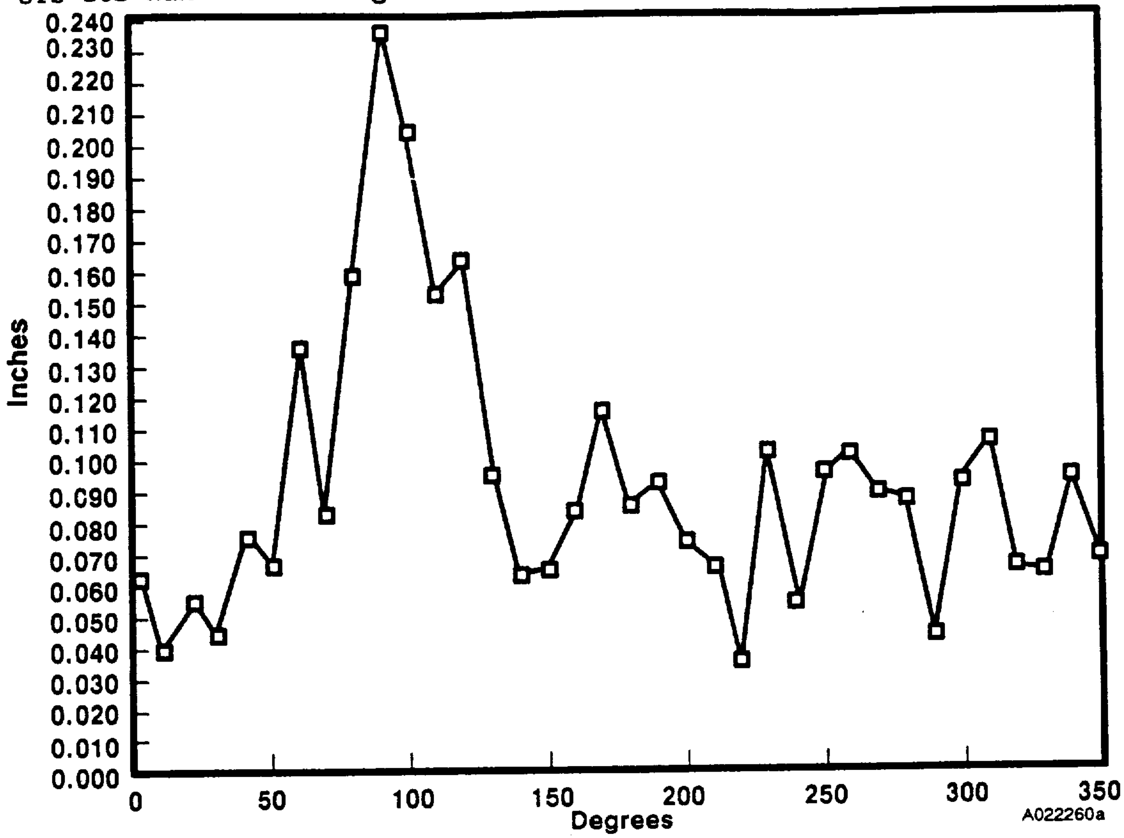


Figure 192 STS-26B Bearing Protector (240 Degrees)

Table 17

STS-26B Maximum Bearing Protector Erosion in Line with Cowl Vent Holes



Circumferential Location (deg)	Erosion (In.) In Line With Cowl Vent Holes
0	0.061
10	0.040
20	0.056
30	0.045
40	0.077
50	0.069
60	0.136
70	0.081
80	0.159
90	0.237
100	0.202
110	0.152
120	0.163
130	0.096
140	0.063
150	0.065
160	0.082
170	0.116
180	0.086
190	0.092
200	0.074
210	0.067
220	0.035
230	0.102
240	0.055
250	0.098
260	0.111
270	0.090
280	0.089
290	0.045
300	0.093
310	0.106
320	0.068
330	0.067
340	0.095
350	0.070

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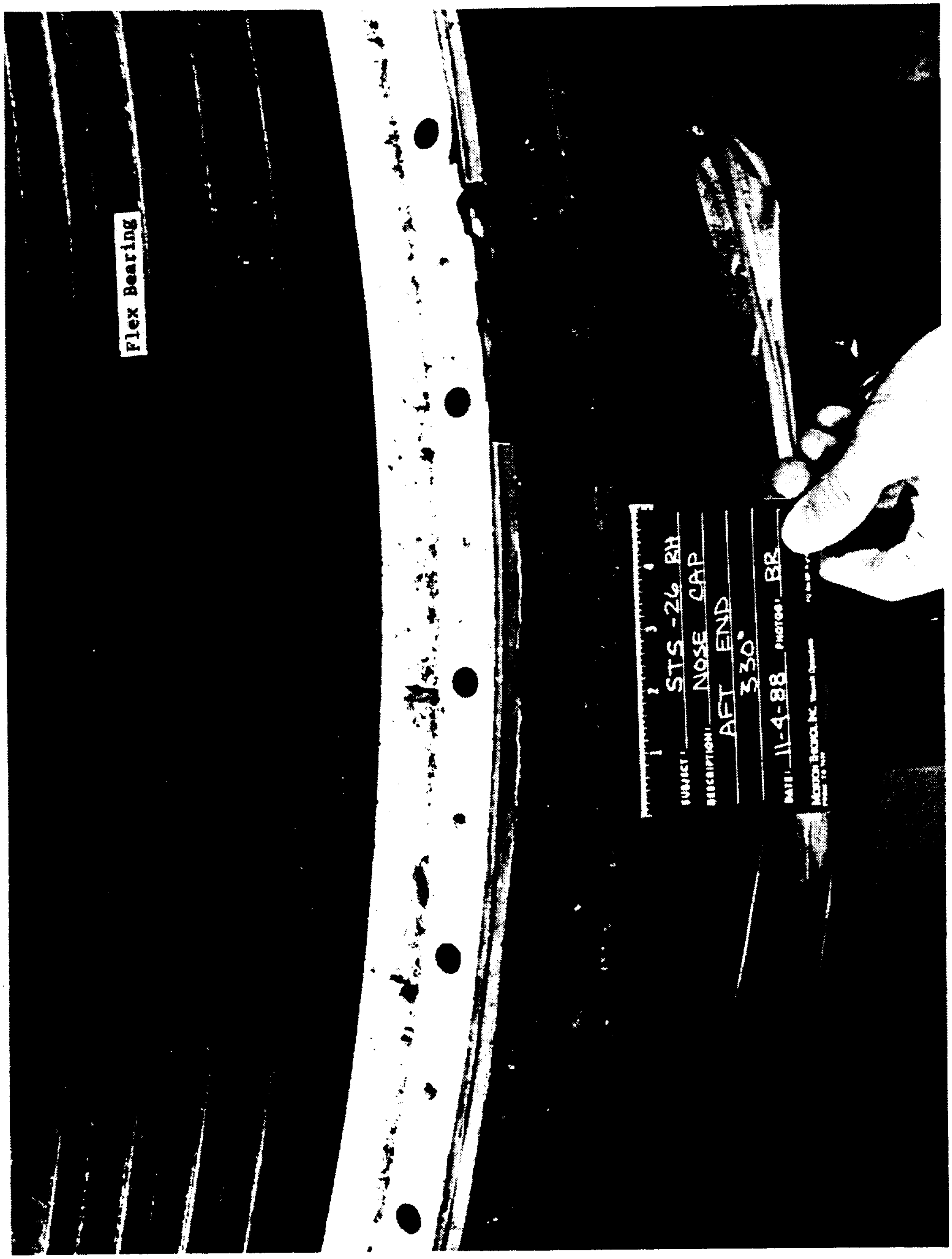

Figure 193 STS-26B Flex Bearing (330 Degrees)

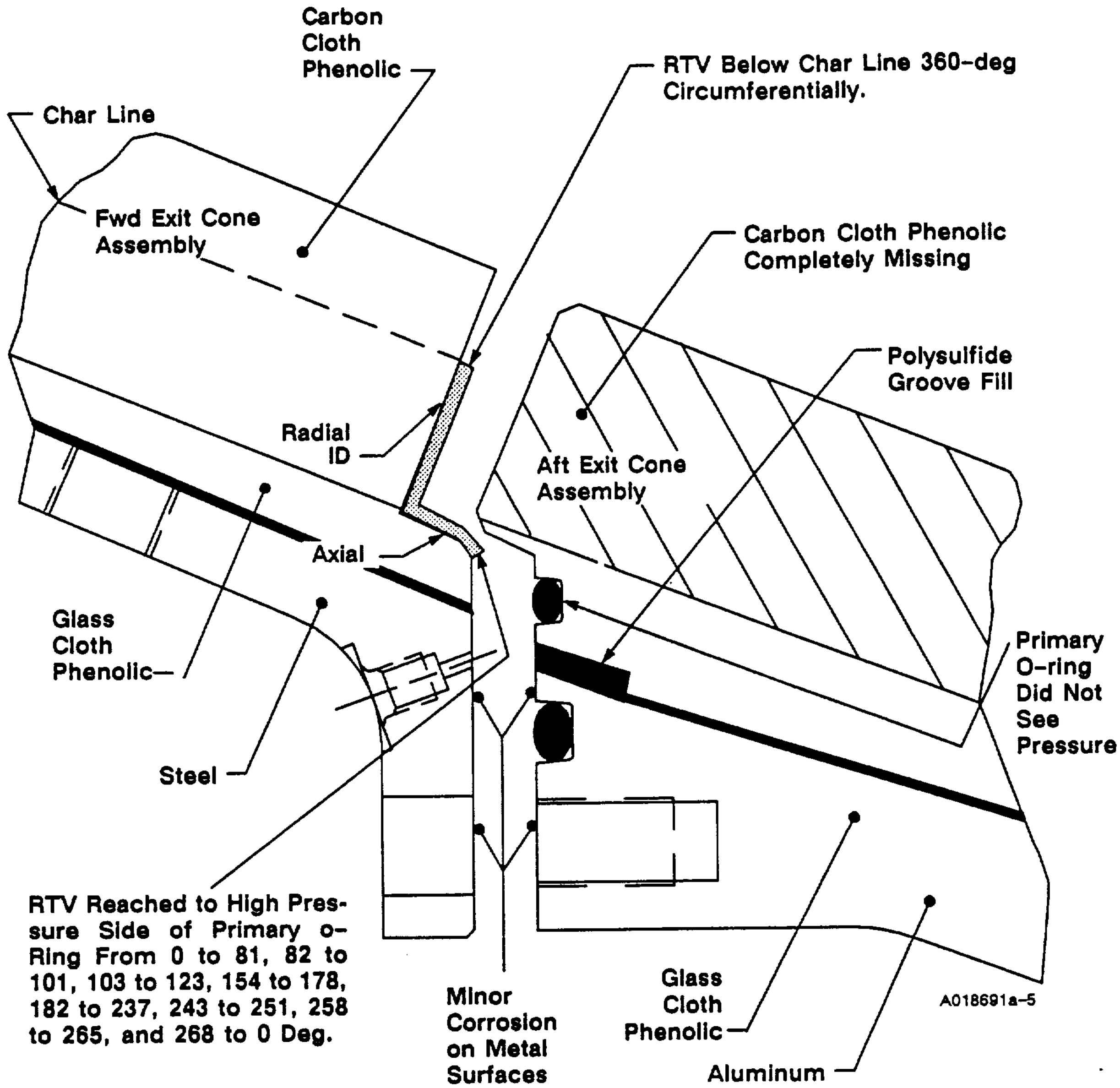

Figure 194 STS-26B—Aft Exit Cone-to-Forward Exit Cone Joint Interface

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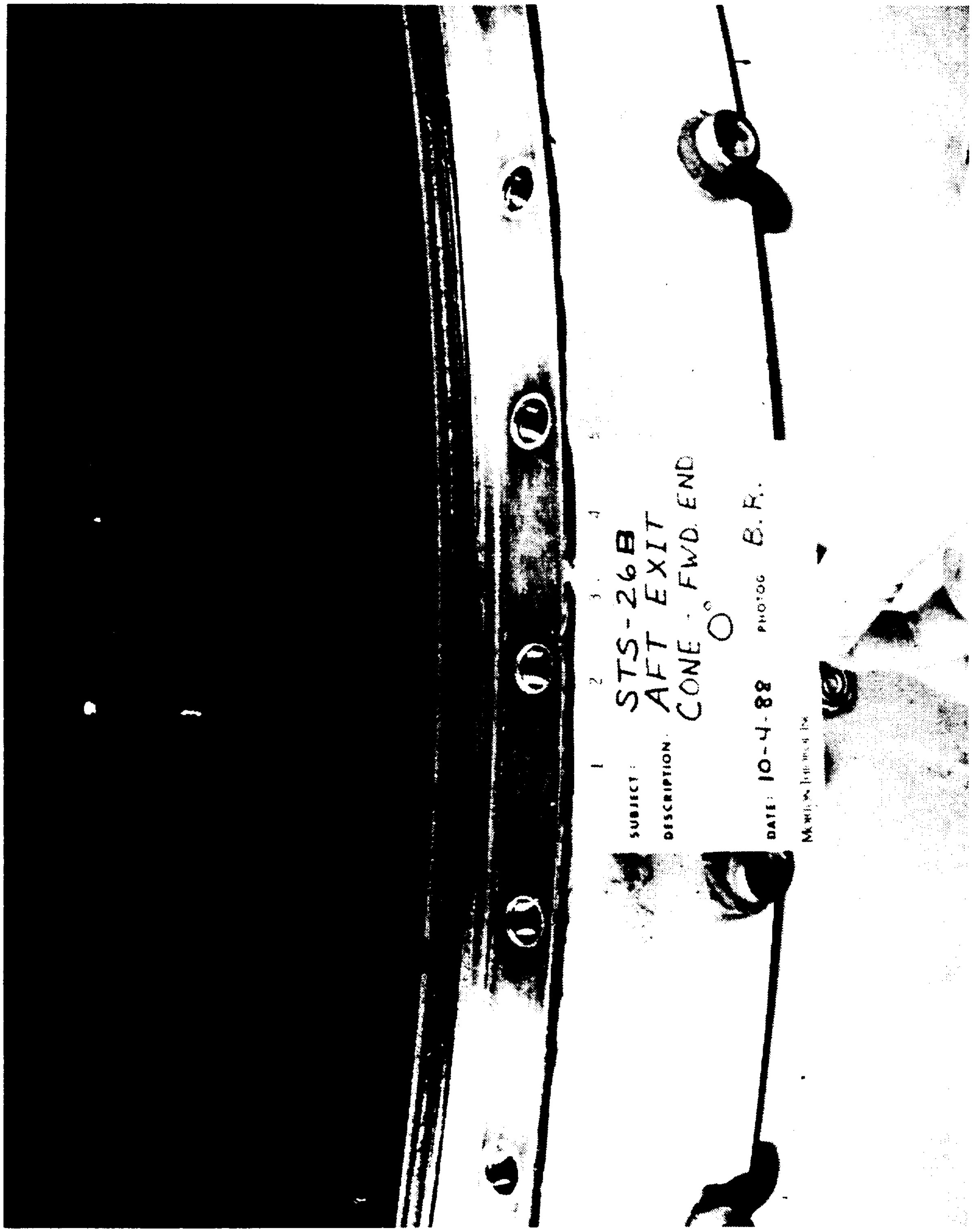

Figure 195 STS-26B Aft Exit Cone Forward End (0 Degrees)

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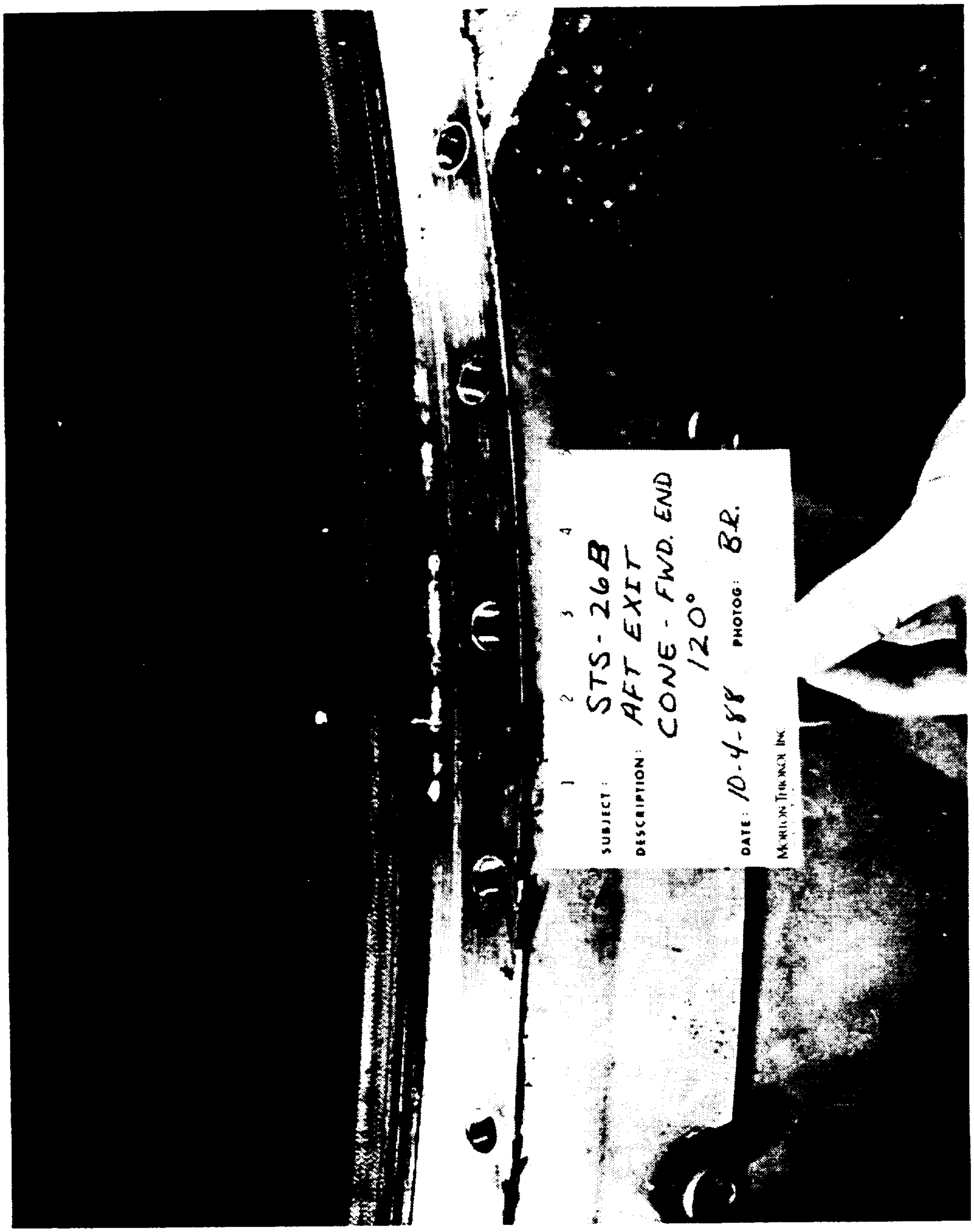

Figure 196 STS-26B Aft Exit Cone Forward End (120 Degrees)

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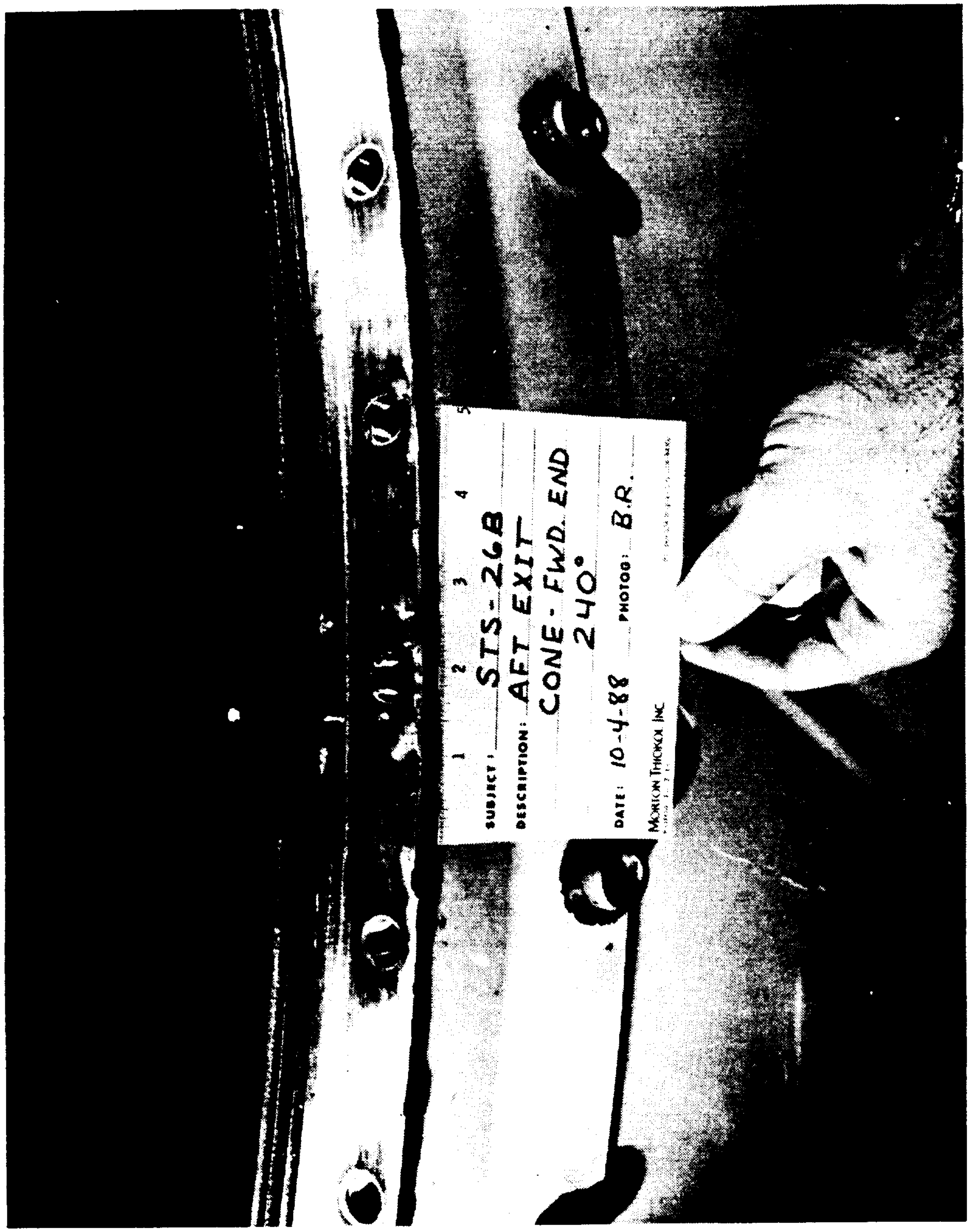

Figure 197 STS-26B Aft Exit Cone Forward End (240 Degrees)

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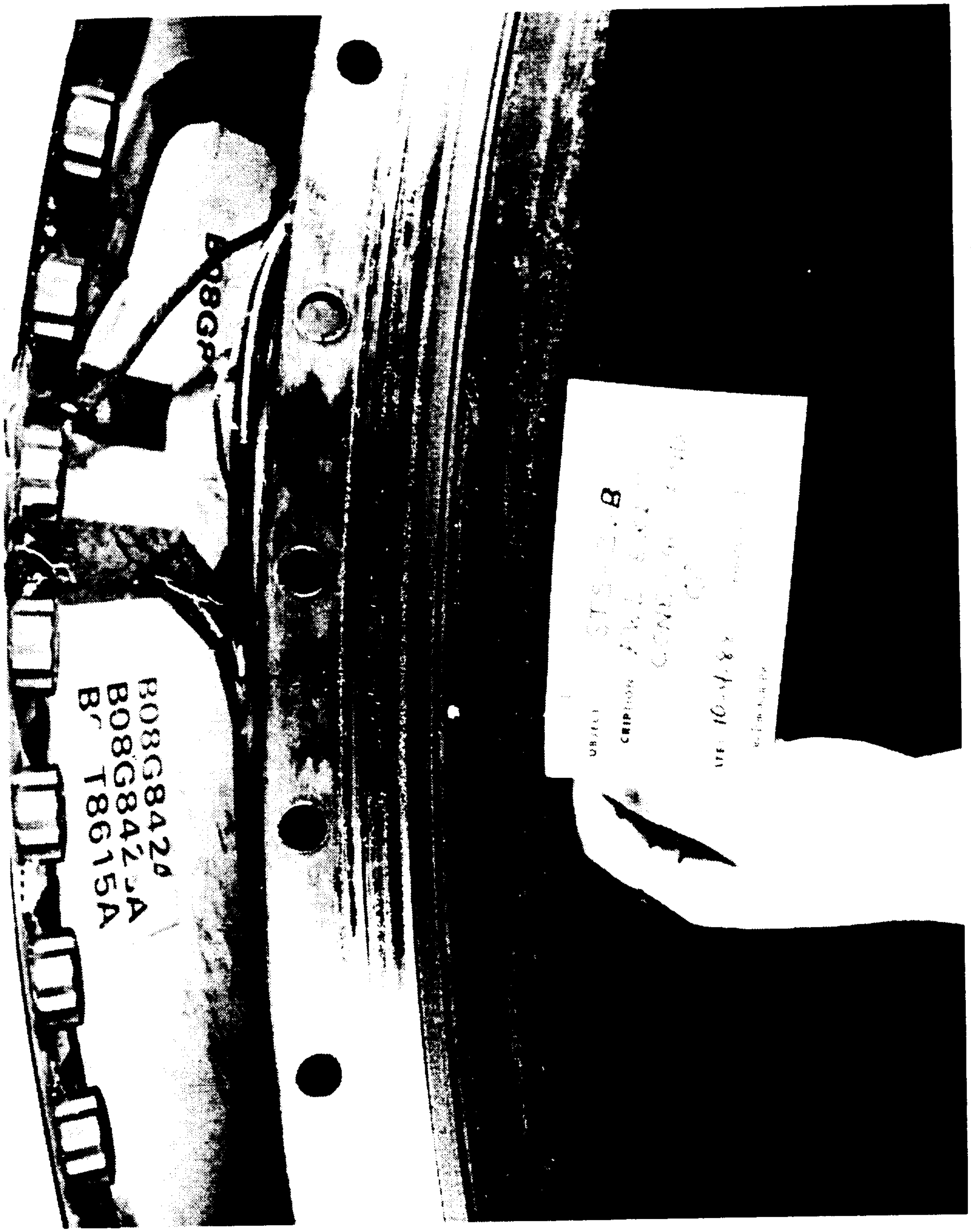

Figure 198 STS-26B Forward Exit Cone - Aft End (0 Degrees)

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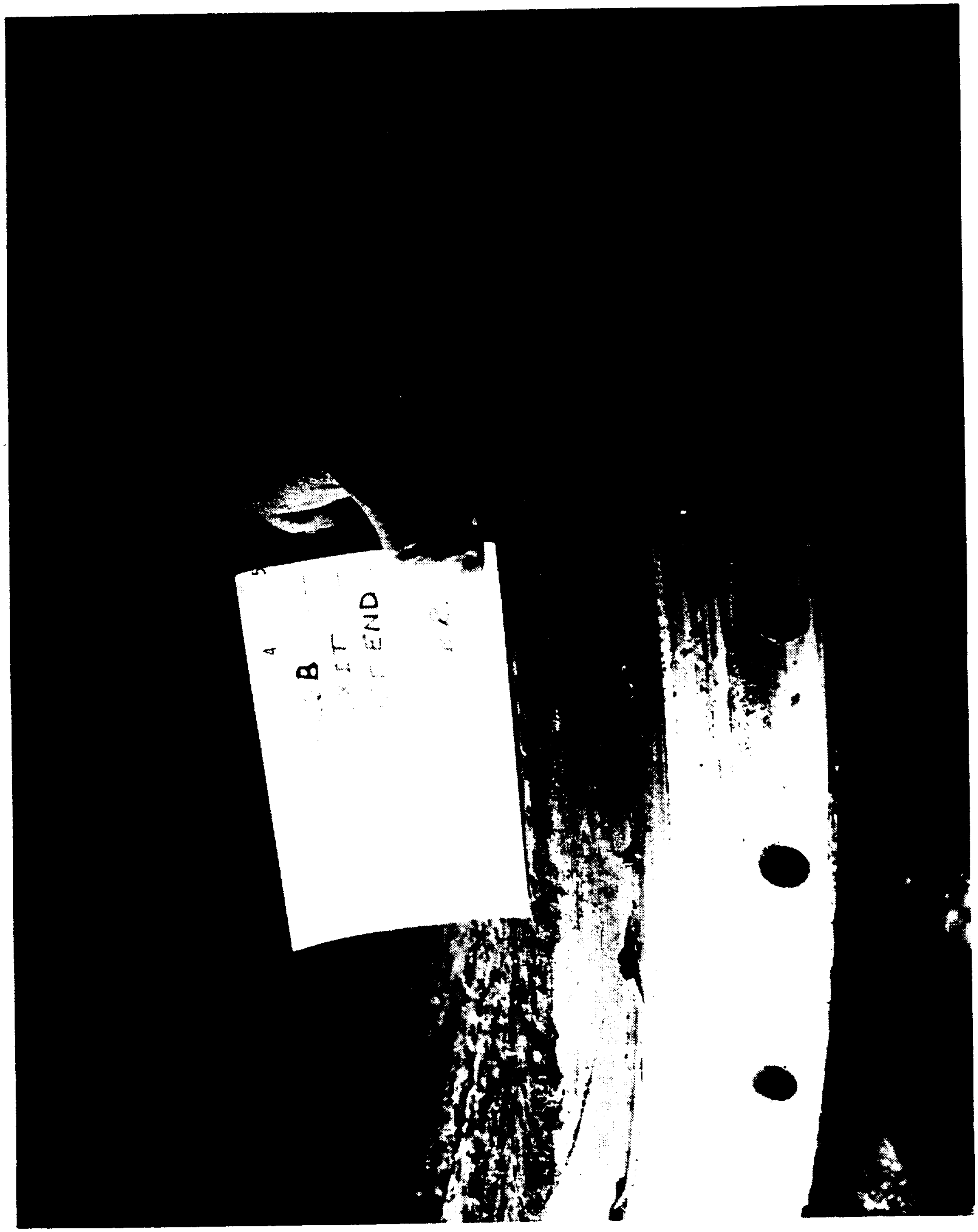

Figure 199 STS-26B Forward Exit Cone - Aft End (120 Degrees)

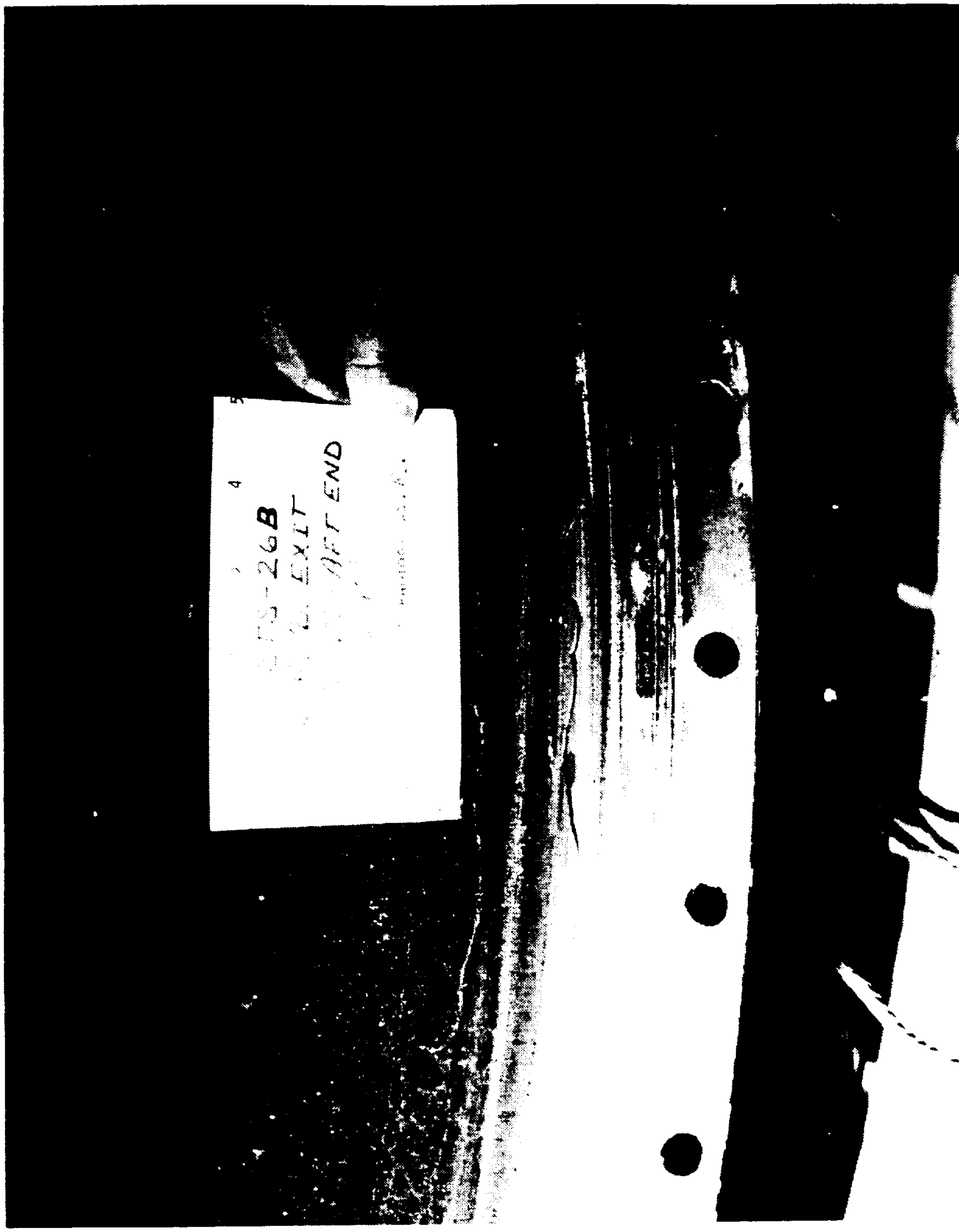

Figure 200 STS-26B Forward Exit Cone - Aft End (240 Degrees)

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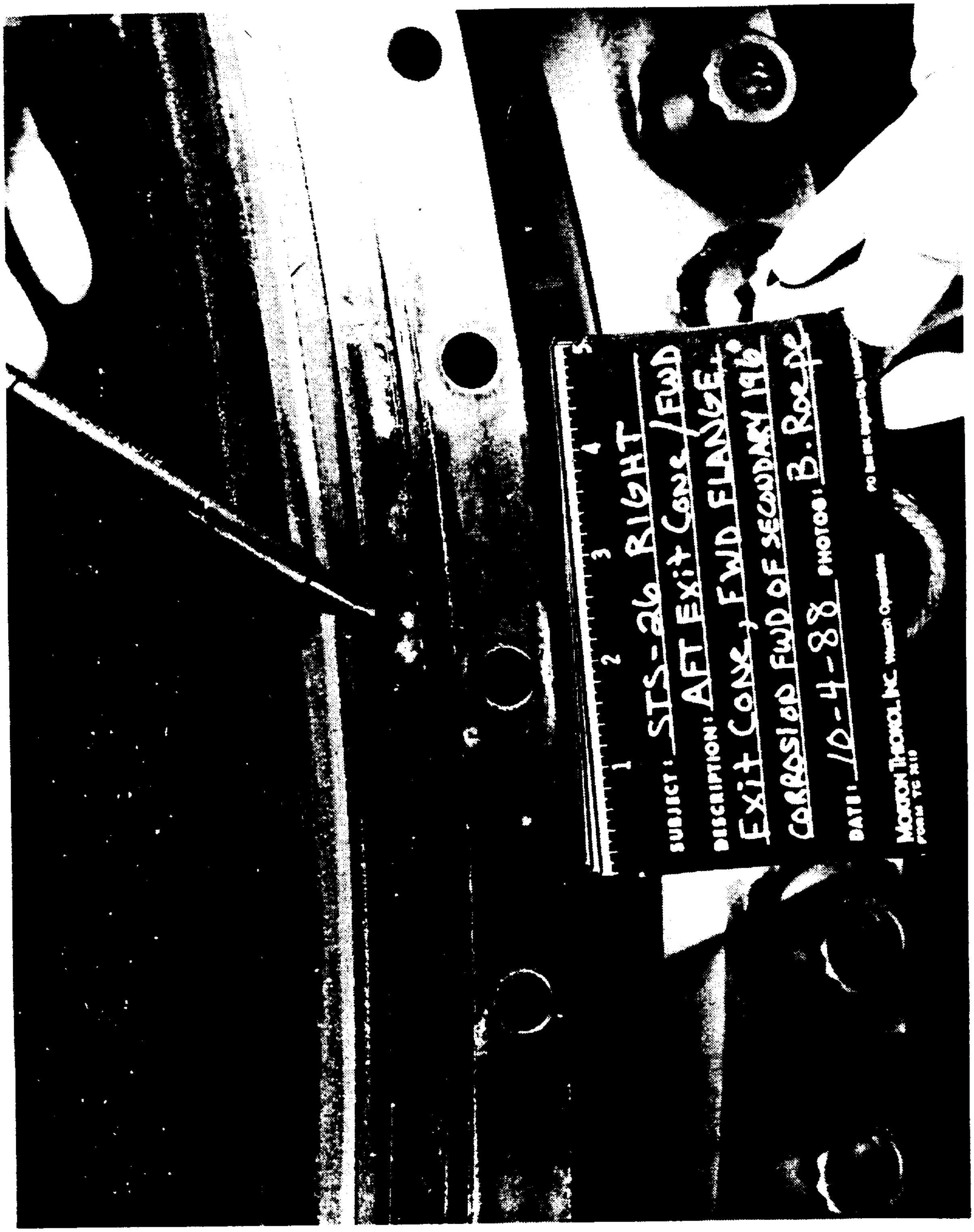

Figure 201 STS-26B Forward Exit Cone Aft End Corrosion

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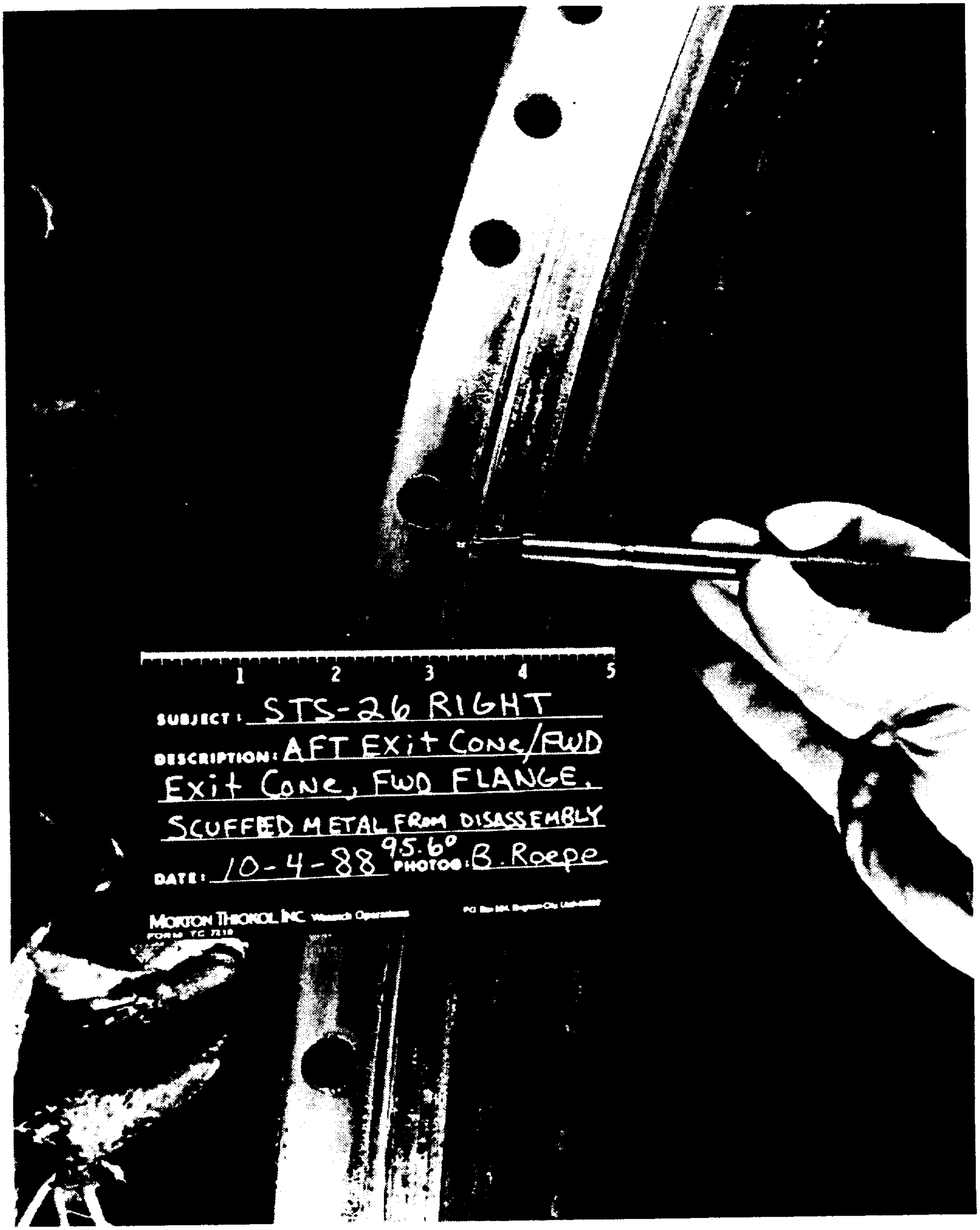

Figure 202 STS-26B Forward Exit Cone Aft End Scuff Mark

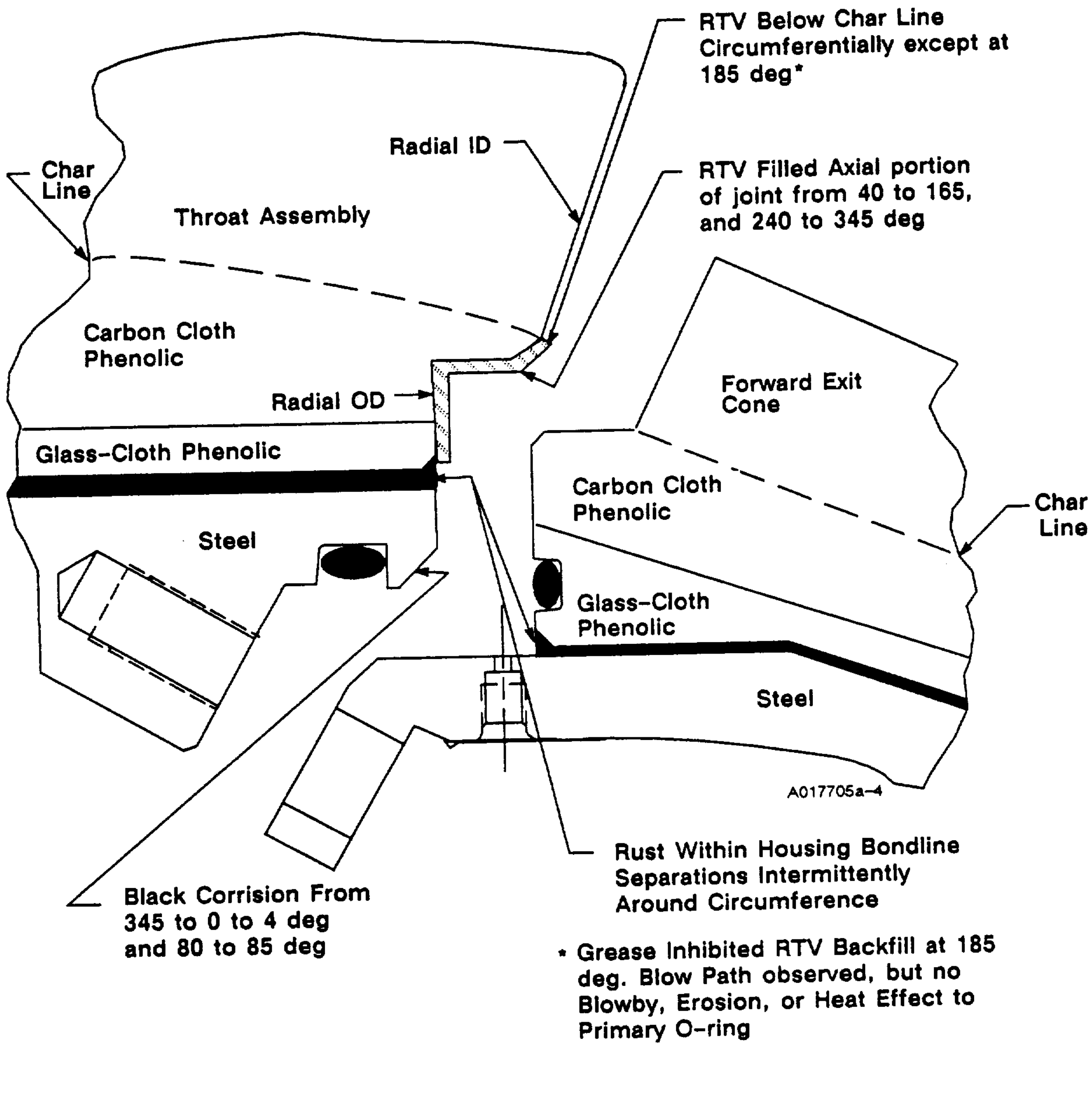

Figure 203 STS-26B Throat/Forward Exit Cone Joint

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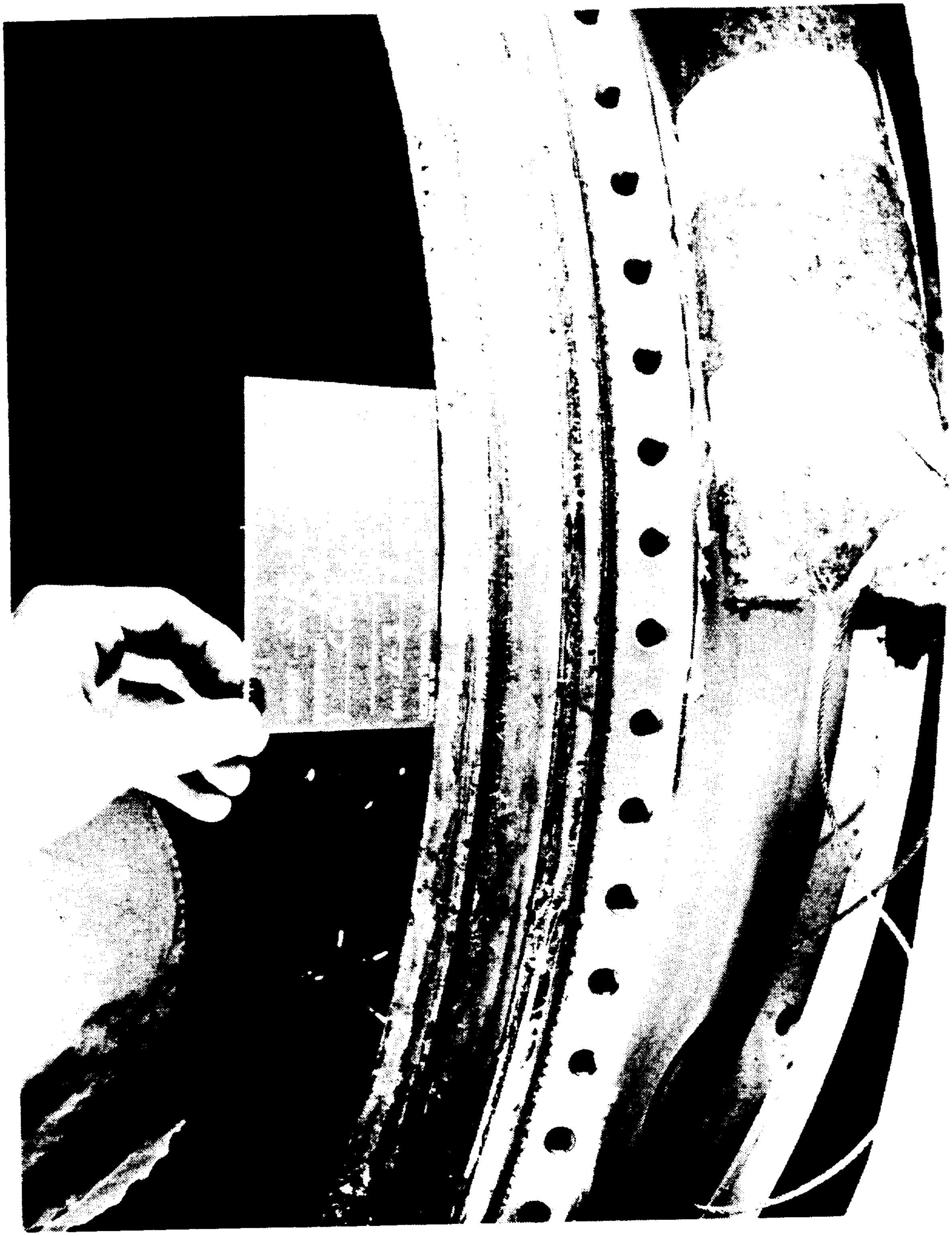

Figure 204 STS-26B Forward Exit Cone - Forward End (0 Degrees)

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Figure 205 STS-26B Forward Exit Cone - Forward End (120 Degrees)

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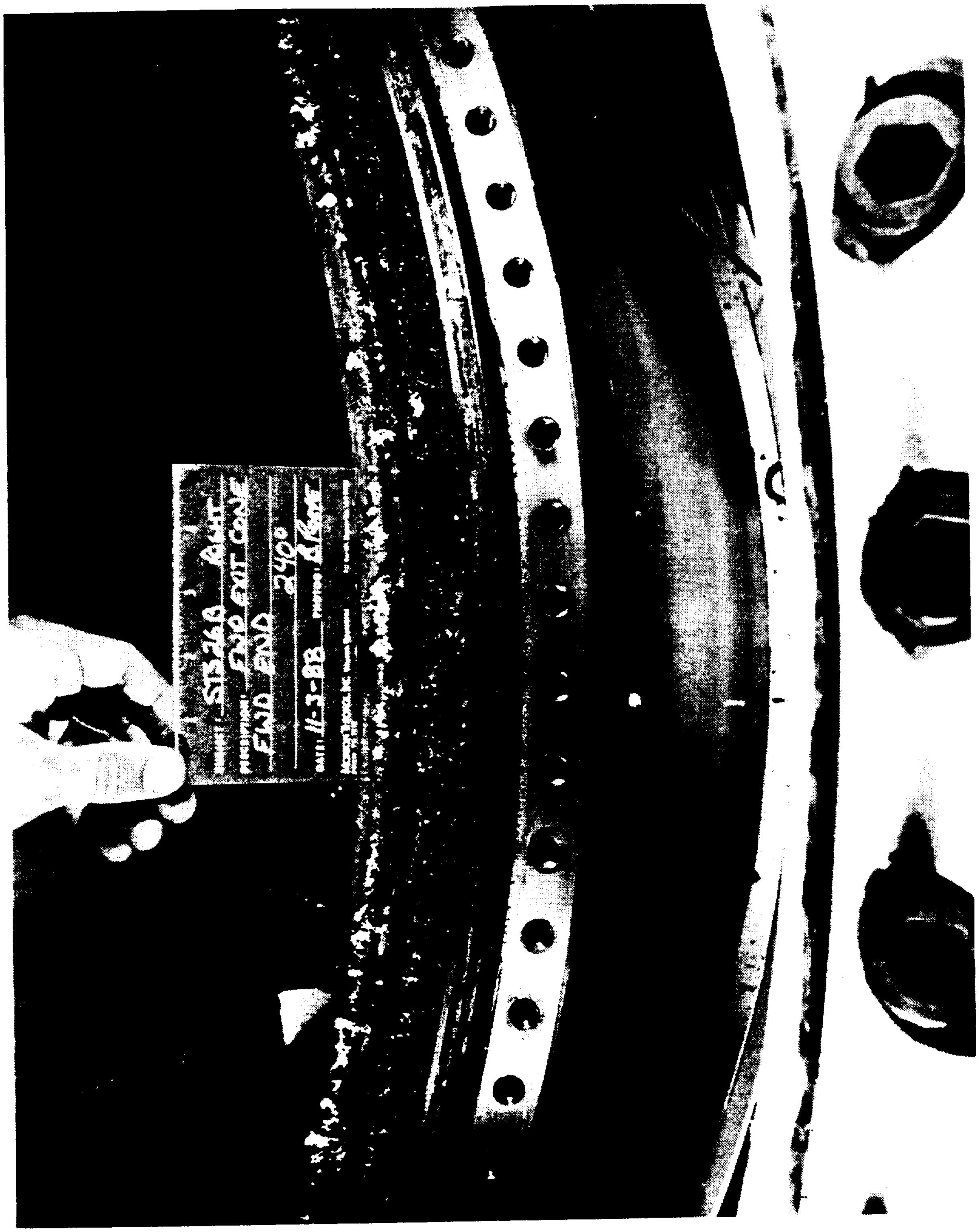

Figure 206 STS-26B Forward Exit Cone - Forward End (240 Degrees)

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Figure 207 STS-26B Throat Aft End (0 Degrees)

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Figure 208 STS-26B Throat Aft End (120 Degrees)

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Figure 209 STS-26B Throat Aft End (240 Degrees)

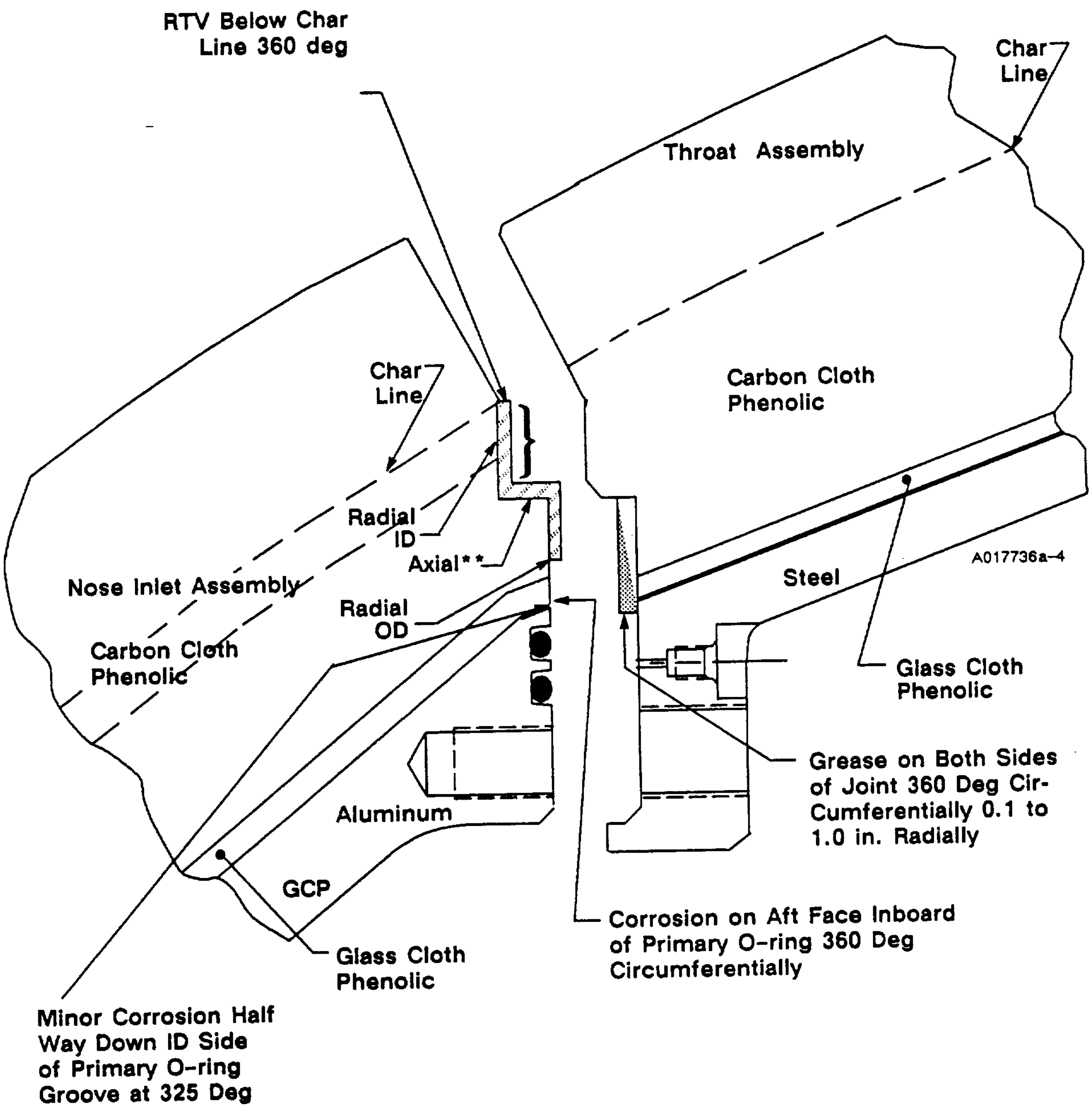

Figure 210 STS-26B Nose Inlet/Throat Housing Joint

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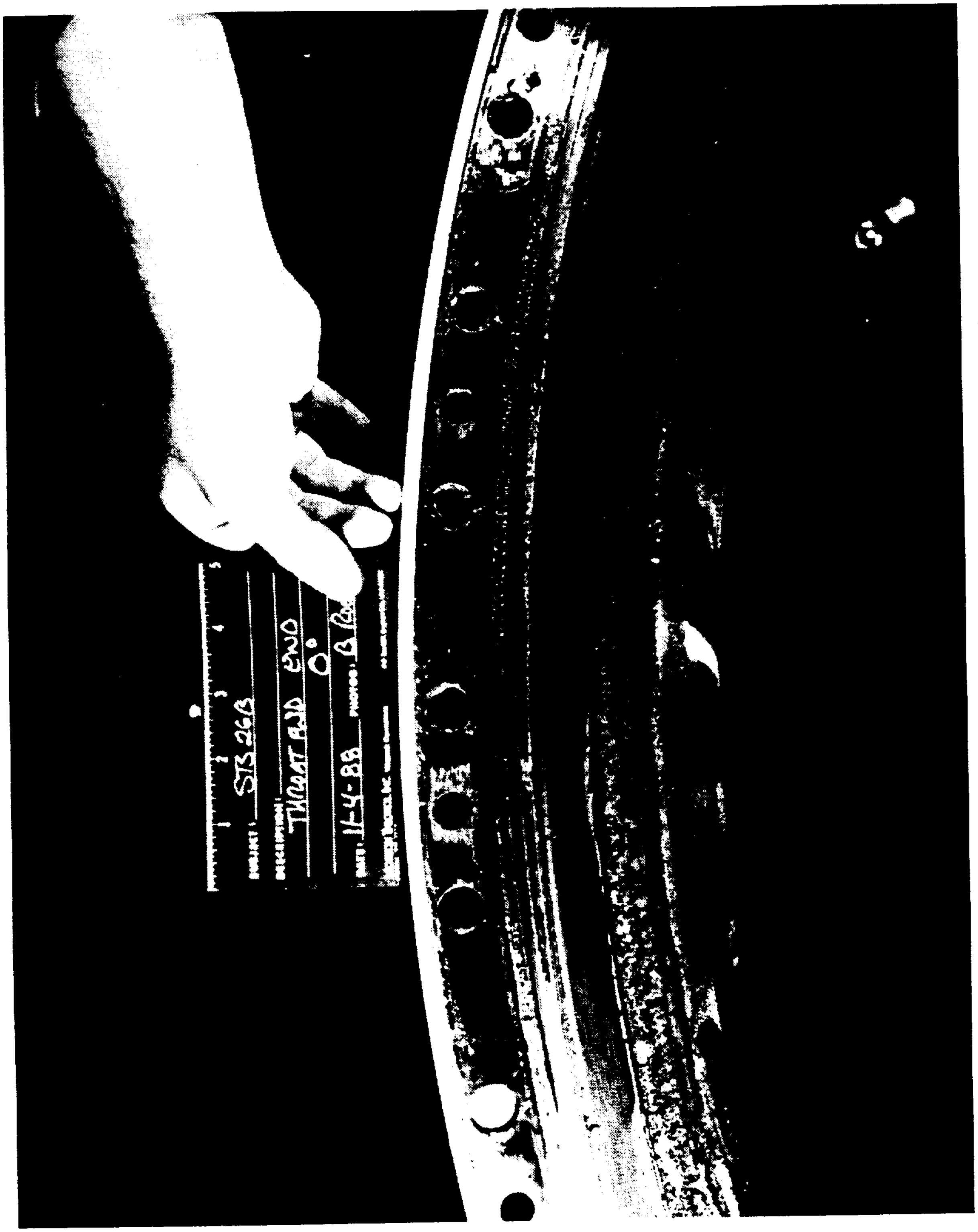

Figure 211 STS-26B Throat-Forward End (0 Degrees)

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Figure 212 STS-26B Throat-Forward End (120 Degrees)

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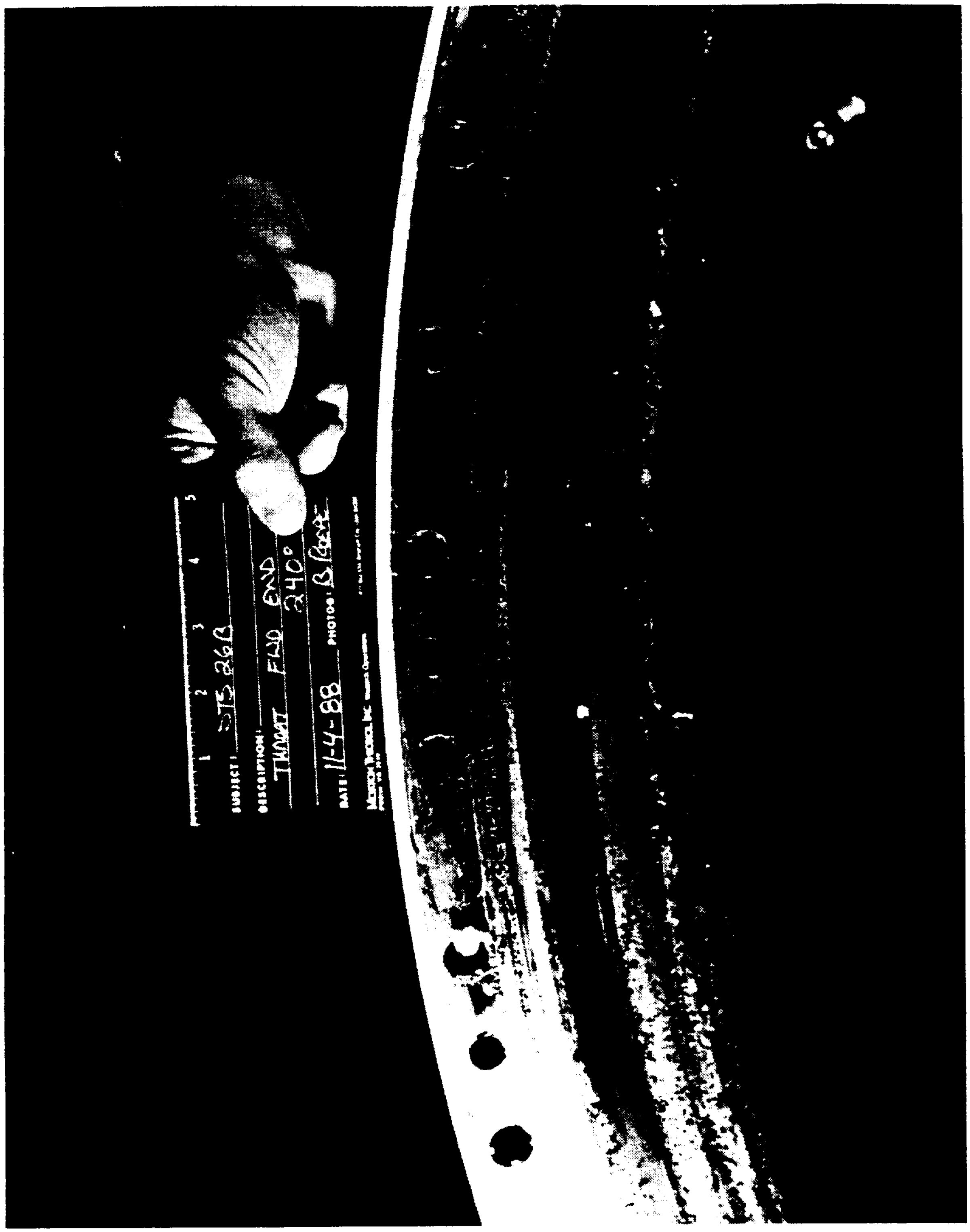

Figure 213 STS-26B Throat-Forward End (240 Degrees)

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Figure 214 STS-26B Aft Inlet (-504) Ring-Aft End (0 Degrees)

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Figure 215 STS-26B Aft Inlet (-504) Ring-Aft End (120 Degrees)

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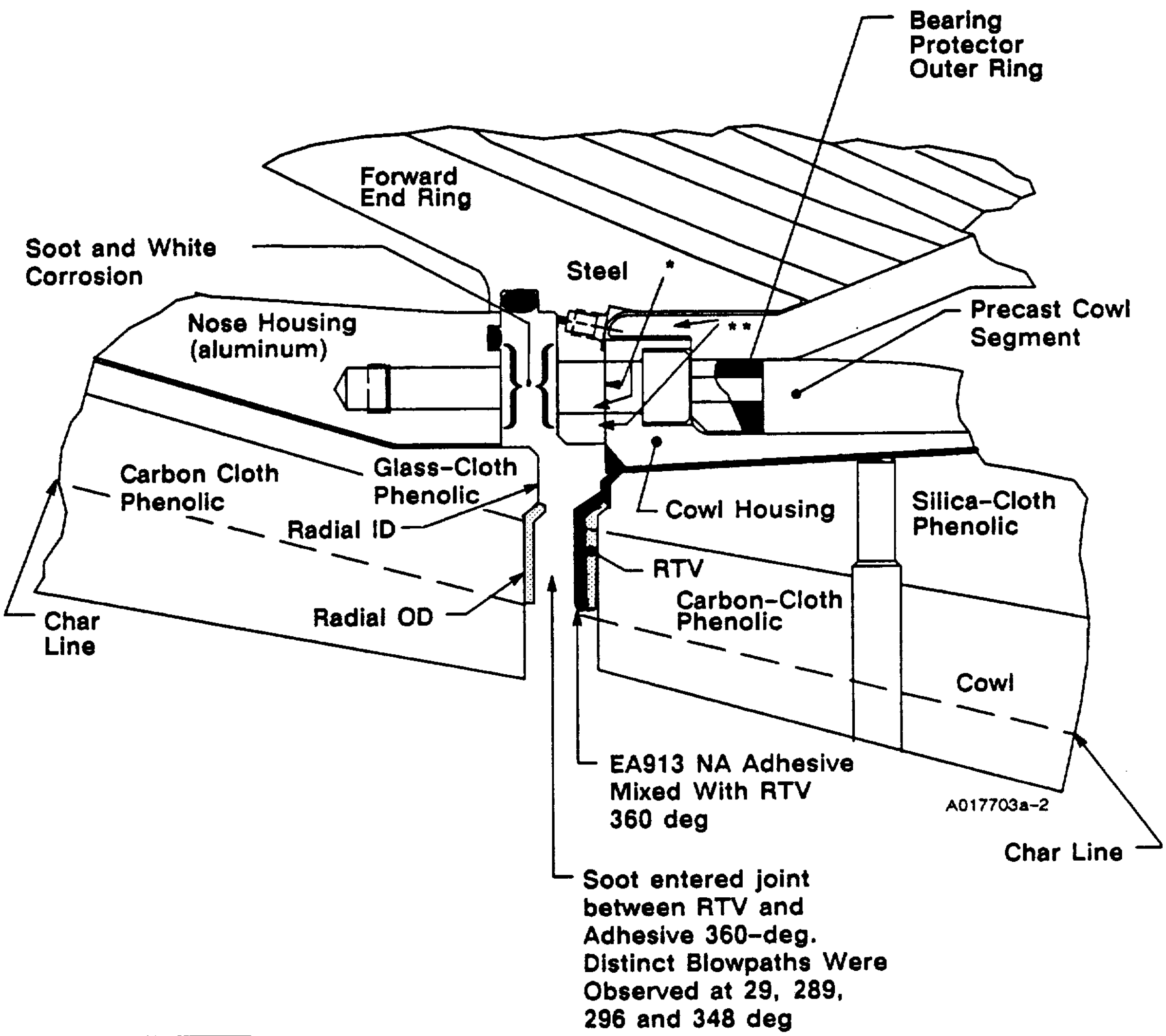
Figure 216 STS-26B Aft Inlet (-504) Ring-Aft End (240 Degrees)



*Soot observed at 130-153, 165, 255, 303-310 deg.
**Intermittent White Corrosion

Figure 217 STS-26B Nose Inlet Housing/Flex Bearing Joint

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Figure 218 STS-26B Cowl-Forward End (0 Degrees)

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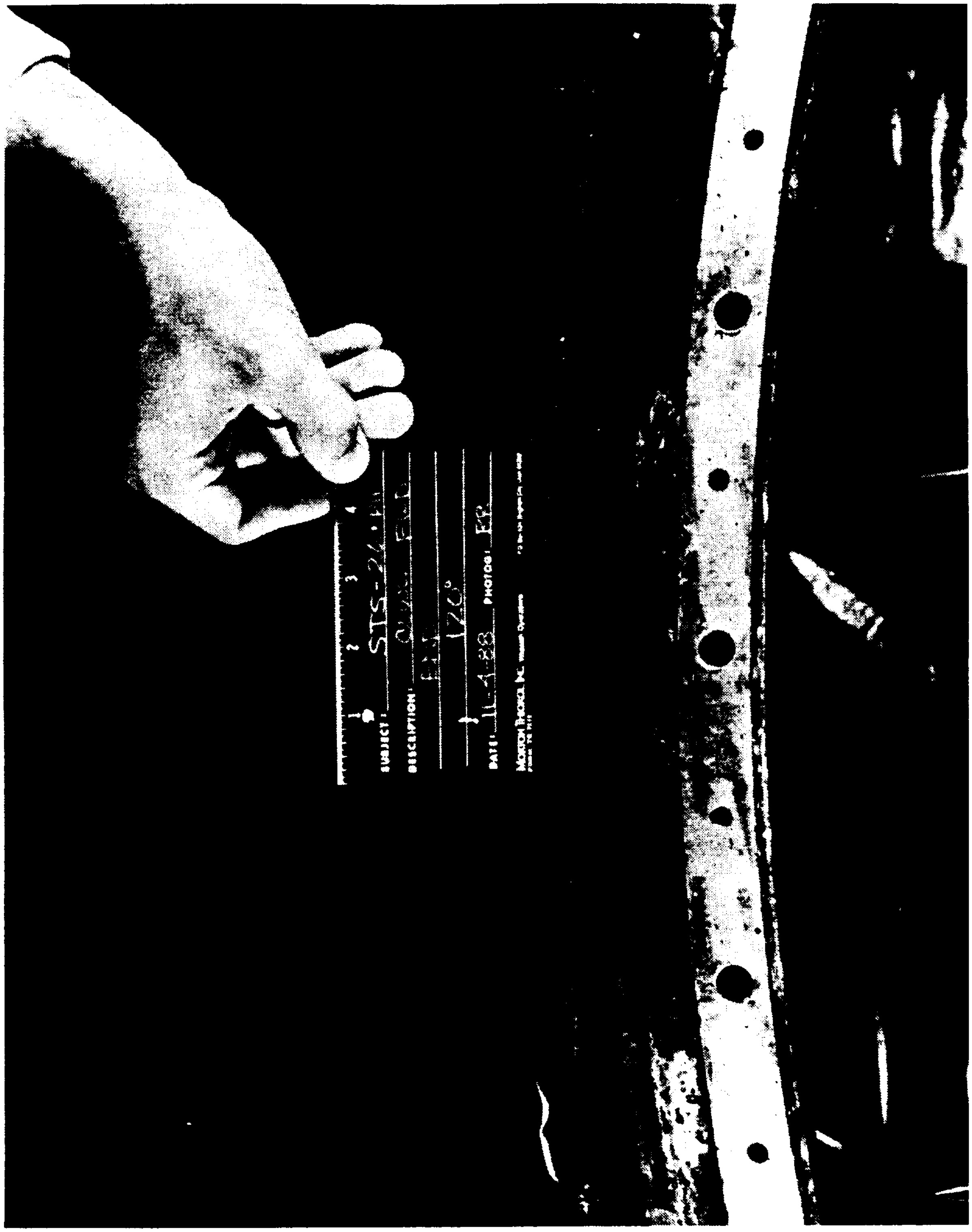

Figure 219 STS-26B Cowl-Forward End (120 Degrees)

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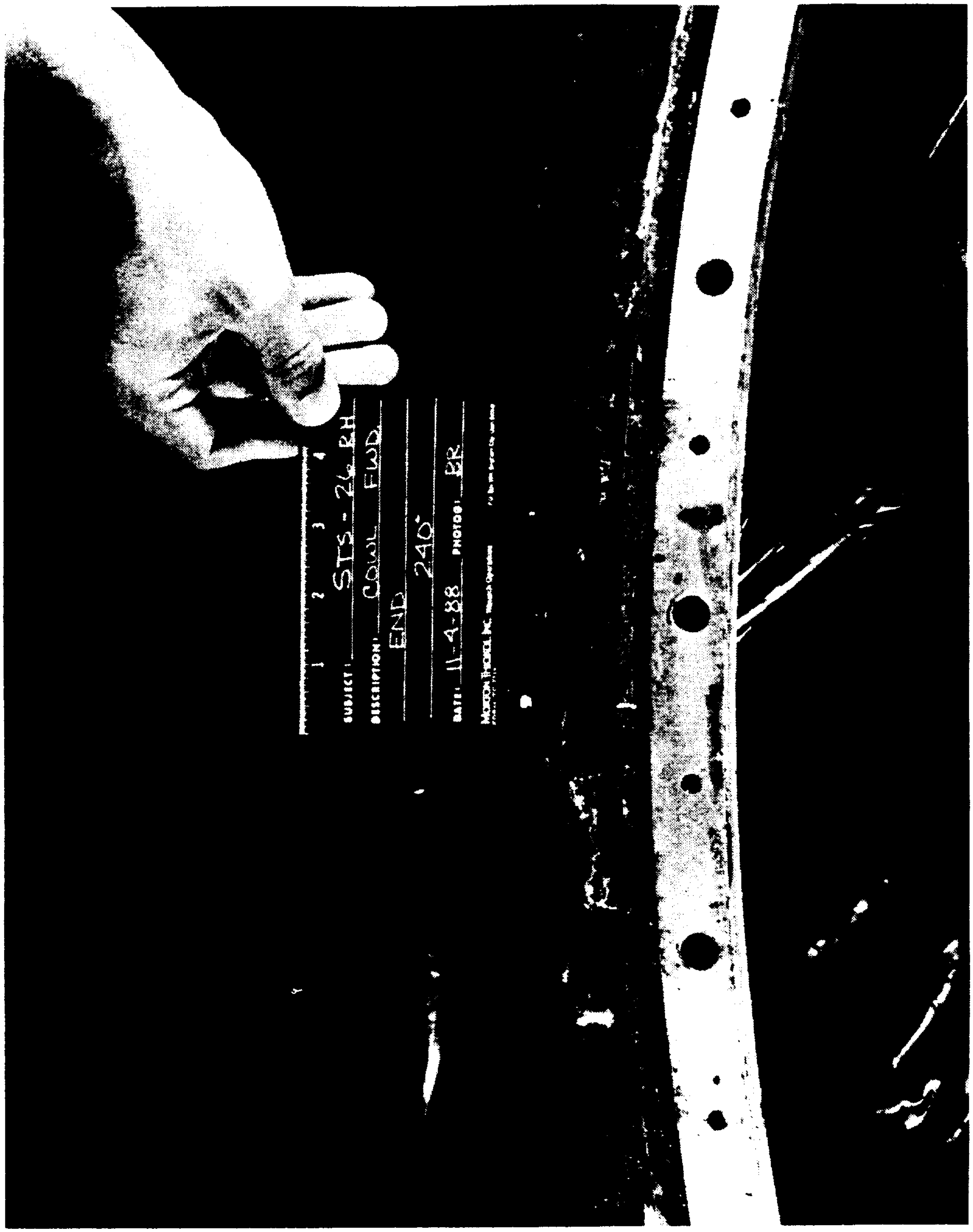

Figure 220 STS-26B Cowl-Forward End (240 Degrees)

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Figure 221 STS-26B Nose Cap-Aft End (0 Degrees)

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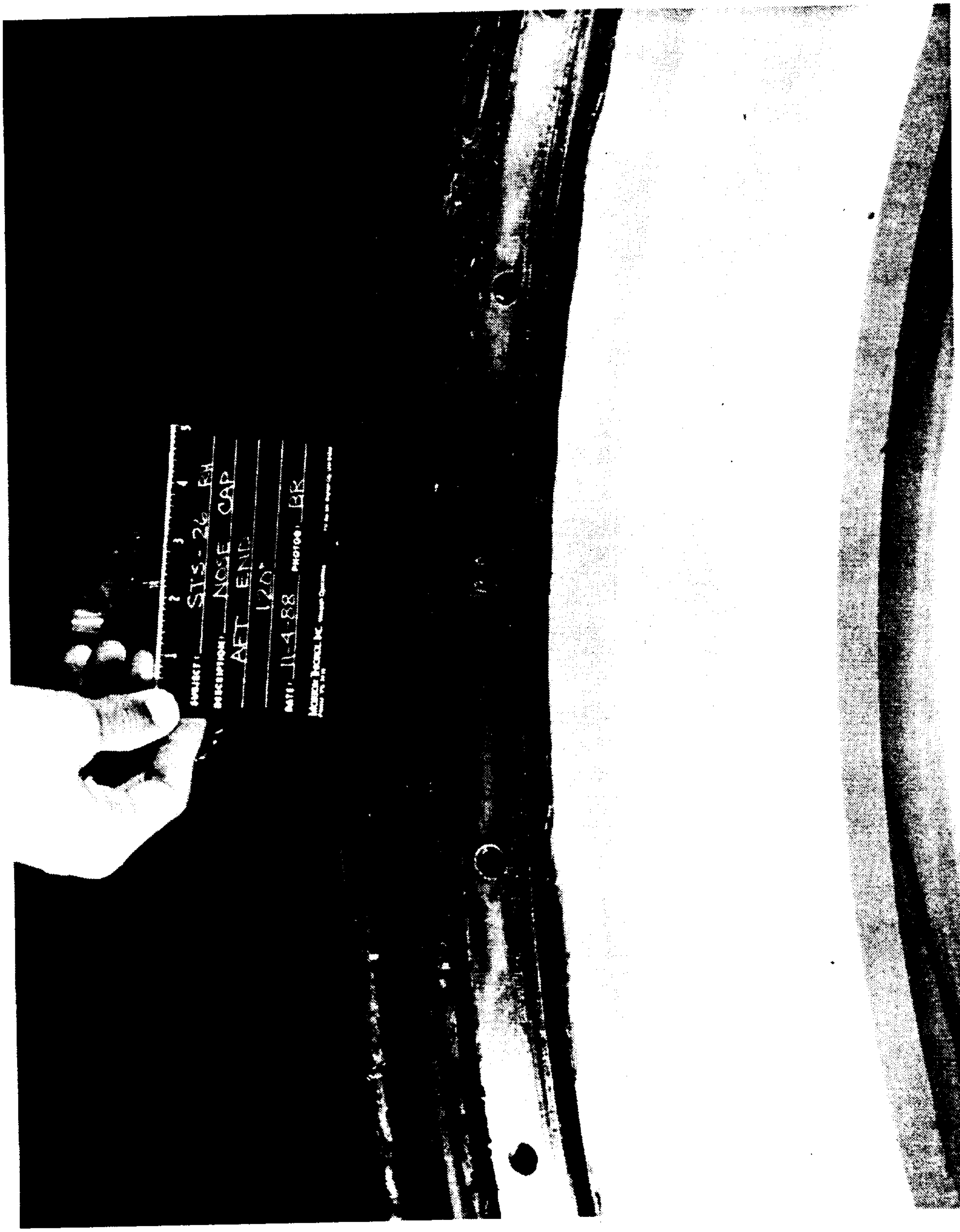

Figure 222 STS-26B Nose Cap-Aft End (120 Degrees)

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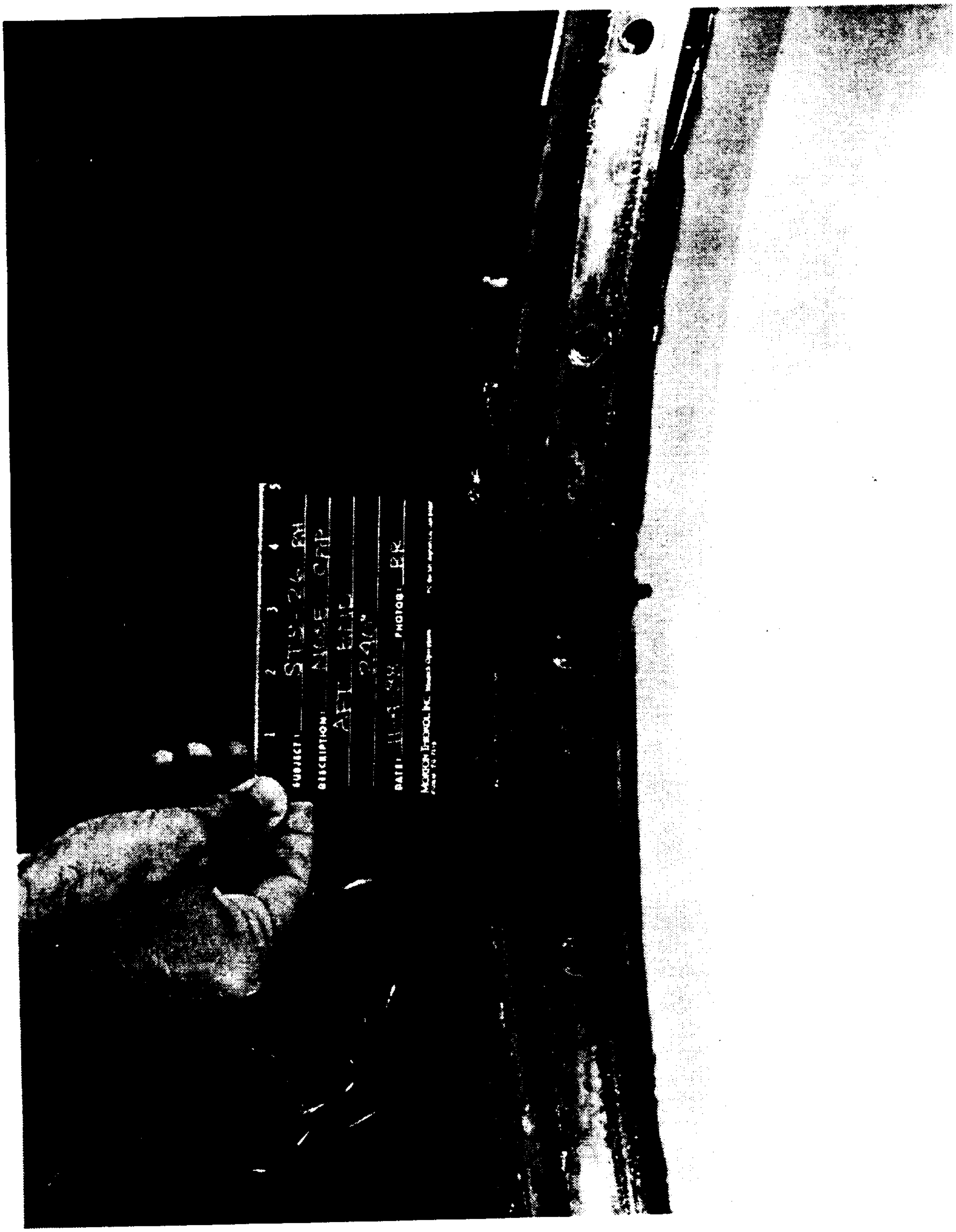

Figure 223 STS-26B Nose Cap-Aft End (240 Degrees)

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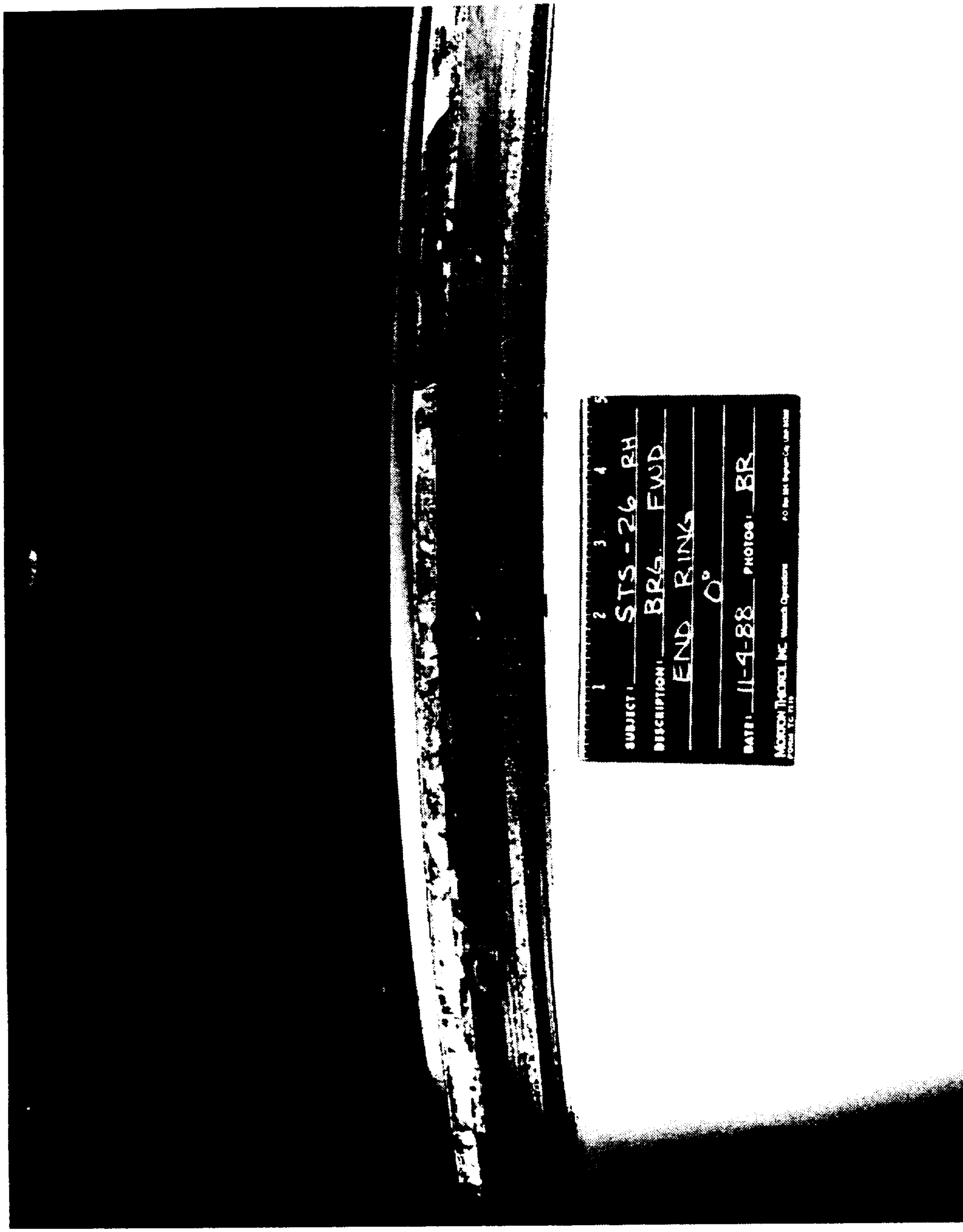

Figure 224 STS-26B Bearing Forward End Ring (0 Degrees)

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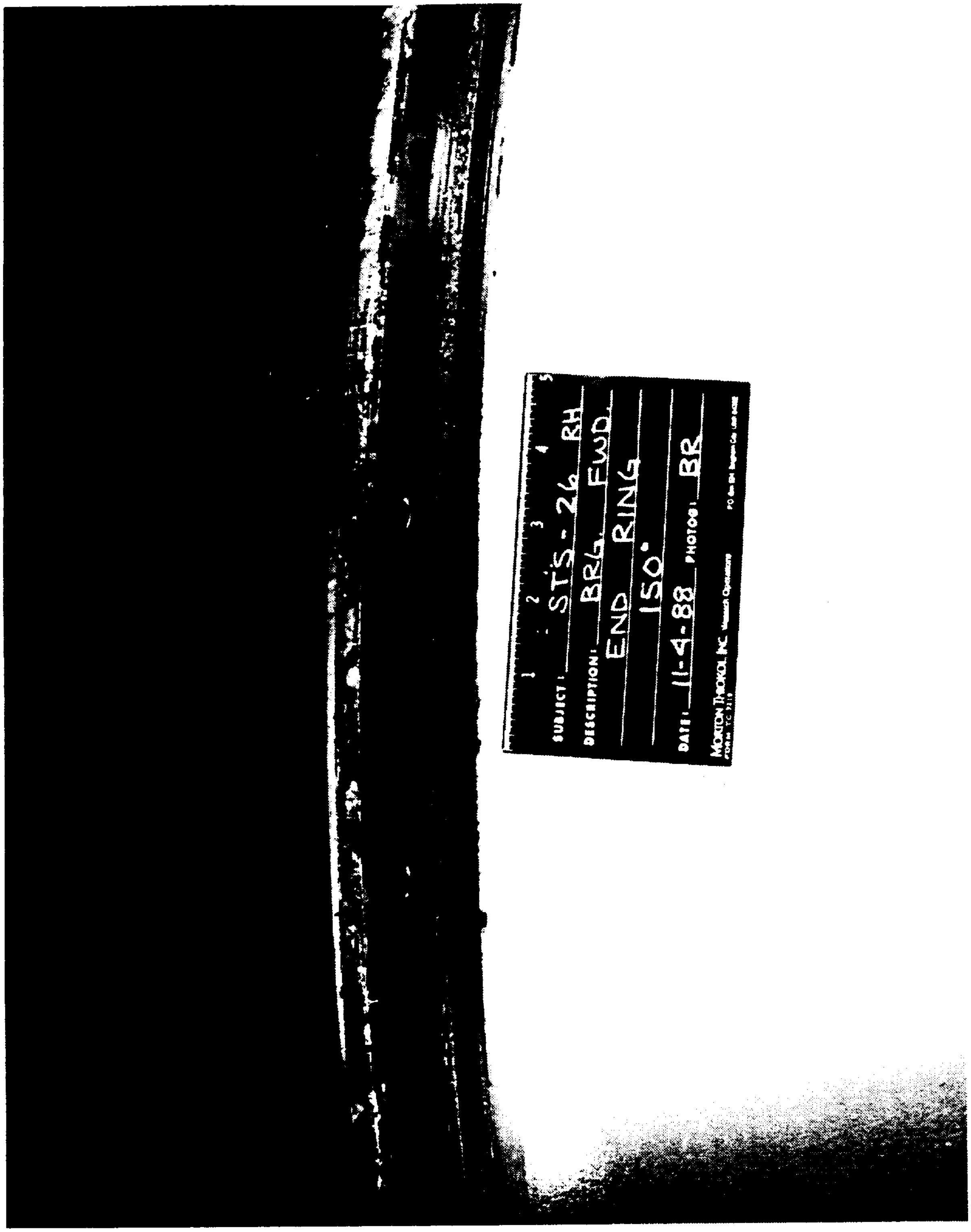

Figure 225 STS-26B Bearing Forward End Ring (150 Degrees)

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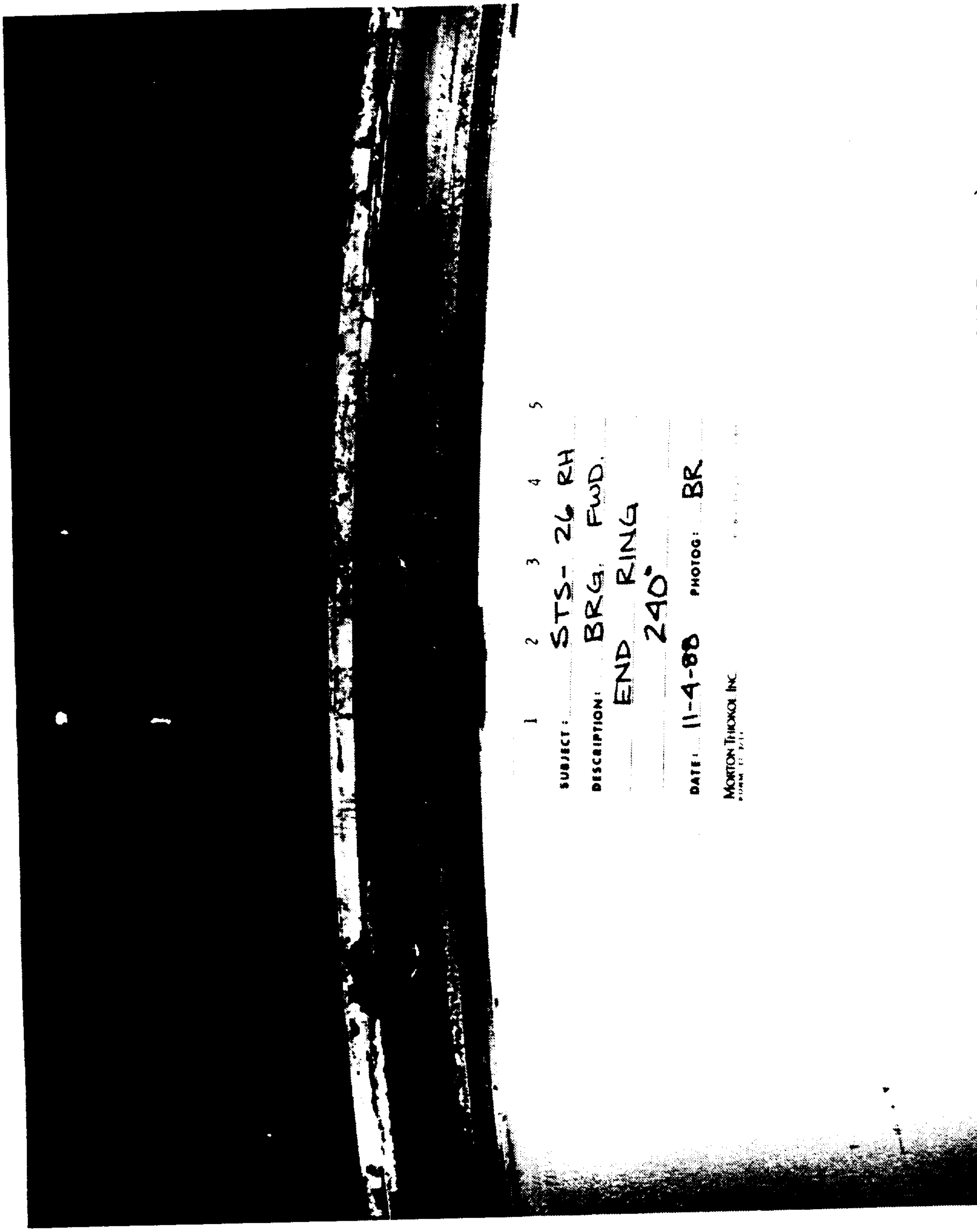

Figure 226 STS-26B Bearing Forward End Ring (240 Degrees)

MORTON THIOKOL, INC.
Aerospace Group

Space Operations

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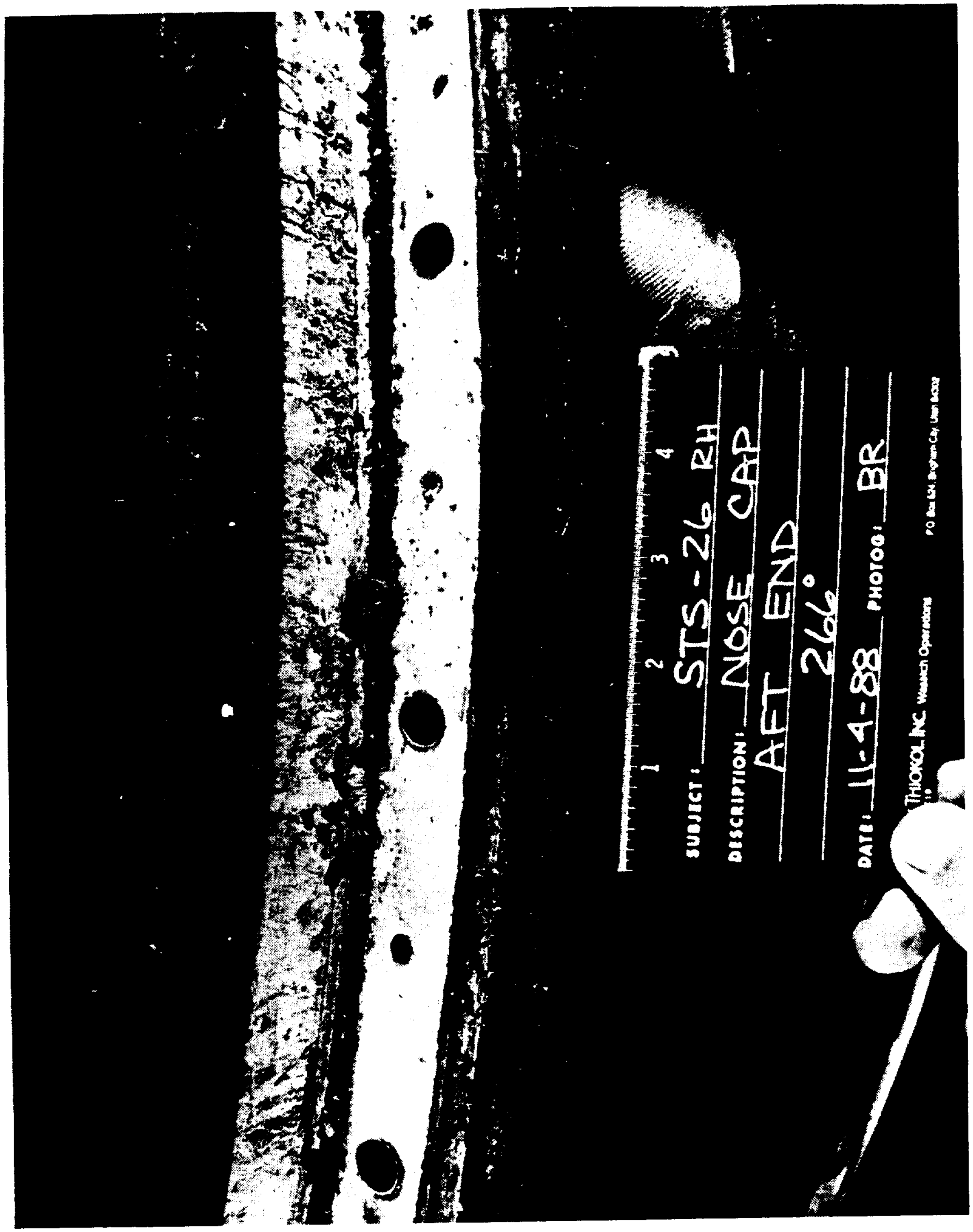

Figure 227 STS-26B Nose Cap-Aft End (266 Degrees)

REVISION ______

FORM TC 7994-310 (REV 2-88)

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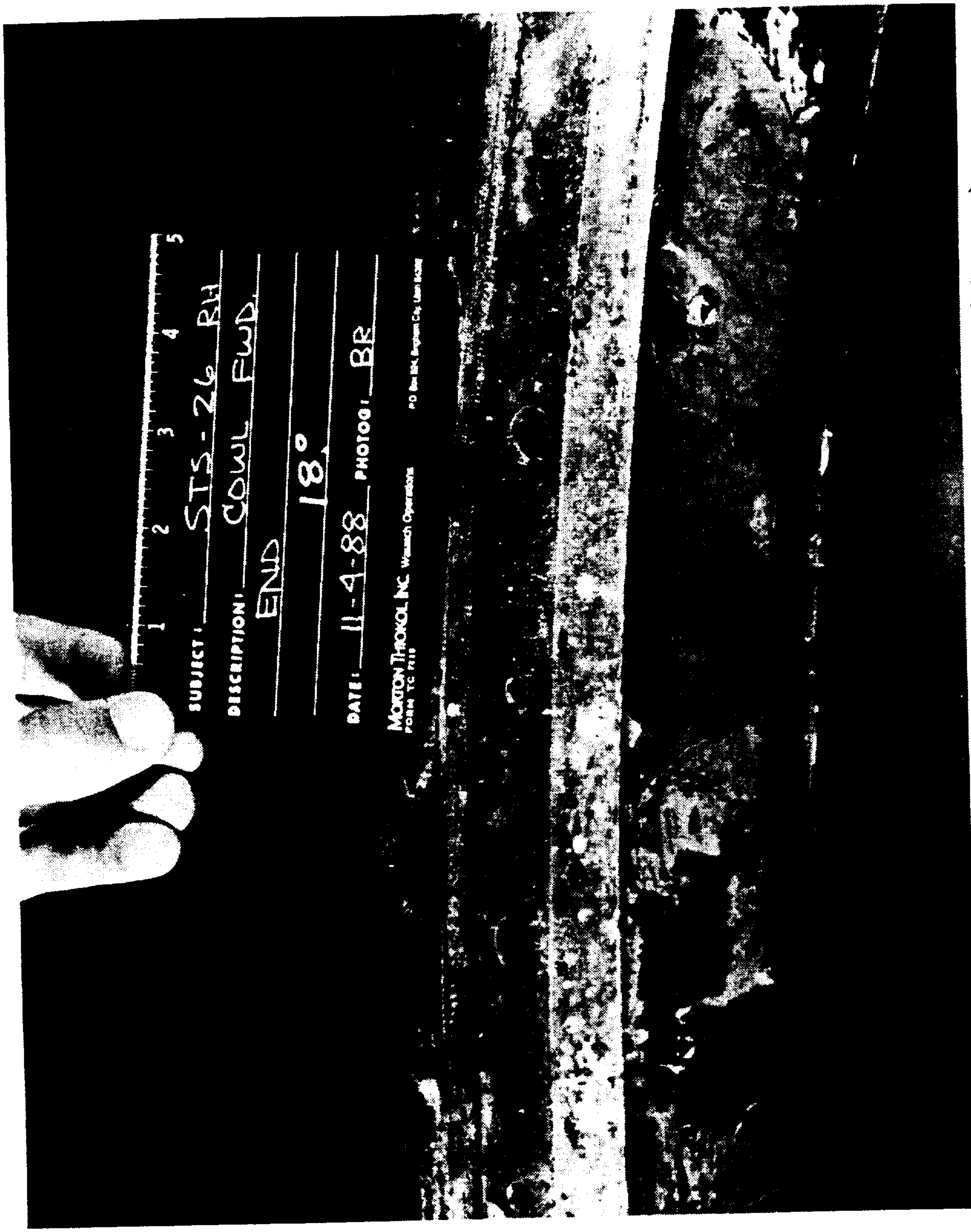

Figure 228 STS-26B Cowl Forward End-Blowpath Location (18 Degrees)

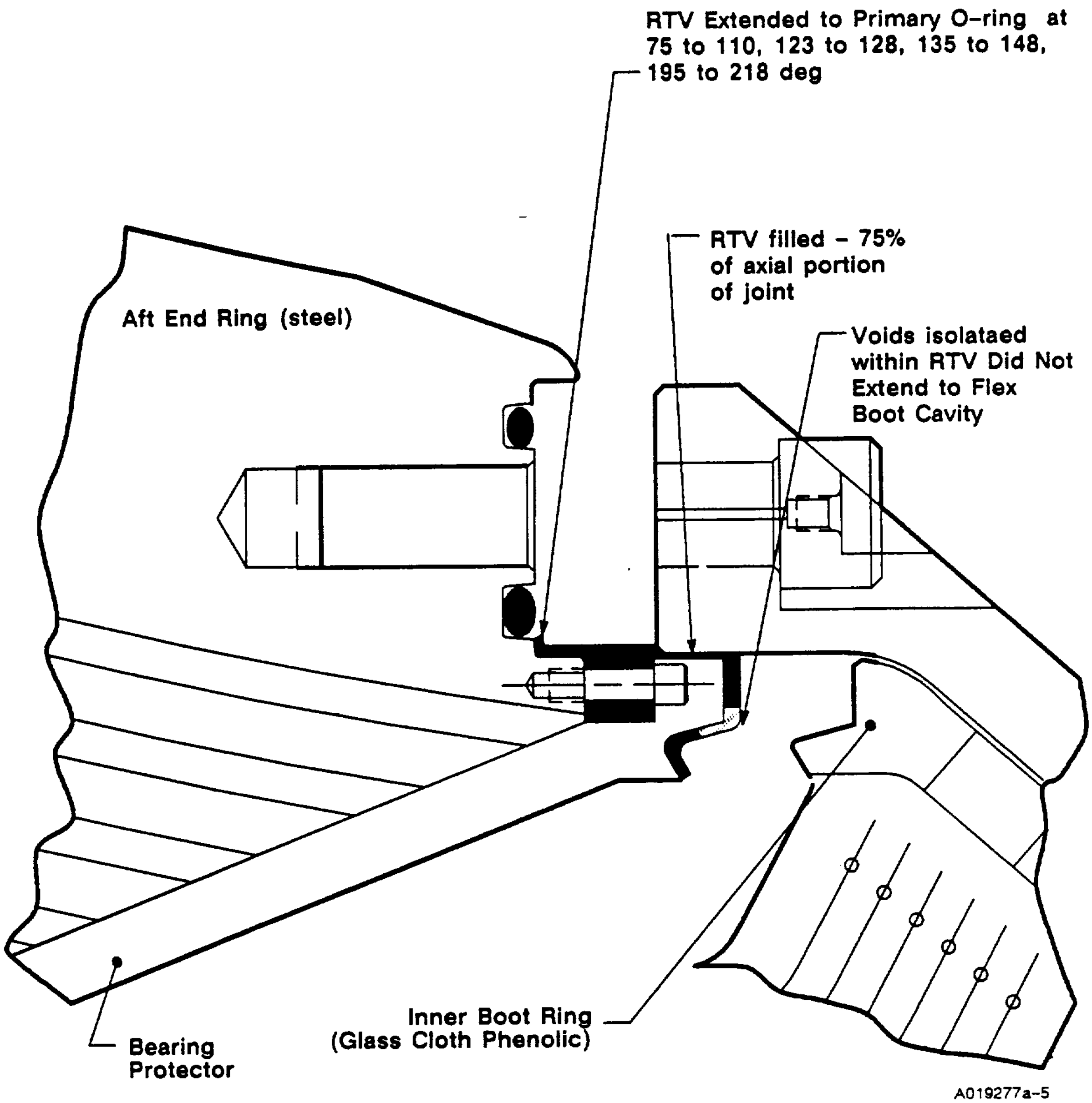

Figure 229 STS-26B Flex Bearing/Fixed Housing Joint

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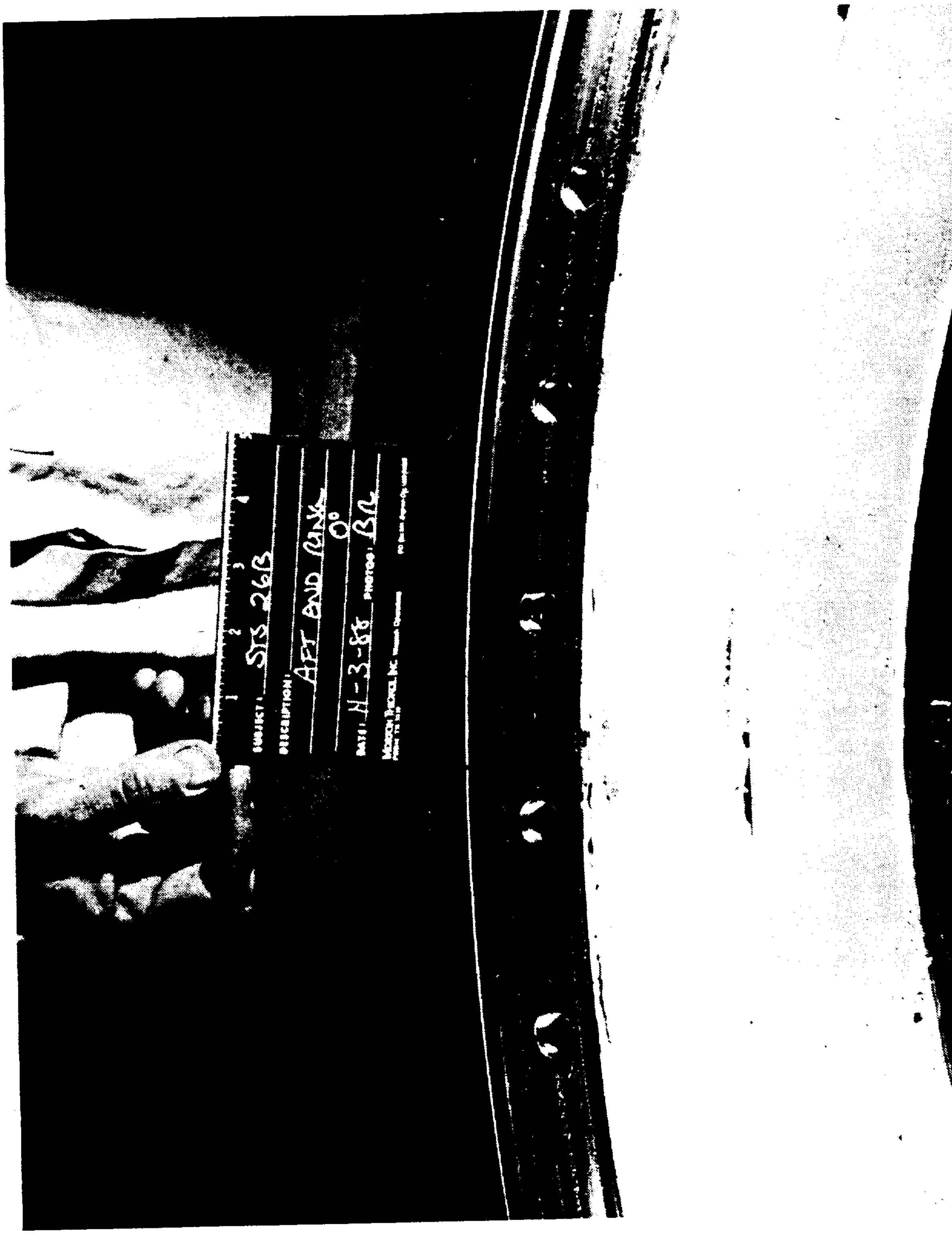

Figure 230 STS-26B Bearing Aft End Ring (0 Degrees)

Figure 231 STS-26B Bearing Aft End Ring (120 Degrees)

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Figure 232 STS-26B Bearing Aft End Ring (240 Degrees)

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Figure 233 STS-26B Fixed Housing Forward End (0 Degrees)

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Figure 234 STS-26B Fixed Housing Forward End (120 Degrees)

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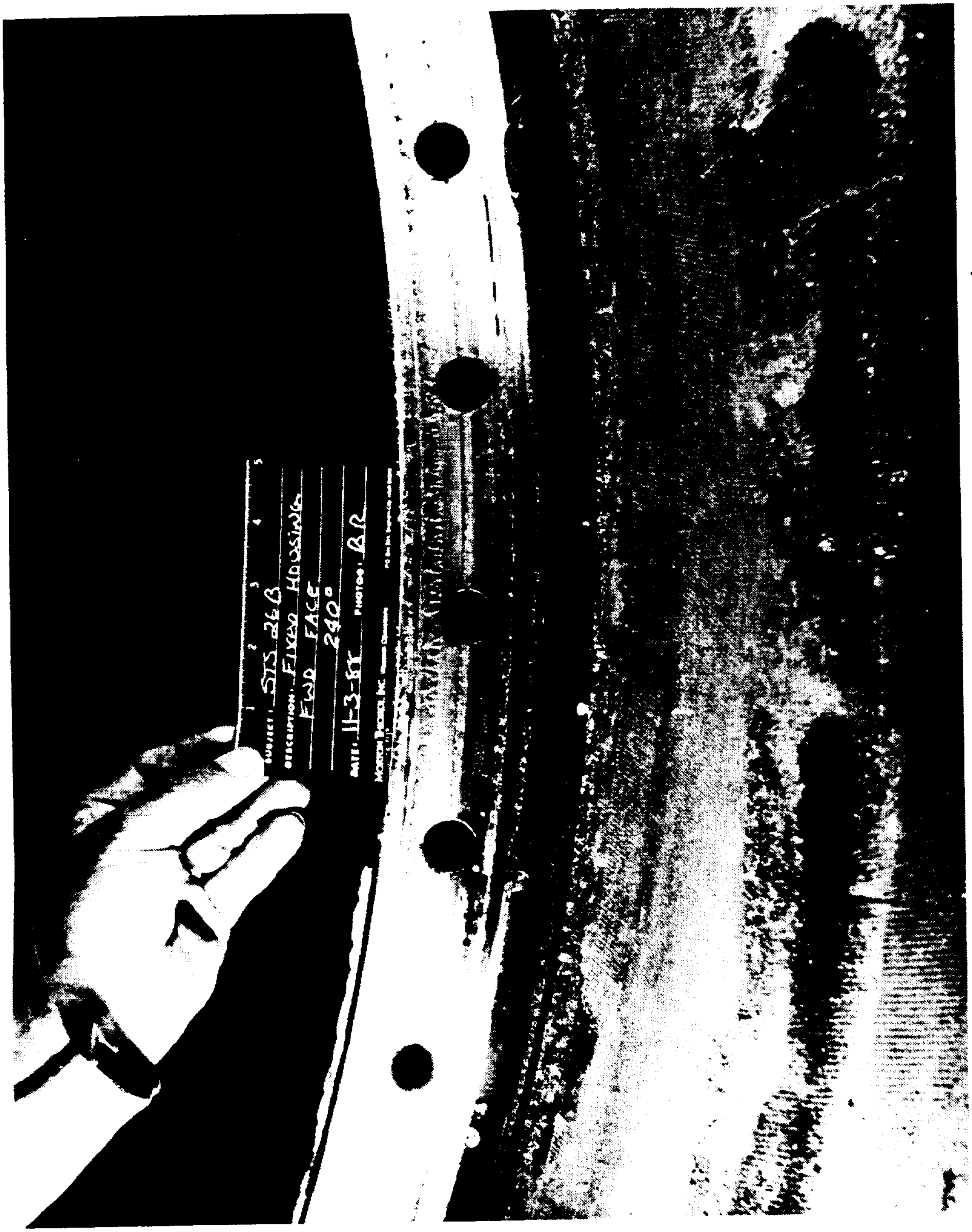

Figure 235 STS-26B Fixed Housing Forward End (240 Degrees)

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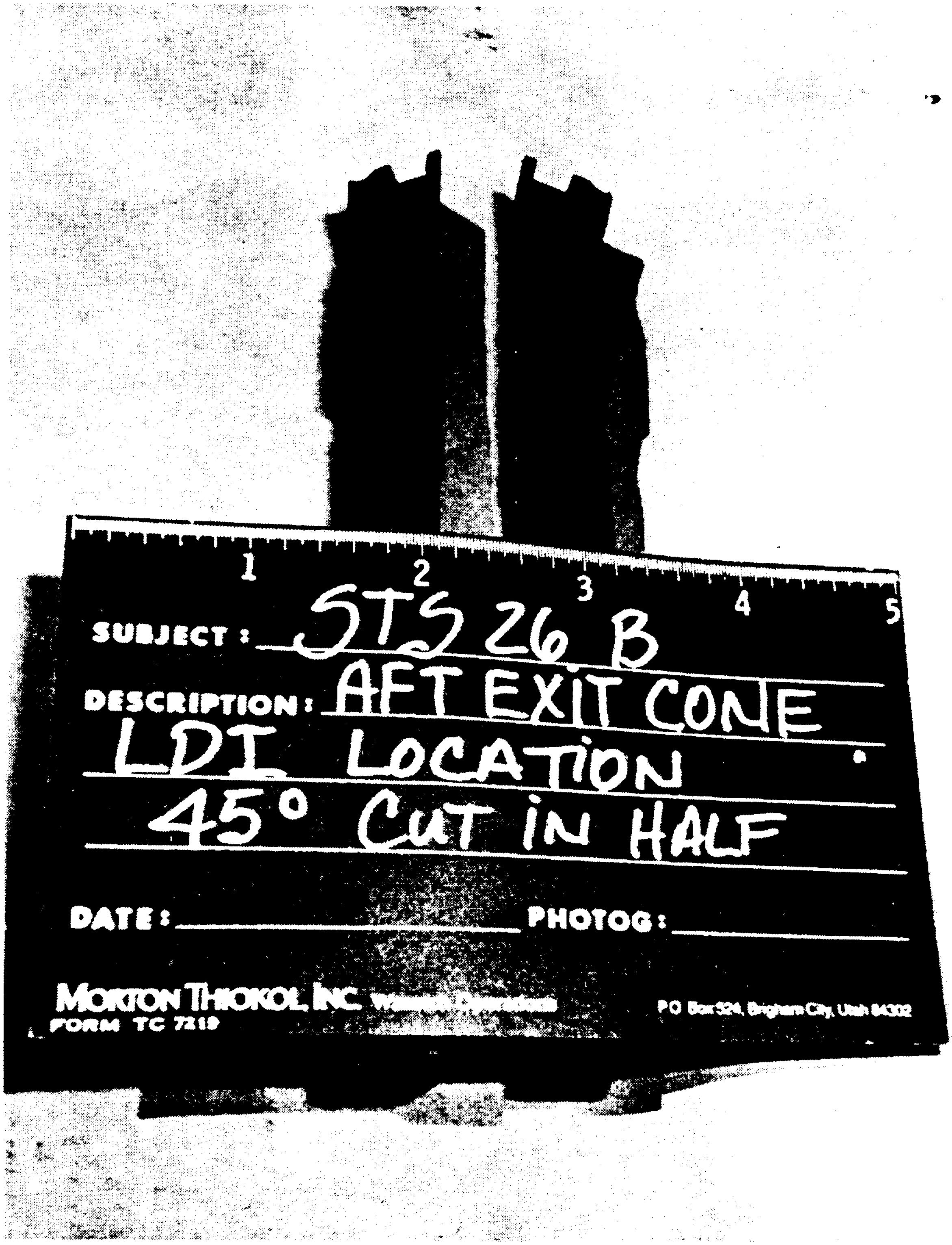
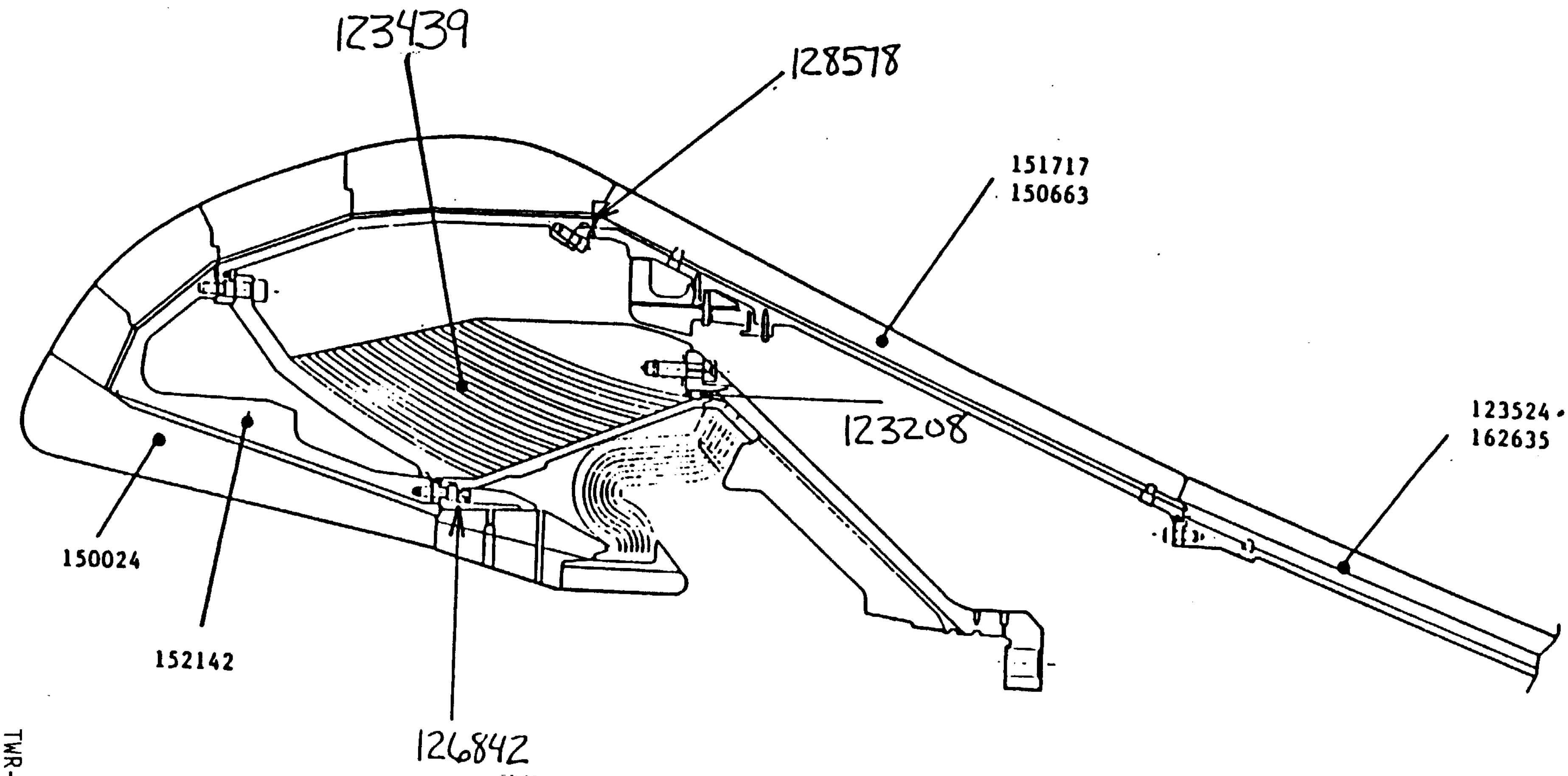


Figure 236 STS-26B Aft Exit Cone LDI Location (45 Degrees)

Appendix A

Nonconformance Discussion

- **Nozzle Assembly—Left Hand Motor**



TWR-17272
A-2

DR 123524-01 Aft Exit Cone Second Machine LEFT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: RWW 404

Discrepancy

SB: Low density indications within the glass cloth phenolic. None greater than 2.5 in. width, 1.9 in. long. length and 0.020 in. radial depth of ply.

IS: At 240 degrees, 54 in. aft of fwd end and 0.29 in. from O.D. of glass checks 4.00 in. long. length and 0.040 in. radial depth.

Disposition

USE-AS-IS

Justification

Thermal-structural analysis shows:

Area of defect is in across ply compression during motor operation.

The minimum margin of safety for the area of defect is 15.4 for delamination propagation and 10.9 for fiber breakage (including a 1.4 factor of safety).

Across ply and interlaminar shear state for the defect area are 81 and 59 psi respectively including actuator stall.

The nominal fiber stress in area of defect is 2730 psi. The fiber strength of glass is 45600 psi.

DR 123524-01 Aft Exit Cone Second Machine LEFT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: RWW 404

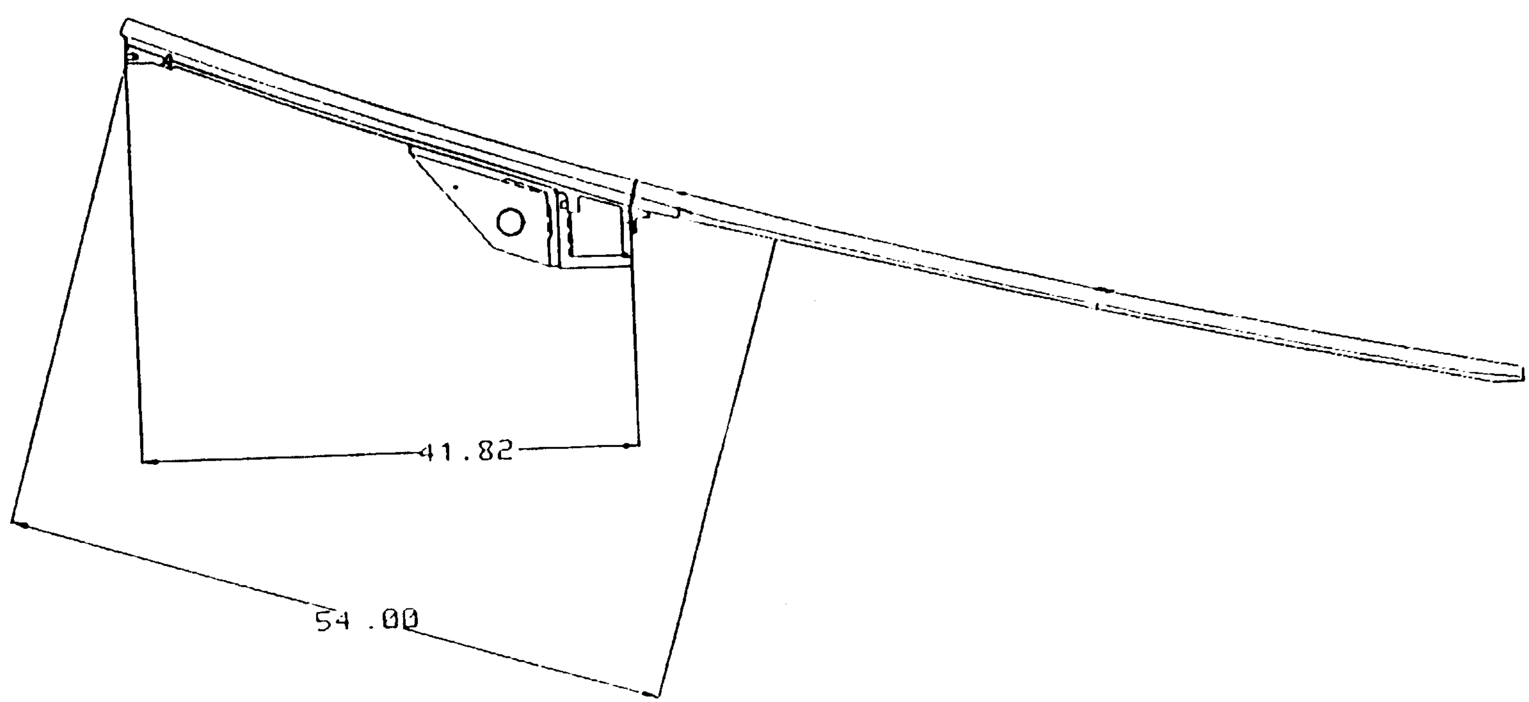
Waiver Status

Submitted to MSFC: 22 Dec 1987

Closed: 10 Mar 1988

Nonconformance Discussion

DR 123524-01



88A34-131A

DR 162635-01 Exit Cone Sub-Assembly - Nozzle, Aft

LEFT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: RWW-405

Discrepancy

SB: Low density indications within the glass cloth phenolic. None greater than 2.5 in. width, 1.9 in. long. length and 0.020 in. radial depth of ply.

IS: At 240 and 243 degrees, 4 in. aft of Compliance Ring and 0.224 in. from part O.D., checks 0.745 in. long. length by 0.224 radial depth.

Note: Glass thickness at this location = .706 in.

Disposition

USE-AS-IS

Justification

Thermal-structural analysis shows:

The area of defect is in across ply compression during motor operation (approximately 50 psi).

Minimum margin of safety for the area of defect is 19.43 (fiber breakage). Includes a 1.4 factor of safety.

The maximum interlaminar shear stress is approximately 60 psi. Interlaminar shear capability of glass cloth phenolic is 4000 psi.

DR 162635-01 Exit Cone Sub-Assembly - Nozzle, Aft

LEFT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: RWW-405

Justification (cont.)

Maximum fiber stress in areas of defect are 2620 psi. The fiber strength of glass cloth phenolic is 45600 psi.

Waiver Status

Date to MSFC: 30 Dec 1987

Closed: 10 Mar 1988

DR 162635-02 Exit Cone Sub-Assembly - Nozzle, Aft **LEFT HAND MOTOR**

SENIOR MRB CRITERIA: 9 WAIVER #: RWW-405

Discrepancy

SB: Low density indications within the glass cloth phenolic. None greater than 2.5 in. width, 1.9 in. long. length and 0.020 in. radial depth of ply.

IS: At 222 degrees, 39.5 in. aft of Compliance Ring and 0.133 in. from part O.D., checks 0.979 in. long. length by 0.031 radial depth.

Disposition

USE-AS-IS

Justification

Thermal-structural analysis shows:

The area of defect is in across ply compression during motor operation (approximately 50 psi).

Minimum margin of safety for the area of defect is 11.43 (fiber breakage). Includes a 1.4 factor of safety.

The maximum interlaminar shear stress is approximately 60 psi. Interlaminar shear capability of glass cloth phenolic is 4000 psi.

Maximum fiber stress in areas of defect is 1610 psi. The fiber strength of glass cloth phenolic is 45600 psi.

DR 162635-02 Exit Cone Sub-Assembly - Nozzle, Aft

LEFT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: RWW-405

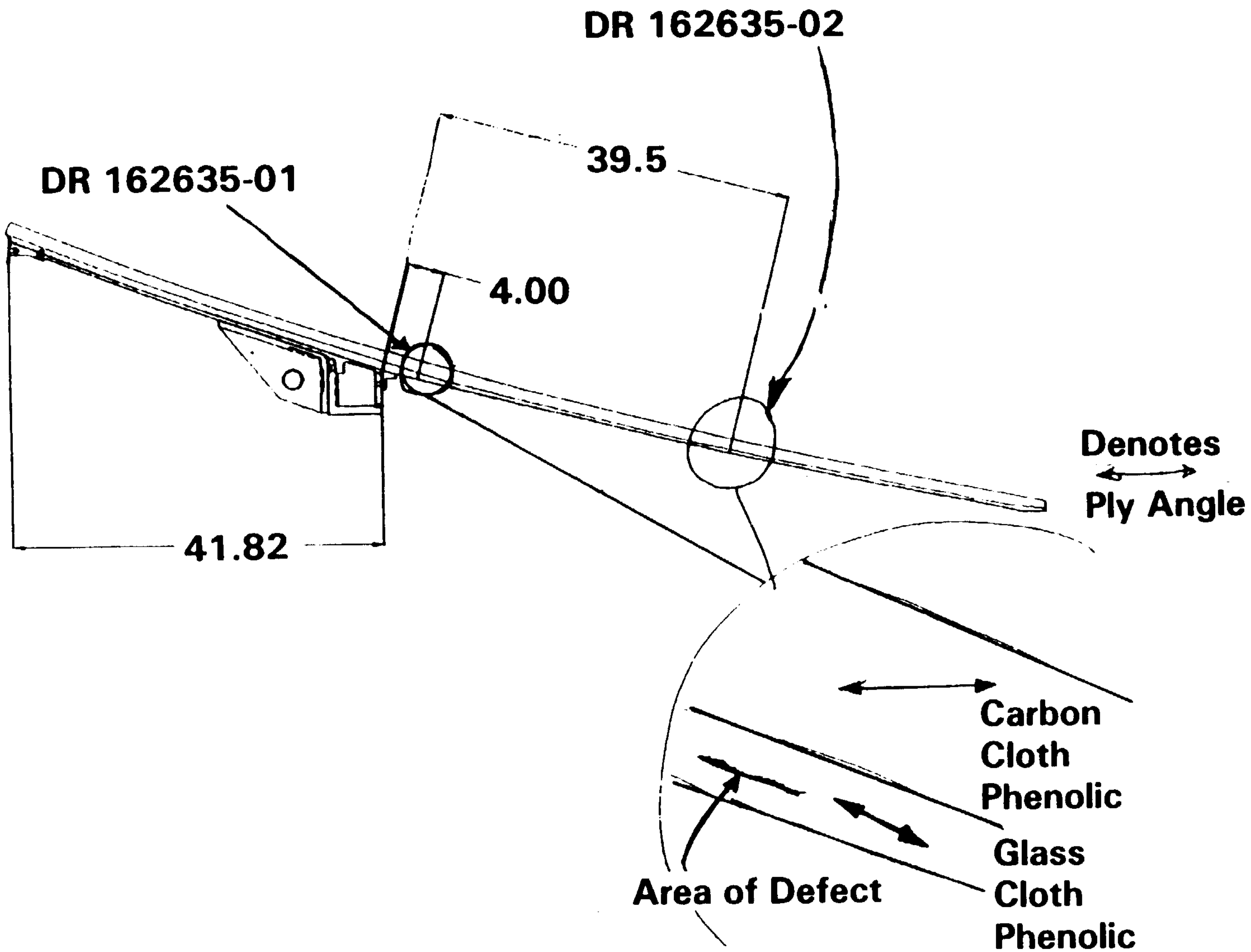
Waiver Status

Date to MSFC: 30 Dec 1987

Closed: 10 Mar 1988

Nonconformance Discussion

360L001
2.3-51



DR 151717-01 Fwd Exit Cone 2nd Machine LEFT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: RWW 387R1

Discrepancy

SB: Low density indications in glass cloth phenolic, none greater than 5.00 in. circum width, 0.025 in. radial depth and full longitudinal length of a ply.

IS: 8 Eight low density indications exist in glass cloth phenolic.

Run 360 degree circumference

Full ply length

Disposition

USE-AS-IS

Justification

Minimum margin of safety for area of defect is 7.72 at T = 20 S. Normal and shear stresses at the minimum M.S. are + 50 psi and 300 psi respectively (includes a 1.4 factor of safety).

Minimum M.S. for interface failure is 75.0 at T = 120 S. Normal and shear stresses at minimum M.S. location are - 80 psi and 60 psi respectively (includes a 1.4 factor of safety).

Carbon-to-glass interface is in normal compression thru motor operation.

DR 151717-01 Fwd Exit Cone 2nd Machine LEFT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: RWW 387R1

Justification (cont.)

Due to low stress states, any delaminations present will not propagate during motor operation.

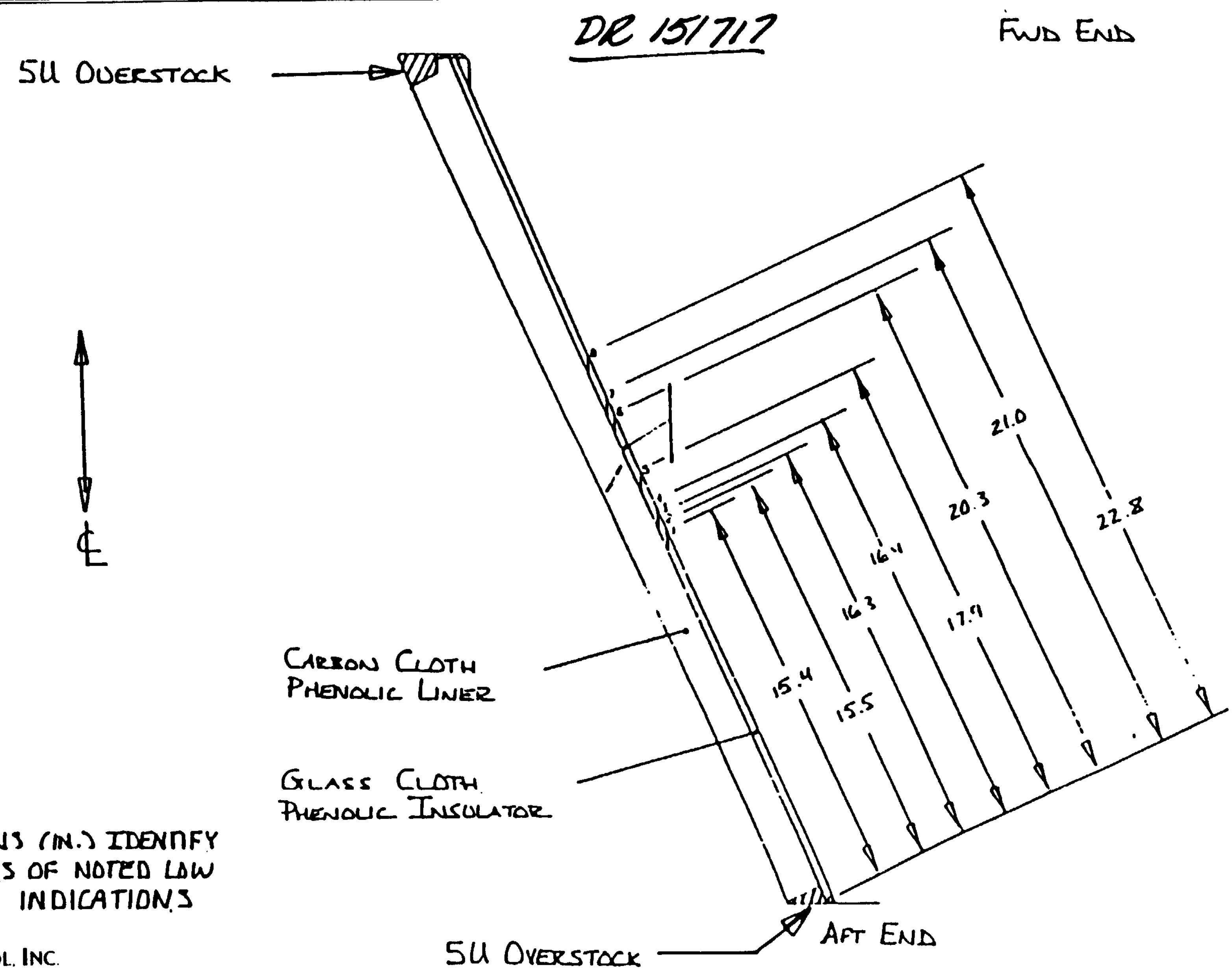
Visual and alcohol wipe inspection of OD surface shows no wetlines or porous areas

Waiver Status

Date to MSFC: 24 Feb 1988

Waiting approval, MSFC

Nonconformance Discussion



NOTE: DIMENSIONS (IN.) IDENTIFY LOCATIONS OF NOTED LOW DENSITY INDICATIONS

MORTON THIOKOL, INC.
Space Operations

NON-CONFORMANCE DISCUSSION

360L001
2.3-43

PD 150663-01 Exit Cone Assembly, Fwd Section LEFT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: NONE

Discrepancy

SB: White stripe on phenolic liner to be in alignment with 90 degree reference on Housing within +/- 1 in.

IS: Alignment between Housing and Liner was incorrect. Max condition is 1.75 in. from 90 degree reference.

Disposition

Acceptable Departure

Justification

Liner was bonded at the same radial location as dry fit, no effect on bondgaps.

Common orientation is to correlate post-test performance with any pre-test anomalies. The 0.75 in. oversize misalignment will not interfere with this process.

The white stripe is identified randomly as 90 degrees on phenolic during radiographic inspection. Location is used to identify X-ray film.

DR 128578-01 Throat Support Housing **LEFT HAND MOTOR**

CRITICALITY 1/1R

Discrepancy

SB: **No pitting allowed on aft sealing surface.**

IS: **Pits intermittently around entire circumference, max condition checks 0.002 in. depth.**

Disposition

REPAIR

Justification

Raised metal and sharp edges have been removed.

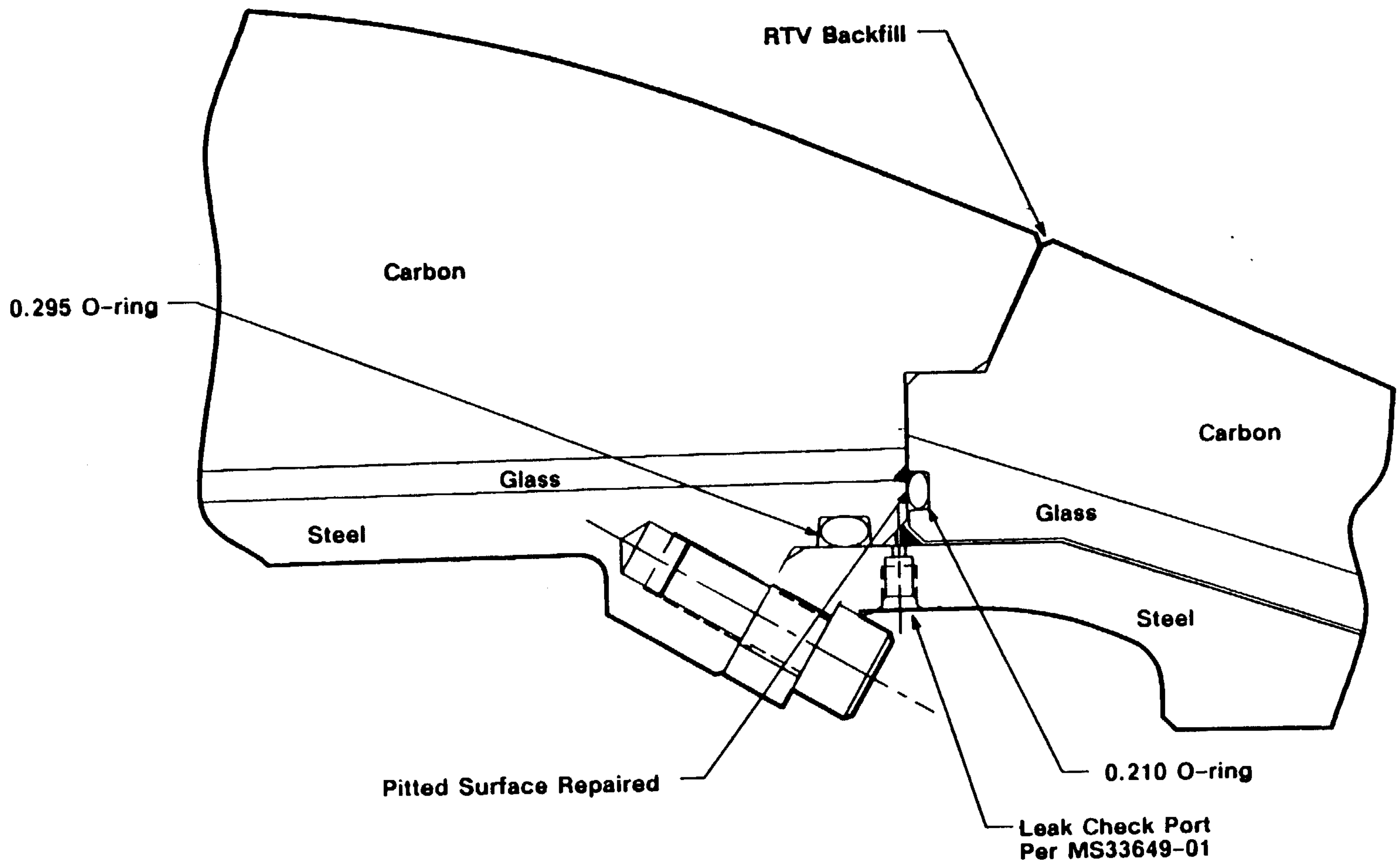
Noted condition results in an O-ring squeeze of 11.43% using 15.7 compressive set and maximum tolerances.

Minimum design goal for % squeeze = 10 %. Worst case squeeze based on max - min part tolerances = 12.28%.

Joint passed leak test requirements.

Nonconformance Discussion (Cont)

DR 128578–01



A014401a

DR 152142-01 Housing Assy- Nose/Inlet, Nozzle LEFT HAND MOTOR

SENIOR MRB CRITERIA: 8 WAIVER #: NONE

Discrepancy

Variation in uniformity of phosphoric acid anodization (PAA) and EA-9228 Primer surface applied to Nose Inlet Housing bond surfaces. (Dark streaks and spots)

Disposition

Repair - Grit blast housing to remove PAA and Primer.

Justification

PAA and Primer system has been deleted from the Engineering (Design change).

Phenolics were bonded using 51-L surface prep techniques (grit blast - methyl chloroform wipe - blacklight inspection).

NON-CONFORMANCE DISCUSSION

360L001
2.3-38

PD 150024-01 Nose-Inlet Assembly, Nozzle LEFT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: NONE

Discrepancy

SB: Completion of EA-946 Adhesive application to housing shall occur within 6 hrs. of end of grit blast.

IS: Adhesive was not applied within the 6 hour from grit blast requirement for nose cap bond.

Disposition

Part reworked to blue print requirements.

Justification

Housing was regrit blasted and methyl chloroform wiped.

Nose Cap was bonded using standard bonding procedures.

NON-CONFORMANCE DISCUSSION

360L001
2.3-39

PD 150024-02 Nose-Inlet Assembly, Nozzle | LEFT HAND MOTOR

SENIOR MRB | CRITERIA: 9 | WAIVER #: NONE

Discrepancy

SB: Application of adhesive to begin within 1 hr of "dry time in" of methyl chloroform wipe.

IS: 1 hr requirement was not met.

Disposition

Part reworked to blue print requirements.

Justification

Housing was methyl chloroform wiped and reinspected for cleanliness.

Nose cap was bonded using standard bonding procedures.

DR 126842-01 Cowl Housing LEFT HAND MOTOR

CRITICALITY 1/1R

Discrepancy

SB: Pits less than 0.100 inch dia. and less the 0.020 inch depth are acceptable

IS: Intermittent pits on entire part, worst case condition is .180 dia. x .039 depth on I.D. flange

Disposition

REPAIR

Justification

Pits have been honed out to remove sharp edges.

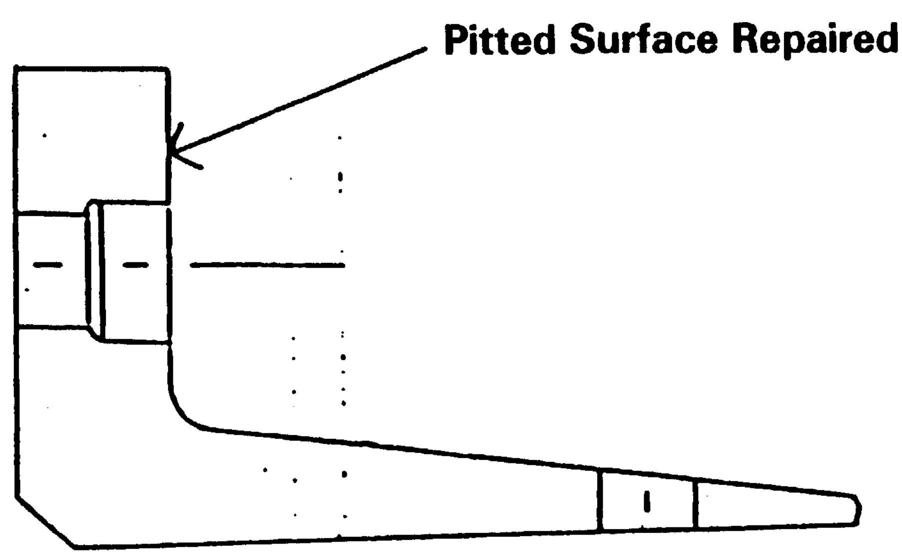
A worse case condition was flown on SRM-11, 8.50 in. x .350 in. x .085 in. depth.

A worse case condition existed on S/N 27 Housing in an adjacent location with pits checking .075 in. depth. Thermal - structural analysis showed the M.S. was reduced from 5.26 to 4.91 using a 1.4 factor of safety.

(Note: This housing has not been flown since refurbishment.)

Nonconformance Discussion (Cont)

DR 126842



TWR-17272
A-21

DR 123208-01 **Aft End Ring** LEFT HAND MOTOR

CRITICALITY 1/1R

Discrepancy

SB: The .190-32 UNF threaded hole shall not accept the NO-GO Threaded Plug Gage (TPG) more than 3 full turns

IS: 1 of 60 holes accepts the NO-GO TPG for 6.5 turns

Disposition

USE-AS-IS

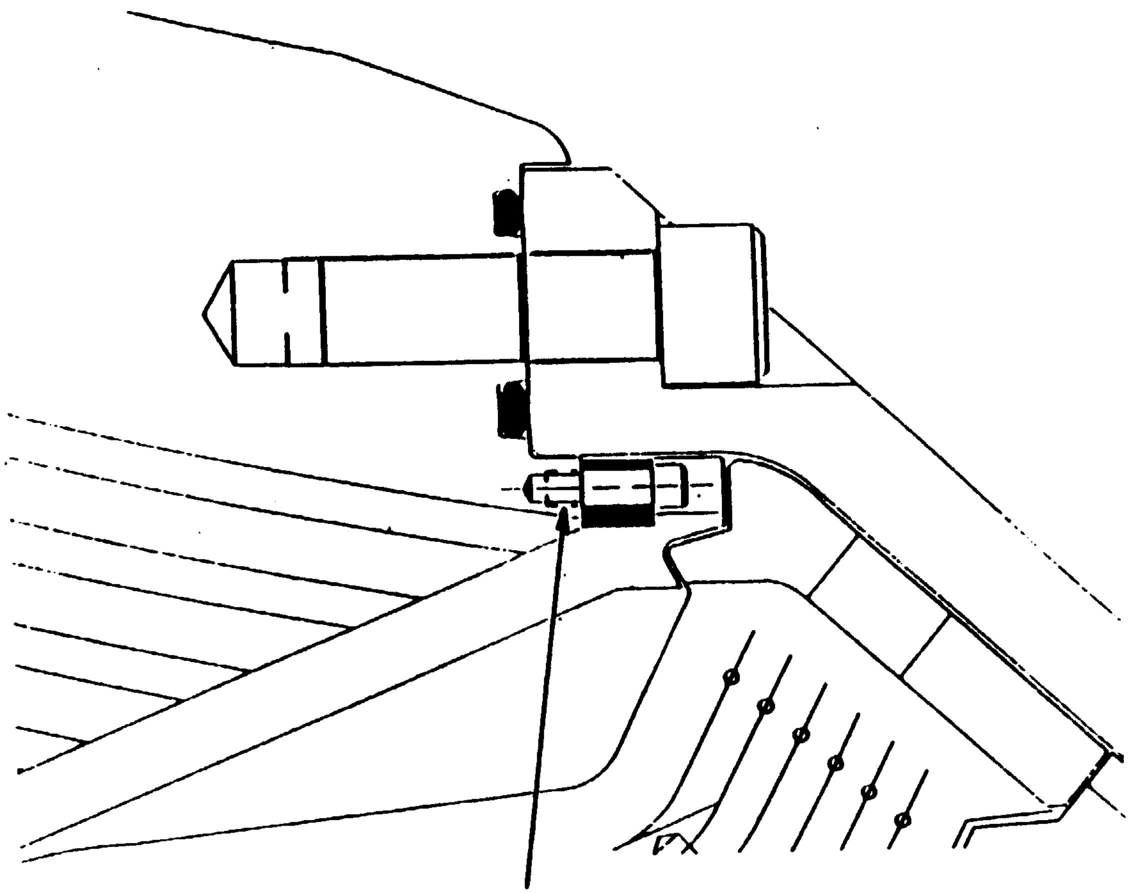
Justification

Proper torque was verified by installing and torquing an acceptable bolt, with the hole showing no damage.

This bolt attaches the Inner Bearing Protector Ring to the Aft End Ring and carries no pressure or thermal loads from motor operation.

Nonconformance Discussion (Cont)

DR 123208-01



DR 123439-01 Flex Bearing

LEFT HAND MOTOR

CRITICALITY 1/1R

Discrepancy

SB: Max. allowable unbond area per pad = 9 sq. in.

IS: Pad 11 (next to fwd end ring) checks with a total of 23.158 sq. in. of unbond area.

Disposition

USE-AS-IS

Justification

Bearing was successfully acceptance tested during which it was vectored more than 7 degrees under load and passed tensile leak test.

Bearing will be in compression during flight which will impede unbond propagation.

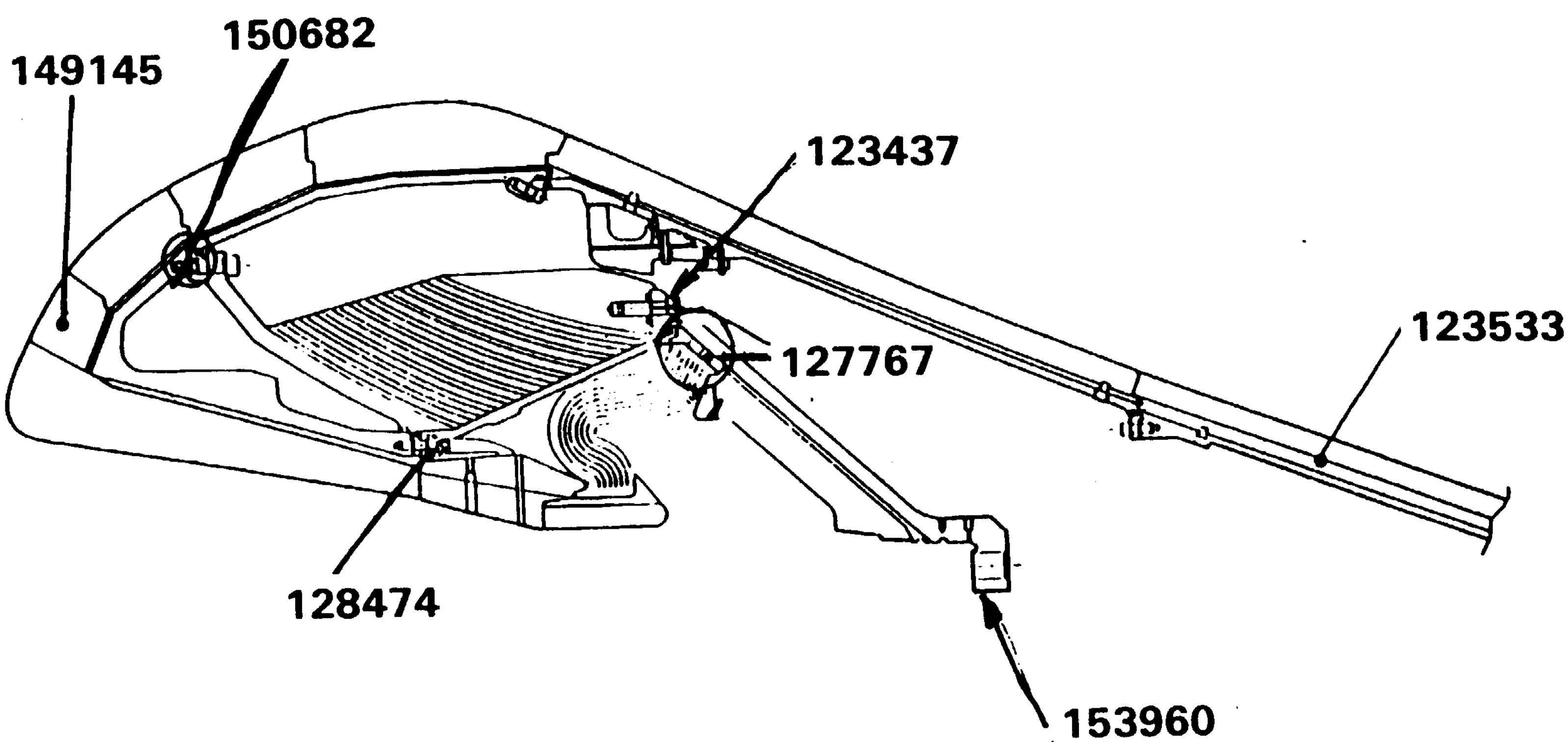
Limits have since been changed to 20 sq. in. per pad for refurbished bearings.

The noted unbond area represents 0.36% of total bond area of pad 11.

1U51060-12, S/N 13 was successfully flown on SRM-15A with 72.1 sq. in. of unbond on a single pad and 103.7 sq. in. total assembly.

Nonconformance Discussion

Nozzle Assembly—Right-Hand Motor



88A34-131E

DR 153960-01 Nozzle - Aft Segment Assembly RIGHT HAND MOTOR

SENIOR MRB CRITERIA: 8 WAIVER #: NONE

Discrepancy

Broken girth gage wire between Aft Dome Boss and Nozzle Assembly

Disposition

USE-AS-IS

Justification

Joint passed leak check (both high & low pressure).

Wire is located at outboard side of joint.

Joint would require disassembly to remove wire.

Testing indicates wire is compressed to 0.002 inch thickness.

0.002 is less than housing and dome flatness requirement.

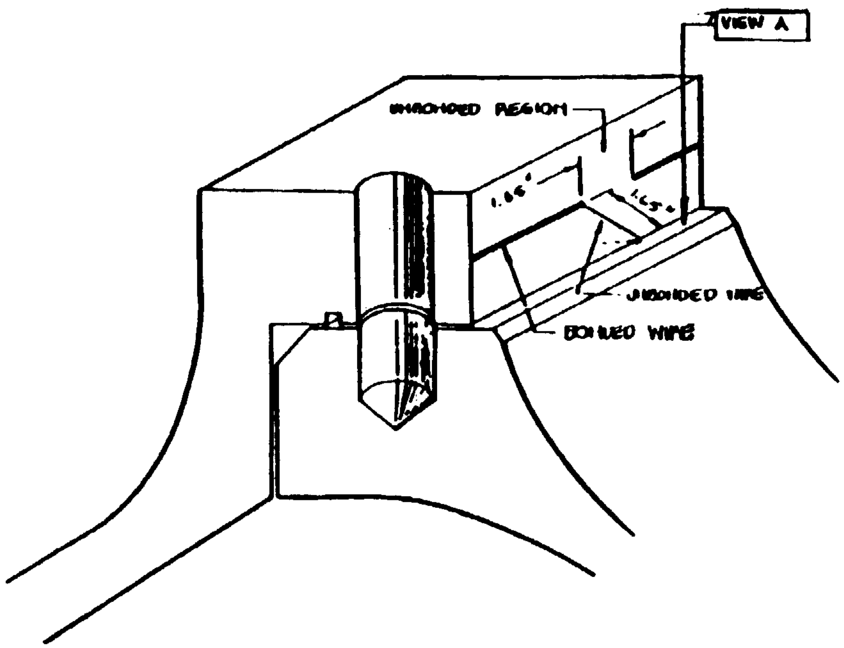
Will not affect O-ring groove gap opening.

Wire is located in low stress area (<110 ksi).

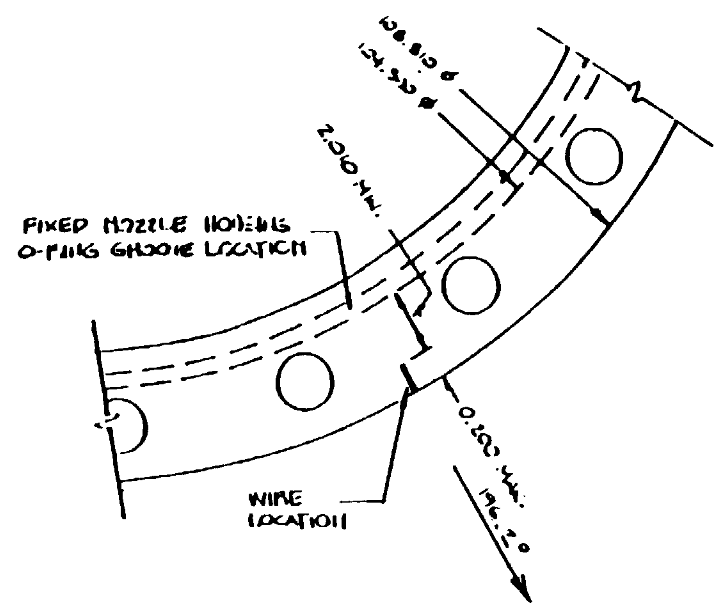
Structural integrity is not affected.

Note: Disposition submitted to MSFC 11 Mar 1988

Nonconformance Discussion



UNBONDED WIRE
LOCATION



VIEW A - LOOKING DOWN
ON AFT DOME AXIAL
CONTACT FACE

TWR-17272
A-27

DR 123533-01 Aft Exit Cone, Second Machine RIGHT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: RWW 406

Discrepancy

SB: Low density indications in glass cloth phenolic - none allowed within 0.75 inches from the forward end of the component.

IS: Low density indication in glass cloth phenolic at 45 degrees; 0.393 in. from forward end - 5U configuration.

Measures 2.35 in. circum. width (3 deg), 1.20 in. long. length, and 0.131 in. radial depth.

Indication measures from 0.126 to 0.173 in. from glass O.D. surface.

Note: Visual examination of defect area after interface and final machining (primary o-ring and polysulfide grooves) indicates that the low density indication is a resin rich area located between the two grooves.

Disposition

USE-AS-IS

DR 123533-01 Aft Exit Cone, Second Machine RIGHT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: RWW 406

Justification

Visual and alcohol wipe inspection of resin rich area indicates no ply separations, wetlines or delaminations within material.

Thermal - strucutral analysis shows:

Area of defect is in across ply compression during motor operation.

Maximum delamination stress yields a margin of safety of 4.5 at T = 80 seconds (Includes a 1.4 factor of safety).

Normal and interlaminar shear stress at minimum margin of safety is -410 and 690 psi respectively.

Inplane shear strength reduced for resin rich condition assumed to be 100% resin, with no fibers present. (Strength reduced from 12300 psi to 4000 psi for margin of safety calculation.)

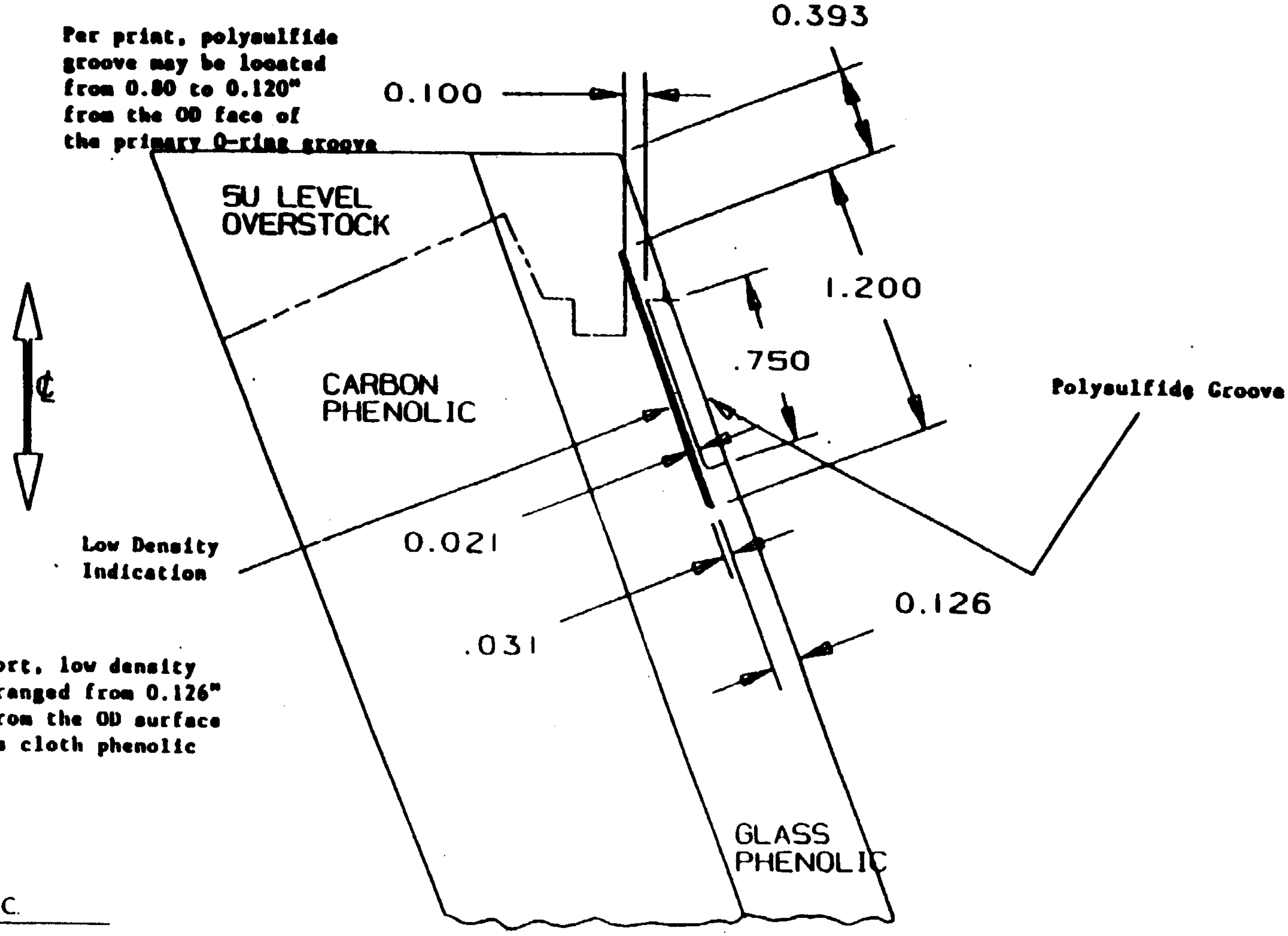
Waiver Status

Submitted to MSFC: 8 Mar 1988

Waiting approval, MSFC

Nonconformance Discussion

DR 123533-01



- Per NDT report, low density indication ranged from 0.126" to 0.173" from the OD surface of the glass cloth phenolic

MORTON THIOKOL INC.
Space Operations

88A34-131H

NON-CONFORMANCE DISCUSSION

360L001
2.3-66

DR 150682-01 Nose-Throat Assembly Nozzle RIGHT HAND MOTOR

SENIOR MRB CRITERIA: 8 WAIVER #: NONE

Discrepancy

SB: Pressurize the primary to secondary seal cavity to 740 +/- 15 psig (high pressure joint check)

IS: Primary to secondary seal cavity was pressurized to 1020 - 1040 psig

Disposition

USE-AS-IS

Justification

This is a double face seal with metal to metal contact

Not a phenolic seal, thus no concern about adhesive bondline damage

The joint passed leak check requirements at the elevated pressure

DR 150682-02 Nose-Throat Assembly Nozzle RIGHT HAND MOTOR

SENIOR MRB CRITERIA: 8 WAIVER #: NONE

Discrepancy

SB: Pressurize the primary to secondary seal cavity to 30 +/- 3 psig (low pressure joint check)

IS: Primary to secondary seal cavity was pressurized to 40 psig

Disposition

USE-AS-IS

Justification

This is a double face seal with metal to metal contact

Not a phenolic seal, thus no concern about adhesive bondline damage

The joint passed leak check requirements at the elevated pressure

PD 149145-01 Nose Ring, Fwd First Wrap (Carbon - hydroclave cure) RIGHT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: NONE

Discrepancy

SB: While holding at 310 +/- 10 degree F, decrease pressure to 200 - 250 psig and hold at this level until the end of cooldown

Note: Overall average pressure decrease not to exceed rate of 50 psig/min

IS: While decreasing pressure, pressure dropped to 168 psig for 4 minutes

Pressure remained within tolerance for the remainder of cure

Disposition

Acceptable departure

Justification

Did not violate the rate change of 50 psig/min. Reduction rate was 17.5 psig/min

Excursion was minor (4 minutes) when compared to overall cooldown time (9 hrs)

Positive pressure is desired to preclude possible affects from cooldown thermal stresses. Positive pressure was maintained (168 psig minimum)

Tag end properties fall within fired HPM Forward Nose Ring database

PD 149145-01 Nose Ring, Fwd First Wrap (Carbon - hydroclave cure) RIGHT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: NONE

Justification (cont.)

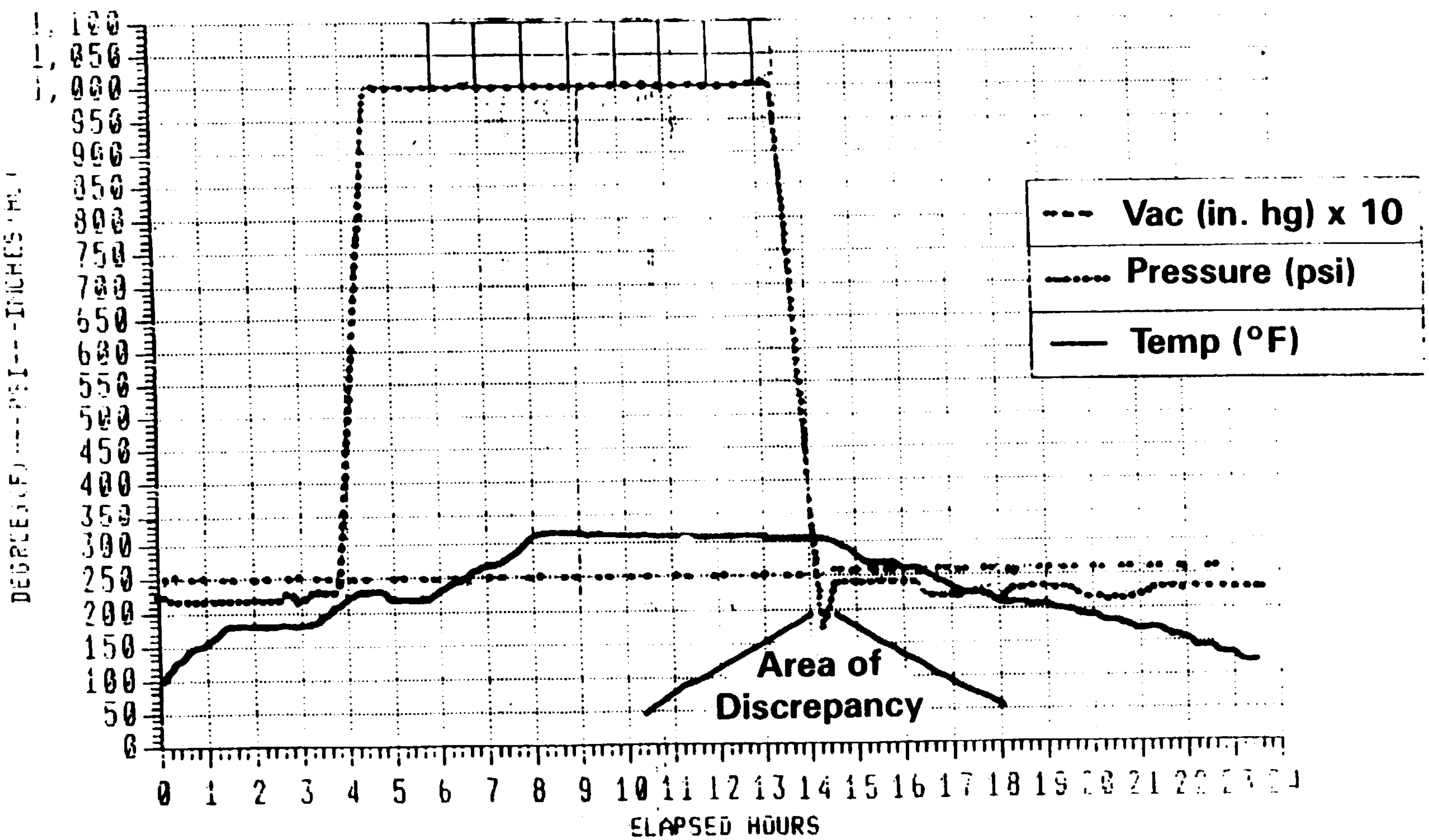
Alcohol wipe inspection met acceptance criteria

100% radiographic (x-ray) inspection was acceptable with no low density indications or anomalies in carbon phenolic liner

		Specification Limits	
	Measured	Minimum	Maximum
Specific Gravity	1.48	1.40	1.55
Residual Volatiles (%)	1.77	----	3.00
Resin Content (%)	32.27	30.0	40.0
Compressive Strength (psi)	28515	18000	55000

Nonconformance Discussion

Hydroclave Cure (PD 149145) Forward Nose Ring (5U52863-103, S/N 0000005)



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TWR-17272
A-35

88A34-131F

DR 128474-01 Cowl Housing RIGHT HAND MOTOR

CRITICALITY 1/1R

Discrepancy

SB: No interconnecting pits or irregular surfaces deeper than 0.030 in

IS: I.D. pits, maximum depth is 0.049 in

O.D. pits, maximum depth is 0.041 in

Disposition

REPAIR - Pits have been blended out to remove sharp edges and raised metal.

Justification

A worse case condition existed on S/N Cowl Housing (has not flown since refurbishment). Thermal - structural analysis shows the maximum pit depth was 0.065 with a M.S. reduced from 3.35 to 3.15 (includes 1.4 factor of safety).

DR 123437-01 Aft End Ring RIGHT HAND MOTOR

CRITICALITY 1/1R

Discrepancy

SB: The .750-16 UNF threaded hole shall not accept the Threaded Plug Gage (TPG) for more than 6 full turns

IS: 1 of 72 holes accepts the NO-GO TPG for 8 turns

Disposition

REPAIR - Hole was drilled and tapped for a helical coil insert.

Justification

Tapped hole was inspected with .750-16 UNF Screw Thread Insert (STI) GO/NO-GO gage and was acceptable.

Helical coil inserts are a standard repair of threaded holes.

PD 127767-01 Bearing Protector, Inner Ring (Glass - autoclave cure) RIGHT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: NONE

Discrepancy

SB: Maintain 15 in. HG vacuum minimum for 2 hrs minimum into 310 +/- 10 degree F hold period

IS: 8 minutes prior to start of 310 degree F hold, vac dropped to 14.8 in. HG

Vac continued to decline to a minimum level of 13 in. HG, 48 minutes into 310 degree F hold

Vac increased to 15 in. HG at 2 hrs 49 min into 310 degree F hold, and remained above 15 in. for the remainder of the cure

Disposition

Acceptable departure

Justification

Minor vacuum drop below required level not detrimental to part integrity

Vacuum bag integrity was maintained

Alcohol wipe inspection met acceptance criteria

Tag end properties are within specification limits

PD 127767-01 Bearing Protector, Inner Ring (Glass - autoclave cure) RIGHT HAND MOTOR

SENIOR MRB CRITERIA: 9 WAIVER #: NONE

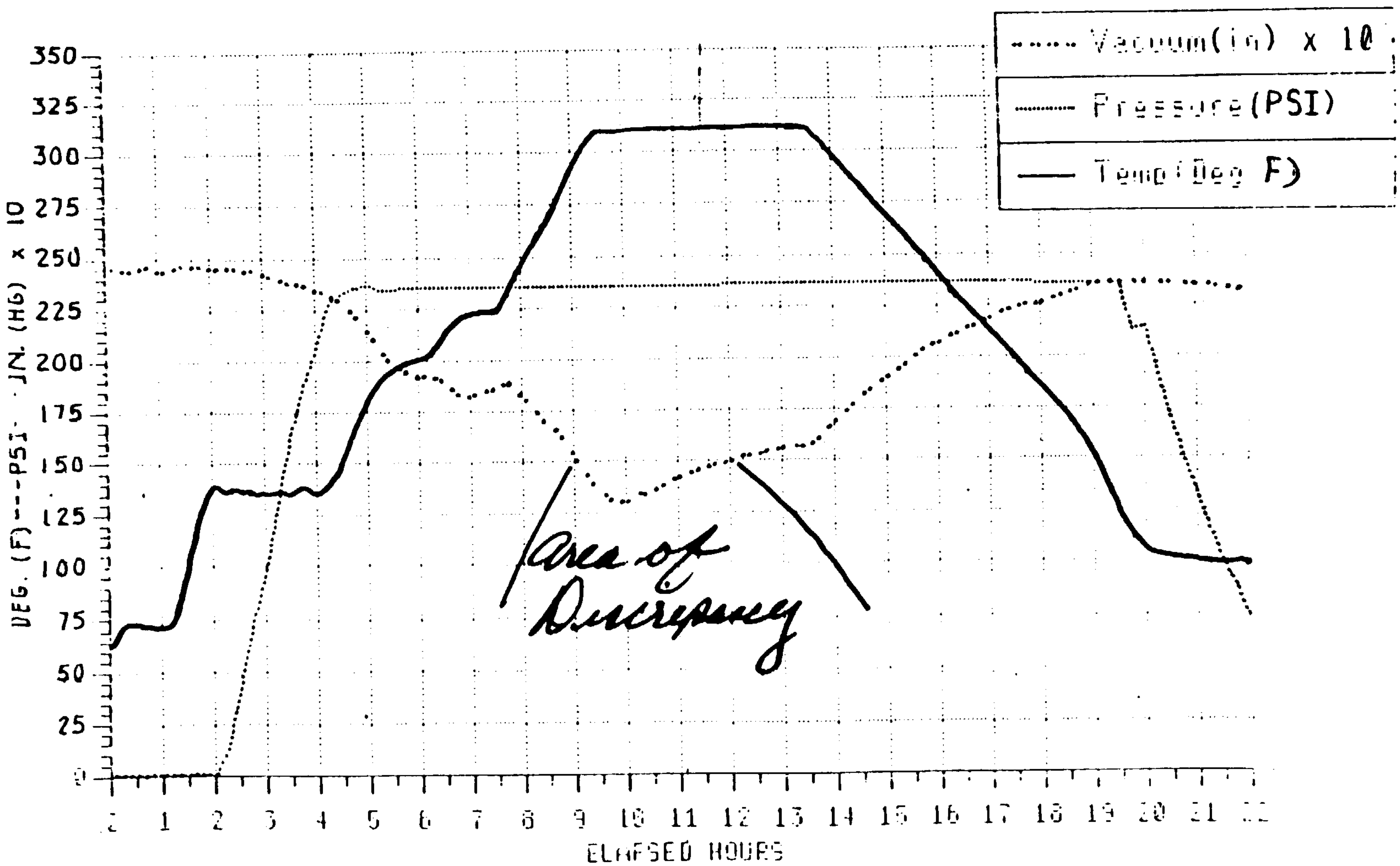
Justification (cont.)

Worst case condition flew on SRM-20A. Throat Inlet Ring S/N 33, 48 minutes after 220 degree hold, lost vacuum down to 0 in. HG for remainder of the cure (Ref DR 116193).

		Specification Limits	
	Measured	Minimum	Maximum
Specific Gravity	1.97	1.70	2.15
Residual Volatiles (%)	0.87	----	3.25
Resin Content (%)	28.16	24.0	38.0
Compressive Strength (psi)	57303	16630	60000

Nonconformance Discussion

Autoclave Cure (PD 127767) Bearing Protector, Inner Ring (5U51130-105 S/N 0000118)



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TWR-17272
A-40

88A34 1658

Appendix B

POSTFIRE ANOMALY RECORD (PFAR)

1. PFAR NUMBER
360L001A-11

2. SRM MOTOR NUMBER
360L001A

3. INSPECTION LOCATION
KSC X T-24/T-97
H-7 A-2

4. REFERENCE SQUAWK NUMBER
26-0045

5. REFERENCE PR NUMBER
PV6-111293

6. REFERENCE IFA NUMBER
N/A

7. REFERENCE SPR NUMBER
N/A

8. TITLE
CORROSION BETWEEN PRIMARY AND SECONDARY AFT EXIT CONE O-RINGS

9. CLASSIFICATION
OBSERVATION ___ MINOR ANOMALY X MAJOR ANOMALY ___ CRITICAL ANOMALY ___

10. PART NUMBER
1U76039-01

11. SERIAL NUMBER
0000001

12. PART DESCRIPTION
AFT EXIT CONE ASSY

13. REPORTED BY (NAME / ORGANIZATION / OBSERVATION DATE)
K. B. NIELSEN / MTI QA / 10/07/88

14. RESPONSIBLE COMPONENT TEAM / PROGRAM MANAGER
NOZZLE / E. L. DIEHL

15. RESPONSIBLE PROJECT ENGINEER (NAME / ORGANIZATION)
D. J. WAGNER / NOZZLE/FLEX BEARING PROJECT ENGINEERING

16. RESPONSIBLE DESIGN ENGINEER (NAME / ORGANIZATION)
S. A. MEYER / NOZZLE/FLEX BEARING DESIGN ENGINEERING

17. DESCRIPTION (ATTACH PFOR, FIGURES, PHOTOGRAPHS, ETC.)
Aluminum oxide corrosion was observed between the primary and secondary o-rings, and outboard of the secondary o-ring in the 360L001A (LH) aft exit cone field joint. No pitting was observed. Structural Applications inspectors noted that grease in both joints appeared lighter than required on STW7-2999.

Minor corrosion has been observed within past flight aft exit cone field joints, but has not been documented.

18. JUSTIFICATION OF CLASSIFICATION (POSTFIRE ENGINEERING EVALUATION LIMITS)
This is not a flight issue. It is believed that sea water entered past the primary o-ring at splashdown, resulting in the minor corrosion observed. This is potentially a reuse issue if the grease application specification (STW7-2999) is not followed.

19. CAUSE
Sea water entering past the primary o-ring at splashdown.

20. RECOMMENDED CORRECTIVE ACTION
1. Train and certify SPC operators on grease application per STW7-2999.

2. Do not write this minor corrosion up as a PR in the future.

21. ANOMALY APPROVAL SIGNATURE
RPRB SECRETARY: /S/T. L. JOHNSON DATE: 11/10/88

22. OBSERVATION/ANOMALY APPROVAL SIGNATURES
PE: D. J. Wagner DATE: 6/27/89
PM: E L Diehl DATE: 6/26/89

23. RESULTS OF RECOMMENDED CORRECTIVE ACTION
1. Effective ___________.

2. Minor corrosion has been observed in this joint on the aft exit cone field joints of 360L002 and 360L003. Observed grease applications were nominal. This was not written up as an observation.

24. REPORT RESULTS TO RPRB? YES X NO ___

25. RPRB CLOSURE SIGNATURE
(REQUIRED ONLY IF BLOCK 24 CHECKED "YES")
RPRB SECRETARY: DATE:

26. OBSERVATION/ANOMALY CLOSURE SIGNATURE
PM: DATE:

27. ORIGINATION DATE
11/09/88

28. REQUIRED STATUS DATE
11/07/88

29. PR CLOSURE DATE
01/12/89

30. PFAR CLOSURE DATE

REV. 3/28/89

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POSTFIRE ANOMALY RECORD (PFAR)

1. PFAR NUMBER
360L001A-12

2. SRM MOTOR NUMBER
360L001A

3. INSPECTION LOCATION
KSC X   T-24/T-97 ___
H-7 ___   A-2 ___

4. REFERENCE SQUAWK NUMBER
26-0046

5. REFERENCE PR NUMBER
PV6-111290

6. REFERENCE IFA NUMBER
N/A

7. REFERENCE SPR NUMBER
N/A

8. TITLE
CORROSION BETWEEN PRIMARY AND SECONDARY AFT EXIT CONE O-RINGS

9. CLASSIFICATION
OBSERVATION ___   MINOR ANOMALY X   MAJOR ANOMALY ___   CRITICAL ANOMALY ___

10. PART NUMBER
1U52839-01

11. SERIAL NUMBER
0000005

12. PART DESCRIPTION
FORWARD EXIT CONE ASSY

13. REPORTED BY (NAME / ORGANIZATION / OBSERVATION DATE)
K. B. NIELSEN / MTI QA / 10/07/88

14. RESPONSIBLE COMPONENT TEAM / PROGRAM MANAGER
NOZZLE / E. L. DIEHL

15. RESPONSIBLE PROJECT ENGINEER (NAME / ORGANIZATION)
D. J. WAGNER / NOZZLE/FLEX BEARING PROJECT ENGINEERING

16. RESPONSIBLE DESIGN ENGINEER (NAME / ORGANIZATION)
S. A. MEYER / NOZZLE/FLEX BEARING DESIGN ENGINEERING

17. DESCRIPTION (ATTACH PFOR, FIGURES, PHOTOGRAPHS, ETC.)
Aluminum oxide corrosion was observed between the primary and secondary o-rings, and outboard of the secondary o-ring, in the 360L001A (LH) aft exit cone field joint. No pitting was observed. Structural applications inspectors noted that grease in both joints appeared lighter than required on STW7-2999.

Minor corrosion has been observed within past flight aft exit cone field joints, but has not been documented.

18. JUSTIFICATION OF CLASSIFICATION (POSTFIRE ENGINEERING EVALUATION LIMITS)
This is not a flight issue. It is believed that sea water entered past the primary o-ring at splashdown, resulting in the minor corrosion observed. This is potentially a reuse issue if the grease application specification (STW7-2999) is not followed.

19. CAUSE
Sea water entering past the primary o-ring at splashdown.

20. RECOMMENDED CORRECTIVE ACTION
1. Train and certify SPC operators on grease application per STW7-2999.

2. Do not write this minor corrosion up as a PR in the future.

21. ANOMALY APPROVAL SIGNATURE
RPRB SECRETARY: /S/T. L. JOHNSON   DATE: 11/10/88

22. OBSERVATION/ANOMALY APPROVAL SIGNATURES
PE: D. J. Wagner   DATE: 6/27/89
PM: E Diehl   DATE: 6/20/89

23. RESULTS OF RECOMMENDED CORRECTIVE ACTION
1. Effective ______.

2. Minor corrosion has been observed in this joint on the aft exit cone field joints of 360L002 and 360L003. Observed grease applications were nominal. This was not written up as an observation.

24. REPORT RESULTS TO RPRB? YES X   NO ___

25. RPRB CLOSURE SIGNATURE
(REQUIRED ONLY IF BLOCK 24 CHECKED "YES")
RPRB SECRETARY: DATE:

26. OBSERVATION/ANOMALY CLOSURE SIGNATURE
PM: DATE:

27. ORIGINATION DATE
11/09/88

28. REQUIRED STATUS DATE
11/07/88

29. PR CLOSURE DATE
11/12/89

30. PFAR CLOSURE DATE

REV. 3/28/89

POSTFIRE ANOMALY RECORD (PFAR)

1. PFAR NUMBER 360L001A-43	3. INSPECTION LOCATION KSC --- T-24/T-97 ---	4. REFERENCE SQUAWK NUMBER N/A	5. REFERENCE PR NUMBER N/A
2. SRM MOTOR NUMBER 360L001A	H-7 X A-2 ---	6. REFERENCE IFA NUMBER N/A	7. REFERENCE SPR NUMBER N/A

8. TITLE
RTV/EA913 ADHESIVE MIXING IN JOINT 2

9. CLASSIFICATION
OBSERVATION --- MINOR ANOMALY X MAJOR ANOMALY --- CRITICAL ANOMALY ---

10. PART NUMBER N/A	11. SERIAL NUMBER N/A	12. PART DESCRIPTION COWL/NOSE INLET JOINT (JOINT 2)

13. REPORTED BY (NAME / ORGANIZATION / OBSERVATION DATE)
R. J. GEORGE / NOZZLE/FLEX BEARING DESIGN ENGINEERING / 10/30/88

14. RESPONSIBLE COMPONENT TEAM / PROGRAM MANAGER
NOZZLE / E. L. DIEHL

15. RESPONSIBLE PROJECT ENGINEER (NAME / ORGANIZATION)
D. J. WAGNER / NOZZLE/FLEX BEARING PROJECT ENGINEERING

16. RESPONSIBLE DESIGN ENGINEER (NAME / ORGANIZATION)
S. A. MEYER / NOZZLE/FLEX BEARING DESIGN ENGINEERING

17. DESCRIPTION (ATTACH PFOR, FIGURES, PHOTOGRAPHS, ETC.)
See continuation sheet.

18. JUSTIFICATION OF CLASSIFICATION (POSTFIRE ENGINEERING EVALUATION LIMITS)
There is no adhesion between the RTV and EA913 adhesive, reducing the capability of the RTV to act as a thermal barrier. The eroded EA913 NA adhesive has not previously been observed (significant departure from the historical data base).

19. CAUSE
Current bonding and joint assembly procedures.

20. RECOMMENDED CORRECTIVE ACTION
At the time this was presented to the RPRB, the PV-1 nozzle Joint #2 had just been examined. It was recommended that we further evaluate the new assembly procedure change on QM-8. It would then be determined if the new assembly process would be incorporated into flight nozzles.

21. ANOMALY APPROVAL SIGNATURE
RPRB SECRETARY: Tracy L Johnson DATE: 6 June 89

22. OBSERVATION/ANOMALY APPROVAL SIGNATURES
PE: [signature] DATE: 6-7-89
PM: E L Diehl DATE: 6-4-89

23. RESULTS OF RECOMMENDED CORRECTIVE ACTION
See continuation sheet.

24. REPORT RESULTS TO RPRB? YES X NO ---

25. RPRB CLOSURE SIGNATURE
(REQUIRED ONLY IF BLOCK 24 CHECKED "YES")
RPRB SECRETARY: Tracy L Johnson DATE: 6 June 89

26. OBSERVATION/ANOMALY CLOSURE SIGNATURE
PM: E L Diehl DATE: 6-4-89

27. ORIGINATION DATE 11/30/88	28. REQUIRED STATUS DATE N/A	29. PR CLOSURE DATE N/A	30. PFAR CLOSURE DATE

REV. 3/28/89

CONTINUATION SHEET FOR PFAR NUMBER 360L001A-43

17. DESCRIPTION (continuation)

The EA913 adhesive used to bond the cowl insulation to the cowl housing extruded into the radial RTV bondline between the cowl ring and nose cap 360-deg. circumferentially. The adhesive that extruded into the radial bondline was typically sandwiched between two layers of RTV. Soot was observed over a majority of the joint circumference and up to the primary o-ring. A distinct blowpath was observed at 216 deg. Heat affected GCP and SCP were observed at the blowpath location. The charred material was approximately 0.01 in. deep. The EA913 NA adhesive adjacent to the cowl housing was eroded approximately 0.1 in. axially x 0.7 in. wide circ. at the blowpath location. There was no blowby, erosion or heat effect to the primary o-ring. Electrical conductivity measurements on the cowl and nose inlet housings showed no heat damage.

The mixing of the adhesive in the cowl/nose cap bondline and the presence of soot was documented on ETM-1A, DM-8, DM-9, QM-6 and QM-7. It is believed that the mixing has occurred on all previous nozzles due to assembly procedures. Charred GCP and SCP insulators have been observed at blowpath locations in the QM-6, and PV-1 nozzle internal Joint #2. Eroded EA913 NA adhesive has not previously been observed.

23. RESULTS OF RECOMMENDED CORRECTIVE ACTION (continuation)

1. The new assembly procedure was tested on PV-1 and QM-8 Joint #2's. Post-test inspections of these joints prompted the decision to further evaluate and refine the new assembly procedure on TEM motors.

As of 360L002, there has never been primary o-ring blowby, erosion or heat effect, or metal heat damage with Joint #2. In the 360L002 RPRB, it was decided to close out all "minor anomalies" similar to this on all previous static tests and flights. All future occurrences, including 360L002, would be considered "observations".

TWR-17198 Vol. V has been updated to include accept/reject criteria for RTV in nozzle joints. The condition noted in this "minor anomaly" is now an "acceptable" condition per this criteria.

POSTFIRE ANOMALY RECORD (PFAR)

1. PFAR NUMBER
360L0018-10

2. SRM MOTOR NUMBER
360L0018

3. INSPECTION LOCATION
KSC X T-24/T-97
H-7 A-2

4. REFERENCE SQUAWK NUMBER
26-0043

5. REFERENCE PR NUMBER
PV6-111312

6. REFERENCE IFA NUMBER
N/A

7. REFERENCE SPR NUMBER
N/A

8. TITLE
CORROSION BETWEEN PRIMARY AND SECONDARY AFT EXIT CONE O-RINGS

9. CLASSIFICATION
OBSERVATION ___ MINOR ANOMALY X MAJOR ANOMALY ___ CRITICAL ANOMALY ___

10. PART NUMBER
1U76039-03

11. SERIAL NUMBER
0000001

12. PART DESCRIPTION
AFT EXIT CONE ASSY

13. REPORTED BY (NAME / ORGANIZATION / OBSERVATION DATE)
K. B. NIELSEN / MTI QA / 10/07/88

14. RESPONSIBLE COMPONENT TEAM / PROGRAM MANAGER
NOZZLE / E. L. DIEHL

15. RESPONSIBLE PROJECT ENGINEER (NAME / ORGANIZATION)
D. J. WAGNER / NOZZLE/FLEX BEARING PROJECT ENGINEERING

16. RESPONSIBLE DESIGN ENGINEER (NAME / ORGANIZATION)
S. A. MEYER / NOZZLE/FLEX BEARING DESIGN ENGINEERING

17. DESCRIPTION (ATTACH PFOR, FIGURES, PHOTOGRAPHS, ETC.)
Aluminum oxide corrosion was observed between the primary and secondary o-rings, and outboard of the secondary o-ring, in the 360L001B (RH) aft exit cone field joint. No pitting was observed. Structural Applications inspectors noted that grease in both joints appeared lighter than required on STW7-2999.

Minor corrosion has been observed within past flight aft exit cone field joints, but has not been documented.

18. JUSTIFICATION OF CLASSIFICATION (POSTFIRE ENGINEERING EVALUATION LIMITS)
This is not a flight issue. It is believed that sea water entered past the primary o-ring at splashdown, resulting in the minor corrosion observed. This is potentially a reuse issue if the grease application specification (STW7-2999) is not followed.

19. CAUSE
Sea water entering past the primary o-ring at splashdown.

20. RECOMMENDED CORRECTIVE ACTION
1. Train and certify SPC operators on grease application per STW7-2999.

2. Do not write this minor corrosion up as a PR in the future.

21. ANOMALY APPROVAL SIGNATURE
RPRB SECRETARY: /S/T. L. JOHNSON DATE: 11/10/88

22. OBSERVATION/ANOMALY APPROVAL SIGNATURES
PE: D. J. Wagner DATE: 6/27/89
PM: [signature] DATE: 6/28/89

23. RESULTS OF RECOMMENDED CORRECTIVE ACTION
1. Effective ____________.

2. Minor corrosion has been observed in this joint and on the aft exit cone field joints of 360L002 and 360L003. Observed grease applications were nominal. This was not written up as an observation.

24. REPORT RESULTS TO RPRB? YES X NO ___

25. RPRB CLOSURE SIGNATURE
(REQUIRED ONLY IF BLOCK 24 CHECKED "YES")
RPRB SECRETARY: DATE:

26. OBSERVATION/ANOMALY CLOSURE SIGNATURE
PM: DATE:

27. ORIGINATION DATE
11/09/88

28. REQUIRED STATUS DATE
11/07/88

29. PR CLOSURE DATE
01/12/89

30. PFAR CLOSURE DATE

REV. 3/28/89

POSTFIRE ANOMALY RECORD (PFAR)

1. PFAR NUMBER 360L001B-38	3. INSPECTION LOCATION KSC X T-24/T-97	4. REFERENCE SQUAWK NUMBER 26-0048	5. REFERENCE PR NUMBER PV6-111292
2. SRM MOTOR NUMBER 360L001B	H-7 A-2	6. REFERENCE IFA NUMBER N/A	7. REFERENCE SPR NUMBER N/A

8. TITLE
DING ON FWD EXIT CONE AFT FLANGE AT 97.6 DEG

9. CLASSIFICATION
OBSERVATION ___ MINOR ANOMALY X MAJOR ANOMALY ___ CRITICAL ANOMALY ___

10. PART NUMBER 1U52839-01	11. SERIAL NUMBER 0000006	12. PART DESCRIPTION FORWARD EXIT CONE ASSY

13. REPORTED BY (NAME / ORGANIZATION / OBSERVATION DATE)
T. B. GREGORIO / MTI QA / 10/07/88

14. RESPONSIBLE COMPONENT TEAM / PROGRAM MANAGER
NOZZLE / E. L. DIEHL

15. RESPONSIBLE PROJECT ENGINEER (NAME / ORGANIZATION)
D. J. WAGNER / NOZZLE/FLEX BEARING PROJECT ENGINEERING

16. RESPONSIBLE DESIGN ENGINEER (NAME / ORGANIZATION)
S. A. MEYER / NOZZLE/FLEX BEARING DESIGN ENGINEERING

17. DESCRIPTION (ATTACH PFOR, FIGURES, PHOTOGRAPHS, ETC.)
During the 360L001B (RH) aft exit cone demate, a guide pin dinged the edge of a hole on the forward exit cone aft flange. The ding was approximately 0.02 inches deep.

Damage has occurred during KSC aft exit cone demates on previous flight nozzles. SRM-15A and 23A forward exit cone aft flange sealing surfaces were scratched by the joint alignment pin. The 360L001A (LH) forward exit cone aft flange was also scratched 0.002 inches deep during demate by a guide pin.

18. JUSTIFICATION OF CLASSIFICATION (POSTFIRE ENGINEERING EVALUATION LIMITS)
The current KSC aft exit cone demating procedure/tooling could cause damage preventing reuse of hardware.

Requires corrective action but has no impact on motor performance or program schedule.

19. CAUSE
Current KSC aft exit cone demating procedures and tooling.

20. RECOMMENDED CORRECTIVE ACTION
See continuation sheet.

21. ANOMALY APPROVAL SIGNATURE
RPRB SECRETARY: /S/T. L. JOHNSON DATE: 11/10/88

22. OBSERVATION/ANOMALY APPROVAL SIGNATURES
PE: D. J. Wagner DATE: 6/27/89
PM: E L Diehl DATE: 6/15/89

23. RESULTS OF RECOMMENDED CORRECTIVE ACTION
See continuation sheet.

24. REPORT RESULTS TO RPRB? YES X NO ___

25. RPRB CLOSURE SIGNATURE
(REQUIRED ONLY IF BLOCK 24 CHECKED "YES")
RPRB SECRETARY: DATE:

26. OBSERVATION/ANOMALY CLOSURE SIGNATURE
PM: DATE:

27. ORIGINATION DATE 11/09/88	28. REQUIRED STATUS DATE 11/07/88	29. PR CLOSURE DATE 11/22/88	30. PFAR CLOSURE DATE

REV. 3/28/89

CONTINUATION SHEET FOR PFAR NUMBER 360L001B-38

20. RECOMMENDED CORRECTIVE ACTION (continuation)

1. Eliminate guide pins. These just add more possibilities of scratching the forward exit cone aft flange after the joint separates and recoils. Eliminating the guide pins leaves only the joint alignment pin to worry about.

2. Near term: Use anti-recoil tools to eliminate the recoil of the aft exit cone after joint separation. This would not allow the alignment pin to contact the forward exit cone aft flange.

ASAP: Design and incorporate a rail system disassembly tool similar to that used at MTI Wasatch T-24 and T-97. This tool supports the aft exit cone assembly so that there is no load on the joint alignment pin during separation. The tool also does not recoil, eliminating any possibility of damage to the forward exit cone aft flange by the alignment pin.

23. RESULTS OF RECOMMENDED CORRECTIVE ACTION (continuation)

1. Effective: RSRM Flight 2 (360L002)

2. Anti-recoil tools effective: __________

Rail system tool effective: __________

KSC has incorporated a load cell into the existing aft exit cone stub removal tool. This load cell allows operators to monitor the load that is being supported by the fork lift. If used correctly, the load on the joint alignment pin can be minimized during separation. This would eliminate relative vertical displacements between the aft exit cone and forward exit cone after joint separation. The load cell was used on the aft exit cone demates of RSRM Flights 2 and 3 (360L002 and 360L003). Only minor raised metal was observed on the forward exit cone 91.8 degree alignment pin holes on the four joints where the load cell was used. This does not violate refurbishment requirements.

POSTFIRE ANOMALY RECORD (PFAR)

1. PFAR NUMBER
360L001B-42

2. SRM MOTOR NUMBER
360L001B

3. INSPECTION LOCATION
KSC X T-24/T-97 ___
H-7 ___ A-2 ___

4. REFERENCE SQUAWK NUMBER
26-0044

5. REFERENCE PR NUMBER
PV6-111324

6. REFERENCE IFA NUMBER
N/A

7. REFERENCE SPR NUMBER
N/A

8. TITLE
CORROSION BETWEEN PRIMARY AND SECONDARY FORWARD EXIT CONE O-RINGS

9. CLASSIFICATION
OBSERVATION ___ MINOR ANOMALY X MAJOR ANOMALY ___ CRITICAL ANOMALY ___

10. PART NUMBER
1U52839-01

11. SERIAL NUMBER
0000006

12. PART DESCRIPTION
FORWARD EXIT CONE ASSY

13. REPORTED BY (NAME / ORGANIZATION / OBSERVATION DATE)
K. B. NIELSEN / MTI QA / 10/07/88

14. RESPONSIBLE COMPONENT TEAM / PROGRAM MANAGER
NOZZLE / E. L. DIEHL

15. RESPONSIBLE PROJECT ENGINEER (NAME / ORGANIZATION)
D. J. WAGNER / NOZZLE/FLEX BEARING PROJECT ENGINEERING

16. RESPONSIBLE DESIGN ENGINEER (NAME / ORGANIZATION)
S. A. MEYER / NOZZLE/FLEX BEARING DESIGN ENGINEERING

17. DESCRIPTION (ATTACH PFOR, FIGURES, PHOTOGRAPHS, ETC.)
Aluminum oxide corrosion was observed between the primary and secondary o-rings, and outboard of the secondary o-ring, in the 360L001B (RH) aft exit cone field joint. No pitting was observed. Structural Applications inspectors noted that grease in both joints appeared lighter than required on STW7-2999.

Minor corrosion has been observed within past flight aft exit cone field joints, but has not been documented.

18. JUSTIFICATION OF CLASSIFICATION (POSTFIRE ENGINEERING EVALUATION LIMITS)
This is not a flight issue. It is believed that sea water entered past the primary o-ring at splashdown, resulting in the corrosion observed. This is potentially a reuse issue if the grease application specification (STW7-2999) is not followed.

19. CAUSE
Sea water engering past the primary o-ring at splashdown.

20. RECOMMENDED CORRECTIVE ACTION
1. Train and certify SPC operators on grease application per STW7-2999.

2. Do not write this minor corrosion up as a PR in the future.

21. ANOMALY APPROVAL SIGNATURE
RPRB SECRETARY: /S/T. L. JOHNSON DATE: 11/10/88

22. OBSERVATION/ANOMALY APPROVAL SIGNATURES
PE: D. J. Wagner DATE: 6/27/89
PM: E L Diehl DATE: 6/28/89

23. RESULTS OF RECOMMENDED CORRECTIVE ACTION
1. Effective ______.

2. Minor corrosion has been observed in this joint on the aft exit cone field joints of 360L002 and 360L003. Observed grease applications were nominal. This was not written up as an observation.

24. REPORT RESULTS TO RPRB? YES X NO ___

25. RPRB CLOSURE SIGNATURE
(REQUIRED ONLY IF BLOCK 24 CHECKED "YES")
RPRB SECRETARY: DATE:

26. OBSERVATION/ANOMALY CLOSURE SIGNATURE
PM: DATE:

27. ORIGINATION DATE
11/09/88

28. REQUIRED STATUS DATE
11/07/88

29. PR CLOSURE DATE
01/12/89

30. PFAR CLOSURE DATE

REV. 3/28/89

POSTFIRE ANOMALY RECORD (PFAR)

1. PFAR NUMBER 360L001B-44	3. INSPECTION LOCATION KSC ___ T-24/T-97 ___ H-7 X ___ A-2 ___	4. REFERENCE SQUAWK NUMBER N/A	5. REFERENCE PR NUMBER N/A
2. SRM MOTOR NUMBER 360L001B		6. REFERENCE IFA NUMBER N/A	7. REFERENCE SPR NUMBER N/A

8. TITLE
RTV BACKFILL IN JOINT 4 INHIBITED BY EXCESSIVE GREASE

9. CLASSIFICATION
OBSERVATION ___ MINOR ANOMALY X MAJOR ANOMALY ___ CRITICAL ANOMALY ___

10. PART NUMBER N/A	11. SERIAL NUMBER N/A	12. PART DESCRIPTION N/A

13. REPORTED BY (NAME / ORGANIZATION / OBSERVATION DATE)
R. J. GEORGE / NOZZLE/FLEX BEARING DESIGN ENGINEERING / 11/03/88

14. RESPONSIBLE COMPONENT TEAM / PROGRAM MANAGER
NOZZLE / E. L. DIEHL

15. RESPONSIBLE PROJECT ENGINEER (NAME / ORGANIZATION)
D. J. WAGNER / NOZZLE/FLEX BEARING PROJECT ENGINEERING

16. RESPONSIBLE DESIGN ENGINEER (NAME / ORGANIZATION)
S. A. MEYER / NOZZLE/FLEX BEARING DESIGN ENGINEERING

17. DESCRIPTION (ATTACH PFOR, FIGURES, PHOTOGRAPHS, ETC.)
See continuation sheet.

18. JUSTIFICATION OF CLASSIFICATION (POSTFIRE ENGINEERING EVALUATION LIMITS)
See continuation sheet.

19. CAUSE
Excess grease applied during joint assembly resulted because no application standards were in place.

20. RECOMMENDED CORRECTIVE ACTION
1. Set up TRACS class to train and qualify technicians, QA and AF on grease application.

2. Continue inspecting future post-test and flight nozzle joints for excess grease problems.

3. Release and Incorporate Rev. C to STW7-2999.

21. ANOMALY APPROVAL SIGNATURE
RPRB SECRETARY: DATE:

22. OBSERVATION/ANOMALY APPROVAL SIGNATURES
PE: DATE:
PM: DATE:

23. RESULTS OF RECOMMENDED CORRECTIVE ACTION
See continuation sheet.

24. REPORT RESULTS TO RPRB? YES X NO ___

25. RPRB CLOSURE SIGNATURE
(REQUIRED ONLY IF BLOCK 24 CHECKED "YES")
RPRB SECRETARY: DATE:

26. OBSERVATION/ANOMALY CLOSURE SIGNATURE
PM: DATE:

27. ORIGINATION DATE 11/30/88	28. REQUIRED STATUS DATE N/A	29. PR CLOSURE DATE N/A	30. PFAR CLOSURE DATE

REV. 3/28/89

CONTINUATION SHEET FOR PFAR NUMBER 360L001B-44

17. DESCRIPTION (continuation)

The 360L001B nozzle forward exit cone/throat joint (Joint #4) showed excessive grease. Grease was observed on the radial O.D. and on the axial portions of the joint interface. It is believed that the presence of the grease at 185 degrees inhibited the backfill of RTV. A blowpath was located at the 185 degree location. There was no blowby, erosion or heat effect to primary o-ring.

Joint #4 on the DM-9, QM-6, QM-7 and PV-1 tests showed excessive grease on phenolic interfaces. It was believed that the excess grease inhibited the RTV backfill in these joints (classified as Minor Anomalies).

Previous flight and static test forward exit cone/throat joints have shown grease on the phenolic joint interfaces. In order to hold the primary o-ring on the o-ring groove during assembly, a thicker layer of grease is applied to the o-ring and groove.

STW7-2999 was released to control amounts of grease applied to the nozzle internal joint o-rings and o-ring grooves. This specification was added to engineering assembly drawings and will be effective RSRM flight 4 (360T004).

18. JUSTIFICATION OF CLASSIFICATION (continuation)

The excess grease in joint #4 required corrective action but has no impact on motor performance or program schedule. The excess grease inhibited the RTV backfill at the 185 degree location.

Grease on the joint phenolic interfaces could prevent the adhesion of the RTV to the phenolic. This would reduce the capability of the RTV to act as a thermal barrier.

23. RESULTS OF RECOMMENDED CORRECTIVE ACTION (continuation)

STW7-2999 was incorporated into nozzle joint assembly planning; effective QM-8 and RSRM flight 4 (360T004).

1. Effective ___________.

2. QM-8 showed excess grease inhibiting RTV backfill in joint #4. The grease application specification did not reduce the excess grease in this joint. Joint #4 will be monitored by structural applications until proper grease applications are being followed. Also, TRACS classes are being set up to train/qualify nozzle joint assembly personnel (effective ___________).

360L001A showed no excess grease in nozzle joints.

360L002A showed no excess grease in nozzle joints.

360L002B showed no excess grease in nozzle joints.

360L003A showed no excess grease in nozzle joints.

360L003B showed no excess grease in nozzle joints.

POSTFIRE ANOMALY RECORD (PFAR)

1. PFAR NUMBER 360L001B-45	3. INSPECTION LOCATION KSC --- T-24/T-97 ---	4. REFERENCE SQUAWK NUMBER N/A	5. REFERENCE PR NUMBER N/A
2. SRM MOTOR NUMBER 360L001B	H-7 X A-2 ---	6. REFERENCE IFA NUMBER N/A	7. REFERENCE SPR NUMBER N/A

8. TITLE
RTV/EA913 ADHESIVE MIXING IN JOINT 2

9. CLASSIFICATION
OBSERVATION --- MINOR ANOMALY X MAJOR ANOMALY --- CRITICAL ANOMALY ---

10. PART NUMBER N/A	11. SERIAL NUMBER N/A	12. PART DESCRIPTION COWL/NOSE INLET JOINT (JOINT 2)

13. REPORTED BY (NAME / ORGANIZATION / OBSERVATION DATE)
S. A. MEYER / NOZZLE/FLEX BEARING DESIGN ENGINEERING / 11/04/89

14. RESPONSIBLE COMPONENT TEAM / PROGRAM MANAGER
NOZZLE / E. L. DIEHL

15. RESPONSIBLE PROJECT ENGINEER (NAME / ORGANIZATION)
D. J. WAGNER / NOZZLE/FLEX BEARING PROJECT ENGINEERING

16. RESPONSIBLE DESIGN ENGINEER (NAME / ORGANIZATION)
S. A. MEYER / NOZZLE/FLEX BEARING DESIGN ENGINEERING

17. DESCRIPTION (ATTACH PFOR, FIGURES, PHOTOGRAPHS, ETC.)
The EA913 adhesive used to bond the cowl insulation to the cowl housing extruded into the radial RTV bondline between the cowl ring and nose cap 360-deg. circumferentially. The adhesive that extruded into the radial bondline was typically sandwiched between two layers of RTV. Soot was observed over a majority of the joint circumference and up to the axial bolt holes. There was no blowby, erosion or heat effect to the primary o-ring.

The mixing of the adhesive in the cowl/nose cap bondline and the presence of soot was documented on ETM-1A, DM-8, DM-9, QM-6 and QM-7. It is believed that the mixing has occurred on all previous nozzles due to assembly procedures.

18. JUSTIFICATION OF CLASSIFICATION (POSTFIRE ENGINEERING EVALUATION LIMITS)
There is no adhesion between the RTV and EA913 adhesive, reducing the capability of the RTV to act as a thermal barrier.

19. CAUSE
Current bonding and joint assembly procedures.

20. RECOMMENDED CORRECTIVE ACTION
1. At the time this was presented to RPRB, the PV-1 nozzle Joint #2 had just been examined. It was recommended that we further evaluate the new assembly procedure change on QM-8. It would then be determined if the new assembly process would be incorporated into flight nozzles.

21. ANOMALY APPROVAL SIGNATURE
RPRB SECRETARY: Tracy L. Johnson DATE: 6 June 89

22. OBSERVATION/ANOMALY APPROVAL SIGNATURES
PE: [signature] DATE: 6-7-89
PM: E L Diehl DATE: 6-9-89

23. RESULTS OF RECOMMENDED CORRECTIVE ACTION
See continuation sheet.

24. REPORT RESULTS TO RPRB? YES X NO ---

25. RPRB CLOSURE SIGNATURE
(REQUIRED ONLY IF BLOCK 24 CHECKED "YES")
RPRB SECRETARY: Tracy L. Johnson DATE: 6 June 89

26. OBSERVATION/ANOMALY CLOSURE SIGNATURE
PM: E L Diehl DATE: 6-9-89

27. ORIGINATION DATE 11/30/88	28. REQUIRED STATUS DATE N/A	29. PR CLOSURE DATE N/A	30. PFAR CLOSURE DATE

REV. 3/28/89

CONTINUATION SHEET FOR PFAR NUMBER 360L001B-45

23. RESULTS OF RECOMMENDED CORRECTIVE ACTION (continuation)

1. The new assembly procedure was tested on PV-1 and QM-8 Joint #2's. Post-test inspections of these joints prompted the decision to further evaluate and refine the new assembly procedure on TEM motors.

As of 360L002, there has never been primary o-ring blowby, erosion or heat effect, or metal heat damage within Joint #2. In the 360L002 RPRB, it was decided to close out all "minor anomalies" similar to this on all previous staic tests and flights. All future occurrences, including 360L002, would be considered "observations".

TWR-17198 Vol. V has been updated to include accept/reject criteria for RTV in nozzle joints. The condition noted in this "minor anomaly" is now an "acceptable" condition per this criteria.

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