APPLIED TECHNICAL SERVICES, INCORPORATED

1049 Triad Court, Marietta, Georgia 30062 • (770) 423-1400 Fax (770) 424-6415

INVESTIGATION OF SWIVEL ASSEMBLY FAILURE, P/N 7438-4, S/N 0748

ATS JOB # D166449 Rev. 1*

PURCHASE ORDER # TBD

Prepared for

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*See Appendix D for customer requested modifications

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CERTIFIED TEST REPORT

Purchase Order # TBD

Mr. Branko Stropnik
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Subject

Investigation of Swivel Assembly Failure, P/N 7438-4, S/N 0748 removed from A/C 5305

Material

Forward and Center Spools, Center and Aft Housings: 6061-T651
Aft Spool and Forward Housing: 7050-T74
Connecting Tubes: 6061-T6

Objective and Background

Components from a failed swivel assembly (P/N 7438-4, S/N 0748) were submitted to Applied Technical Services (ATS) for failure analysis. The assembly that failed during landing was used in a hydraulic landing gear circuit. The failure resulted in a hydraulic fluid leak from the swivel assembly. The aircraft had accumulated 10.4 flight hours and 5 landings at the time of failure. A similar assembly from another aircraft exhibited similar a failure; however, it was not available for analysis. The assembly included spools, housings, and connecting tubes, which were reportedly aluminum alloys 6061-T651, 6061-T6, and 7050- T74.

The analysis was conducted at ATS in Marietta, Georgia and the majority of the testing was witnessed by NTSB, FAA, Gulfstream, Pneudraulics, and Goodrich personnel on April 26-28, 2011. See Appendix A for the list of the attendees. A combination of the work scope submitted by Gulfstream (Appendix C) and tests suggested by ATS personnel and the attendees during the investigation were used. All destructive testing was conducted with the approval of the attendees.

The purpose of this analysis was to determine if the failure of the swivel assembly was related to any material aspect by using fractographic, metallurgical, and chemical techniques. Some additional testing was conducted (i.e. dimensional analysis) as requested by the attendees; however, the results were not interpreted by ATS personnel and were only supplementary.

Test Procedure and Results

A sealed box (Figure 1) containing the sample was opened under supervision of the attendees. The samples were documented in the as-received condition (Figures 2 and 3). The spool and housing samples, the t-seals and backing rings that were removed from the center spool, and the vials containing the residue that was removed during the disassembly of the components were submitted for analysis.

Dimensional Analysis:

The housing and spool samples were analyzed per the customer's instructions and supplied drawings. See Appendix B for the dimensional analysis data. It should be noted that the dimensional analysis was conducted on the failed/used parts.

Analyses of the Connecting Tube:

The inboard connecting tube between the center and the aft housing was fractured near the braze joint to the center housing end (Figure 4). Only a small area around the circumference of the tube remained intact (Figure 5). The adjacent tube exhibited multiple parallel paint cracks near the braze joint at the center housing end, showing a distinct angle approximately 30º-45º from the tube axis, a possible indication of torsional stress (Figure 6). Similar paint cracks were also observed on the fractured tube (Figure 7).

The crack on the connecting tube was opened to expose the fracture surface. In order to open the fracture surface, the center-to-aft housing assembly was sectioned as shown in Figure 8. See Figures 9 and 10 for the overall views of the fracture surface. The fracture surface exhibited a thin area of flat, shiny faceted appearance near the outer diameter around the circumference including the lab induced overload area, consistent with brittle fracture. The rest of the fracture surface was angled and exhibited a dull appearance.

The fracture surfaces were examined using a scanning electron microscope (SEM) equipped with energy dispersive spectroscopy (EDS). See Figures 11 through 15 for SEM images from the fracture surface. The tube exhibited a thin area of interdendritic fracture at the OD, followed by a thin area of intergranular fracture appearance zones, consistent with a brittle fracture of the braze and alloyed tube areas. The rest (majority) of the fracture surface exhibited microvoid dimples, indicating ductile overload. The lab induced overload fracture surface exhibited the same zones and characteristics. No evidence of progressive cracking (i.e. fatigue) was observed.

The fracture surface was chemically analyzed by energy-dispersive spectroscopy (EDS) per ASTM E1508-98 (2008), *Standard Guide for Quantitative Analysis by Energy-Dispersive Spectroscopy*. See Figure 16 for the EDS spectra. The ductile area of the fracture surface was consistent with reported 6061 aluminum alloy. The interdendritic areas near the OD surface exhibited higher concentrations of silicon, which is consistent with braze material per AMS 4185 as reported in the supplied certification.

The fractured and adjacent connecting tubes were sectioned longitudinally and metallographically prepared per ASTM E 3-01(07), *Standard Practice for Preparation of Metallographic Specimens*. See Figures 17 through 22 for the photomicrographs. The failed tube fractured at the braze fillet exhibiting interdendritic/intergranular features and the crack progressed as ductile overload into the original tube material. No microstructural abnormalities were observed. Some alloying of the braze material with the tube material was observed; however, no maximum alloying depth requirement was specified in MIL-B-7883B brazing specification. Both tubes exhibited some areas with no braze coverage; however, these areas were not near the fracture location. The adjacent tube sample exhibited cracks in the coating. Some shallow cracks were observed in the braze fillet area, which aligned with the paint cracks.

Hardness of the tube base materials and alloyed zones were measured per ASTM E 384-10, *Standard Test Method for Knoop and Vickers Hardness of Materials,* on the Vickers 1 kgf scale and converted to the approximate Rockwell values per ASTM E 140-07, *Standard Hardness Conversion Tables.* See Table I for the results. Both tube samples met 6061-T6 requirement of 47 HRB minimum per AMS 2658B. No significant hardness difference was observed between the core and alloyed zones.

Analyses of Housings and Spools:

The visual examination of the housing and spool samples revealed some wear/galling on the inner diameters of the housings and the matching spool samples (Figures 23 through 29). The center housing and the spool exhibited severe galling around the circumference on the matching surfaces at the outboard and inboard side of the swivel assembly. The other housings and spools also exhibited some damage in similar areas; however, they were more localized and less severe.

The housing and spool samples were sectioned to expose worn/galled areas for further examination. See Figures 30 through 32 for photomacrographs. The center housing sample exhibited a circumferential wear pattern at the inner diameter at the outboard location. Also, other wear marks that were perpendicular to the circumferential wear were observed approximately every 90°. The matching area of the center spool showed a similar pattern. Pneudralics personnel reported that these longitudinal marks may have been due to post-incident disassembly. The aft and forward components exhibited partial wear and were less severe.

The worn and unaffected surfaces of the housing and the spool samples were chemically analyzed by EDS). See Figures 33 through 39 for the EDS spectra. No evidence of a foreign object that may have caused the damage was detected on worn areas. All samples exhibited elements that were consistent with the reported aluminum alloys. The spool samples exhibited significant levels of oxygen and sulfur, consistent with the reported anodizing process. The housing samples did not exhibit any evidence of anodizing on the undamaged surfaces adjacent to the worn areas. Only worn areas exhibited some concentrations of oxygen and sulfur, consistent with transfer of the anodizing from the spool samples at the contact points. Recessed areas of the housing samples exhibited anodizing (Figure 40).

The housing and spool samples were metallographically prepared through the worn areas. The worn areas of all samples appeared to be due to mechanical damage. The housing samples did not exhibit anodized layers on the lands (closest to spool contact) but did exhibit anodizing in the recessed grooves. The spool samples exhibited anodized layers. No microstructural abnormalities were observed in the samples. See Figures 41 through 46 for the photomicrographs.

The hardness of the housings and spools were tested per ASTM E 18-08, *Standard Test Method for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*, and the electrical conductivity was measured per ASTM E 1004-10, *Standard Test Method for Electromagnetic (Eddy-Current) Measurements of Electrical Conductivity*. The tubes were too small for this type of testing. The results are presented in Tables II and III. The forward-center spools, and center-aft housings met 6061 –T6 requirements per AMS 2658B. The aft spool and forward housing exhibited slightly lower hardnesses than the AMS 2658B requirements.

The anodizing layer thicknesses on the spools and groove areas of the housings were measured per ASTM B 487-85(07), *Standard Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examinations of a Cross Section*. The thickness results are shown in Table IV. The samples had thicker coatings and did not meet the customer reported requirements of 0.0001"-0.0002".

Surface roughness of the housing and spool samples were measured at relatively undamaged areas near the damaged areas using ANSI B46.1 as a guide. See Table V for the results. The samples met the drawing requirements of 16 µin for the housings and 32 µin for the spools.

Analysis of Debris:

Debris on one of the submitted vials (Figure 47) were chemically analyzed by EDS. See Figures 48 through 50 for representative EDS spectra and SEM images. The debris samples were collected by the customer during disassembly of the swivel. No evidence of foreign metallic materials was found. All particles were consistent with aluminum, paint, and Teflon.

Analysis of T-seals and Backing Rings:

Hardness of the t-seal and backing rings that were removed from the spool samples (Figure 51) were measured using ASTM D 2240 - 05(2010), *Standard Test Method for Rubber Property—Durometer Hardness,* as a guide. See Tables VI and VII for the results. All t-seal samples met the minimum customer supplied requirement of 75 Shore A. No requirements were supplied for the backing ring samples.

Materials of the t-seal and the backing ring samples from the center spool were verified using FT-IR techniques. The materials of the t-seals were consistent with known ethylene propylene rubber (EPR), such as EPDM (Figure 52). The materials of backing rings were consistent with known PTFE (Figure 53).

Conclusions

The connecting tube sample from the swivel assembly most likely fractured due to a single overload event. The angled paint cracking in the failed and adjacent intact tubes suggests that the component experienced a torsional/twisting type of stress. The customer reported that under normal conditions, the connecting tubes should not be subjected to these types of stresses. No evidence of progressive cracking (i.e. fatigue or corrosion) was observed. The failed tube met the hardness requirement of the specified heat treatment condition requirements and no microstructural abnormalities were observed. Even though lack of braze coverage was observed in some areas of the failed and intact tube joints, it is not believed to have contributed to the failure since the tube was fractured in the braze fillet which was an area with full braze coverage.

The spool and housing components exhibited wear/galling at the matching surfaces that reportedly should not have been in contact. The center spool and housing at the outboard locations exhibited the most severe damage. No evidence of a foreign abrasive material contamination that may have caused this damage was observed. The spool and housing samples did not exhibit any microstructural abnormalities and mostly met the heat treatment requirements with the exception of the aft spool and center housing having slightly lower hardnesses than AMS 2658B requirements. The housing samples did not exhibit anodized layers on the spool contact surfaces. The rest of the areas of the spool and housing samples exhibited thicker anodized layers than the customer supplied requirements. Possible contributions, if any, of the lack of anodizing at the housing side of the contact surfaces and thicker than the required anodizing at the spool side of contact surfaces are unknown at this time. The t-seals and backing rings from the spools exhibited normal hardness and material properties.

Given the above observations, the swivel assembly failure was most likely caused by overloading of the connecting tube due to seizure of the spool/housing assembly. The seizure may have been caused by dimensional and/or assembly (i.e. misalignment) issues, which could not be fully assessed from the supplied components, already disassembled. The root cause of the housing/spool seizure should be investigated by the involved parties using the supplied and/or additional analyses, including but not limited to dimensional, stress, and evaluation of the assembly procedures/practices.

Table I: Hardness Results for the Tube Samples

Sample	Base	Near Braze
Failed	60 HRB (114 HV 1kgf)	62 HRB (120 HV 1kgf)
Intact	60 HRB (115 HV 1kgf)	60 HRB (114 HV 1kgf)
6061 T6 Requirements[(1)]	47 HRB minimum	

(1)AMS 2658B

Table II: Hardness and Conductivity Measurements for 6061-T651 Materials

Identification	Hardness (HRB W)	Conductivity (%IACS)
Center Housing	61	43.4
Aft Housing	63	43.4
Center Spool	65	43.0
Forward Spool	65	44.2
6061-T6[(2)]	47 HRB min.	40.0-50.0

(2) AMS 2658B

Table III: Hardness and Conductivity Measurements for 7050-T74 Materials

Identification	Hardness (HRB W)	Conductivity (%IACS)
Forward Housing	79	42.4
Aft Spool	80	41.0
7050-T74[(3)]	82 HRB min.	40.0-44.0

(3) AMS 2658B

Table IV: Coating Thickness Results

Identification	Thickness
Center Housing	0.0003"
Aft Housing	0.0003"
Forward Housing	0.0003"
Center Spool	0.0004"
Forward Spool	0.0004"
Aft Spool	0.0004"

Table V: Surface Roughness Results

Identification	Surface Roughness (μin)
Center Housing	11.8
Aft Housing	6.2
Forward Housing	5.2
Center Spool	25.2
Forward Spool	31.5
Aft Spool	31.5

Table VI: Durometer Hardness Results for T-Seals

Identification		Hardness (Shore A)
Forward Spool	Center	81
	Inboard	83
	Outboard	81
Center Spool	Center	83
	Inboard	81
	Outboard	82
Aft Spool	Center	82
	Inboard	81
	Outboard	83

Table VII: Durometer Hardness Results for Backing Rings

Identification		Hardness (Shore D)
Forward Spool	Center	55
	Inboard	56
	Outboard	55
Center Spool	Center	55
	Inboard	55
	Outboard	56
Aft Spool	Center	55
	Inboard	55
	Outboard	55

Figure 1: Photographs of the box that contained the samples

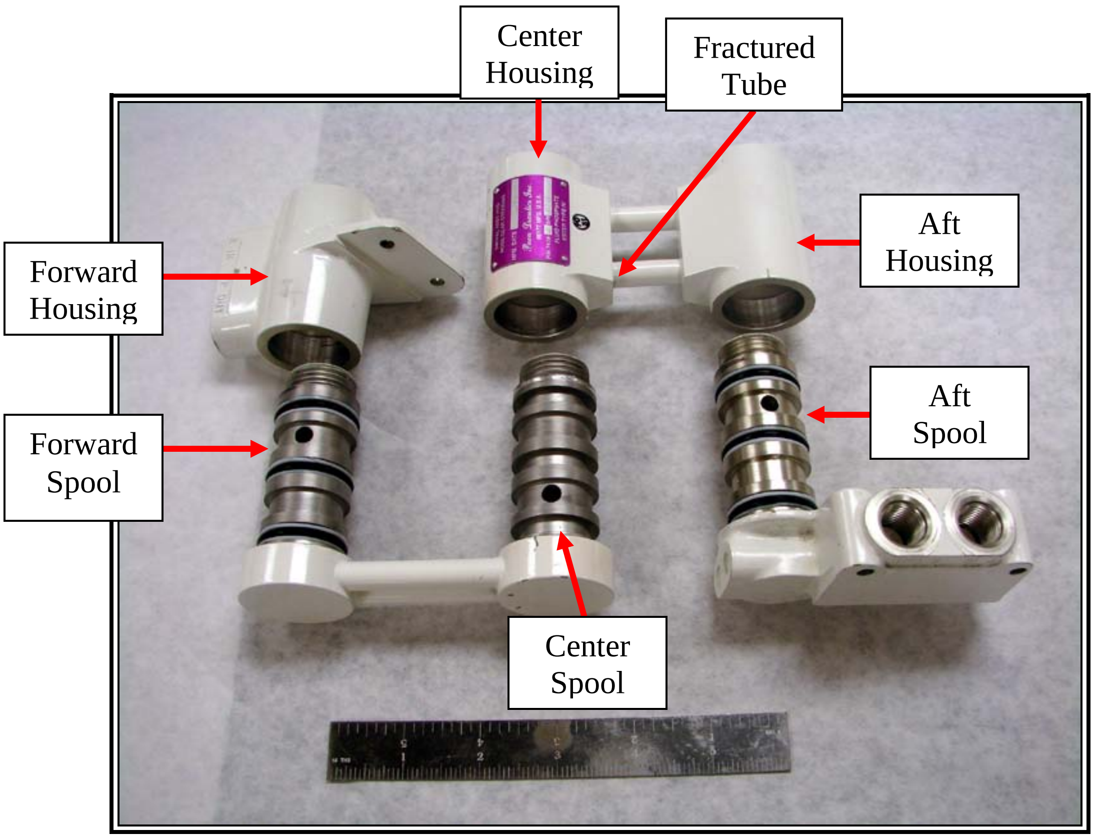


Figure 2: Photograph of the as-received components

Figure 3: Photographs of the as received residue (top) and seal (bottom) samples

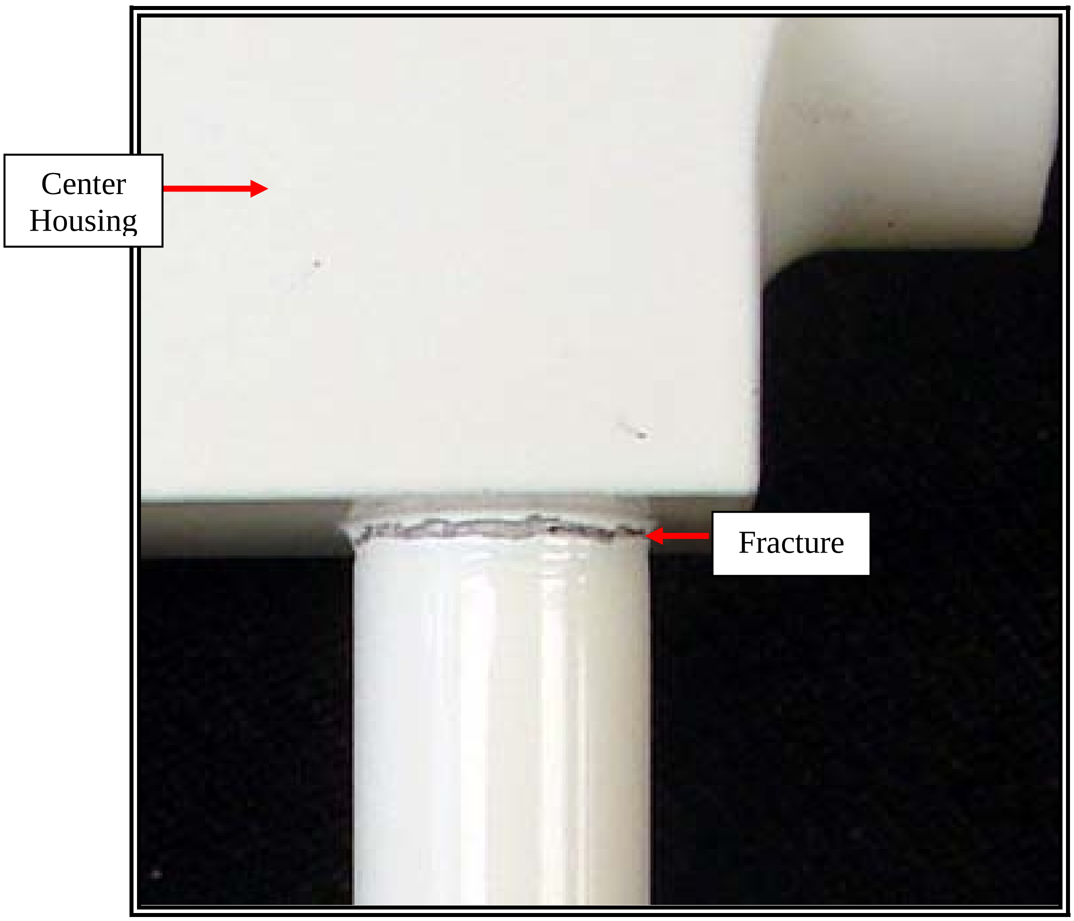
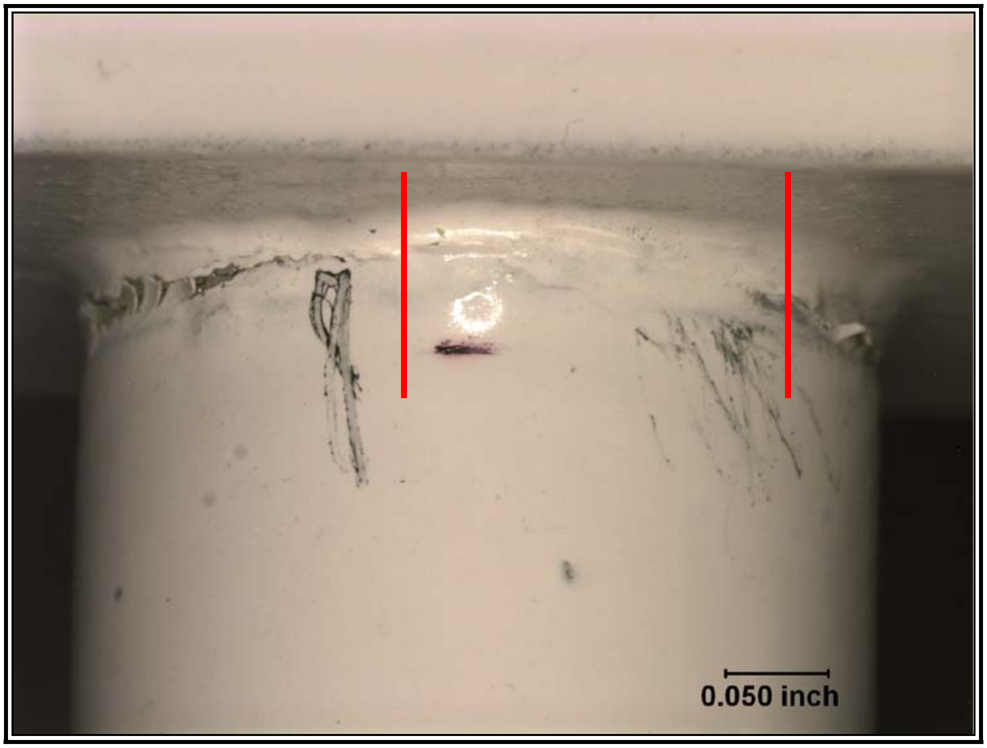


Figure 4: Photograph of the fractured tube



Magnification: 10X

Figure 5: Photomacrograph of the fractured tube showing the intact area between two red lines

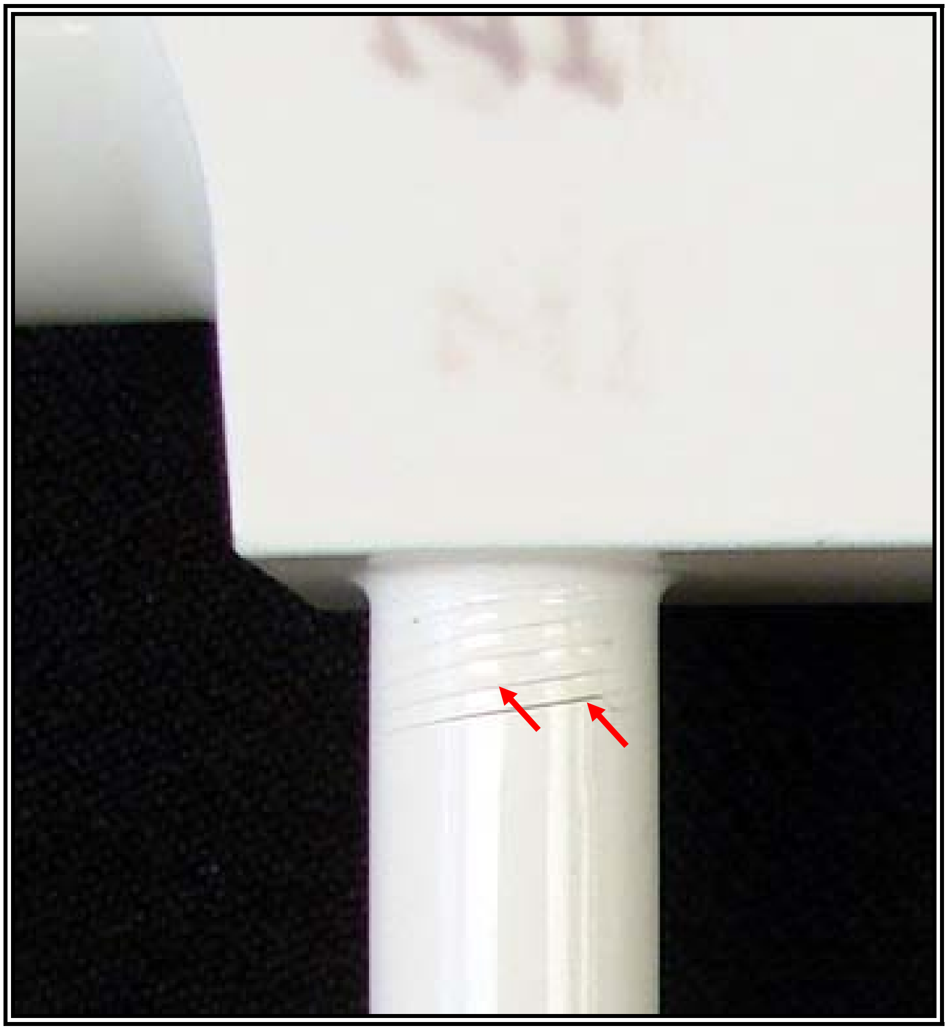
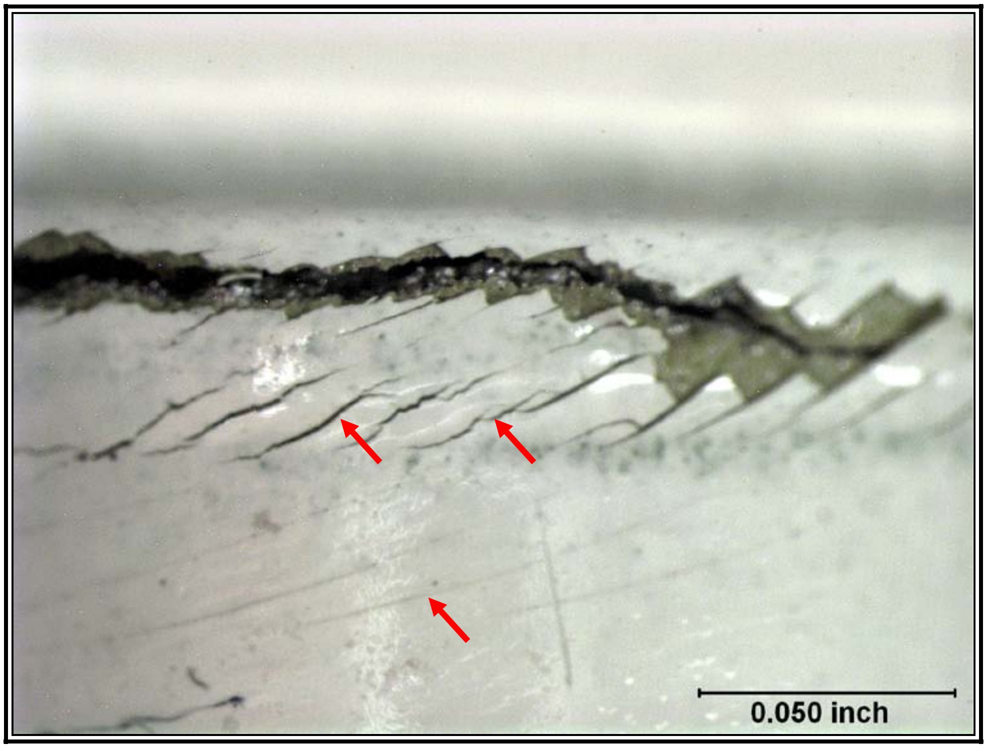


Figure 6: Photograph of the adjacent tube with paint cracks (arrows)



Magnification: 25X

Figure 7: Photomacrograph of the fractured tube with paint cracks (arrows)

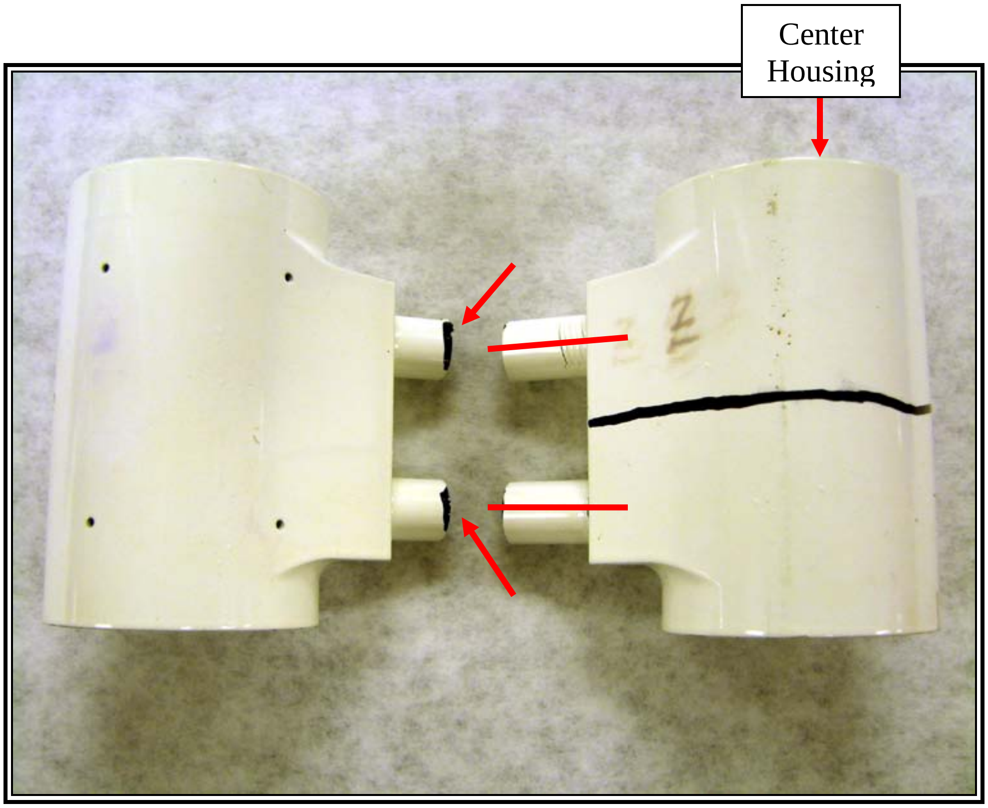
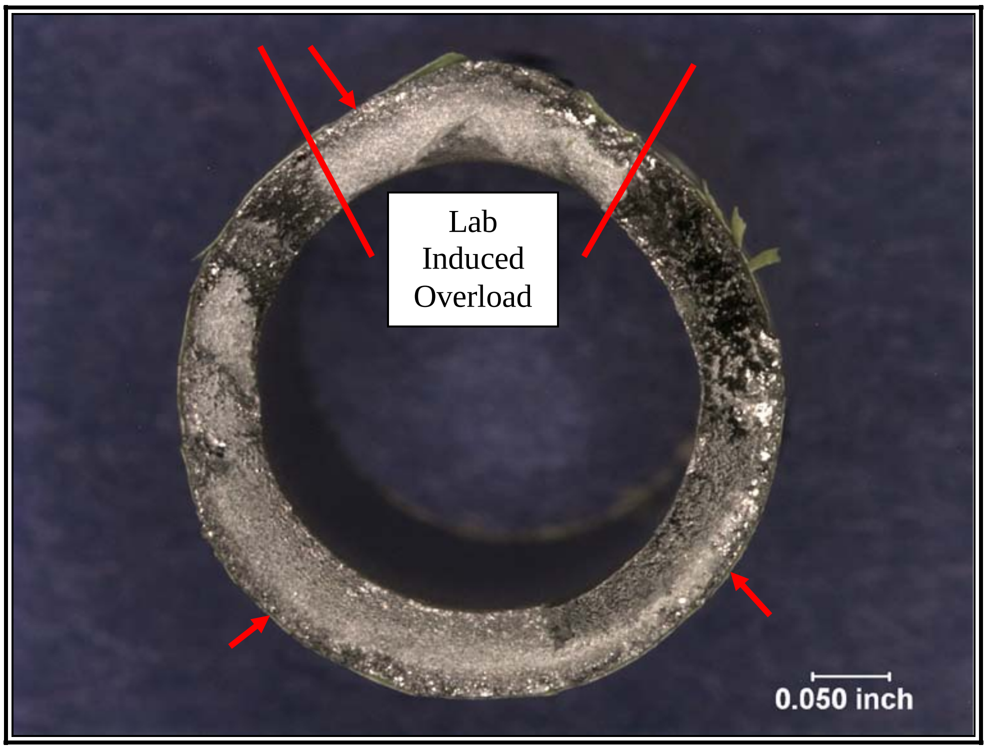


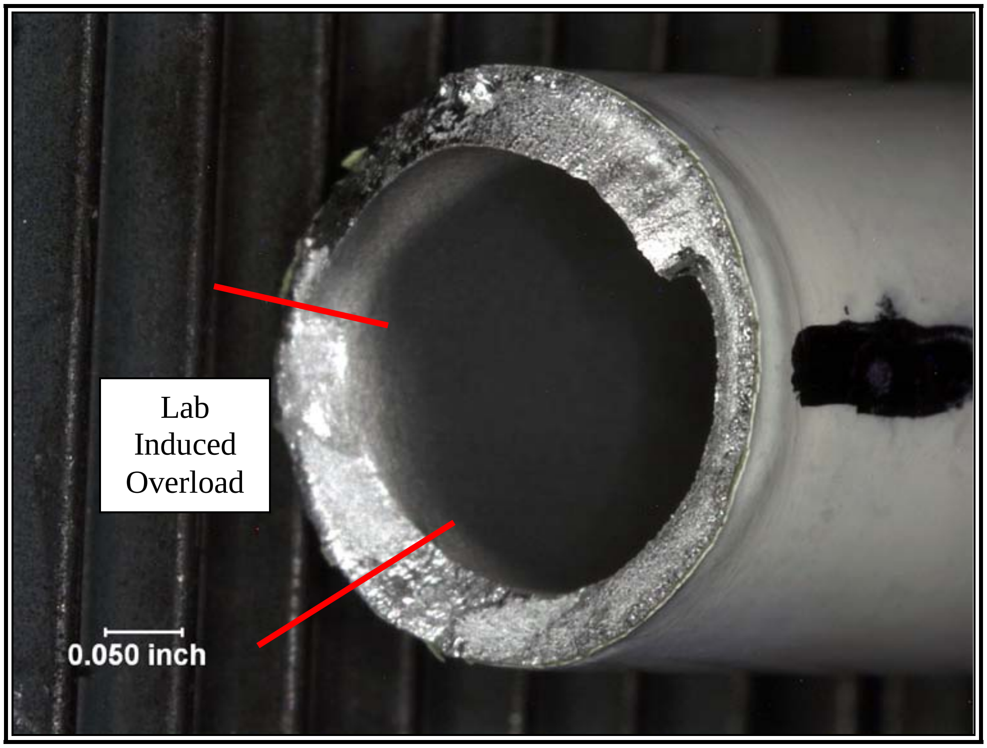
Figure 8: Photograph showing sectioned locations to open the fracture surface (arrows)

Red lines indicate the sectioning locations for microstructural exam.



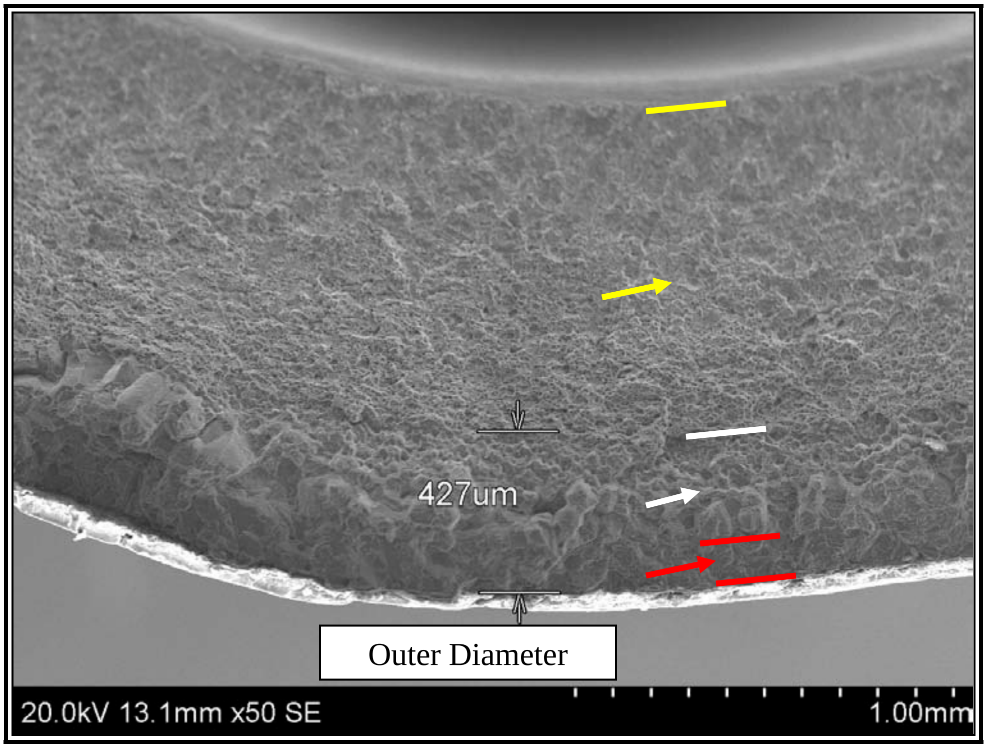
Magnification: 8X

Figure 9: Photomacrograph of the tube fracture surface showing shiny faceted appearance near the OD (arrows)



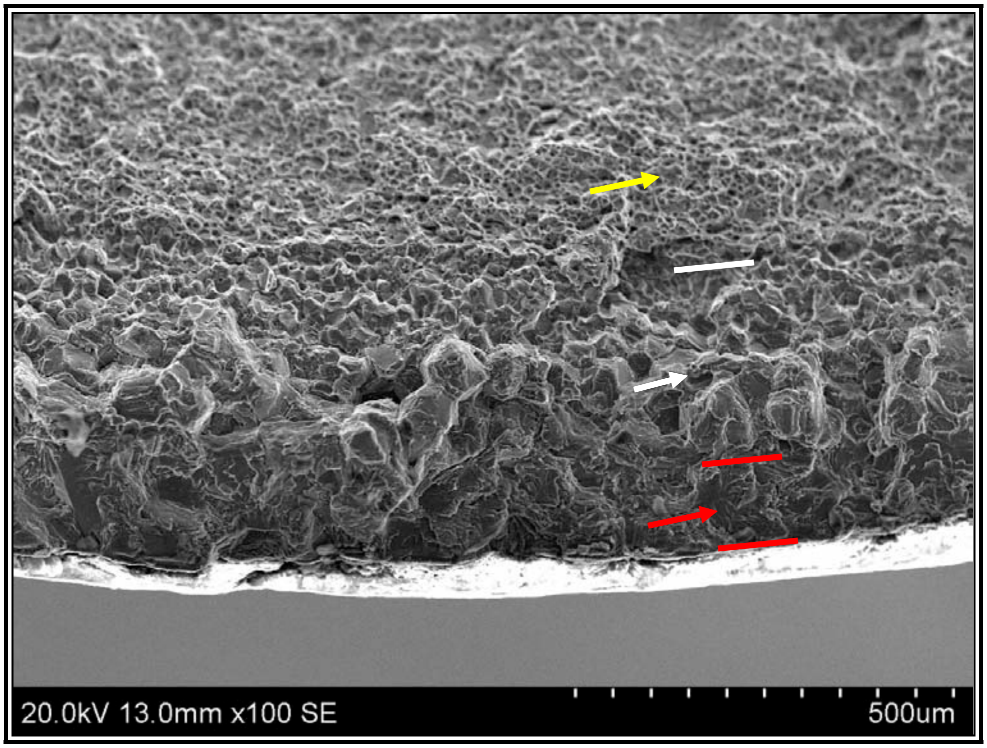
Magnification: 8X

Figure 10: Photomacrograph of the tube fracture surface



Magnification: 50X

Figure 11: SEM image of the fracture surface exhibiting interdendritic (red arrow), intergranular (white arrow), and ductile (yellow arrow) areas



Magnification: 100X

Figure 12: SEM image of the fracture surface exhibiting interdendritic (red arrow), intergranular (white arrow), and ductile (yellow arrow) areas

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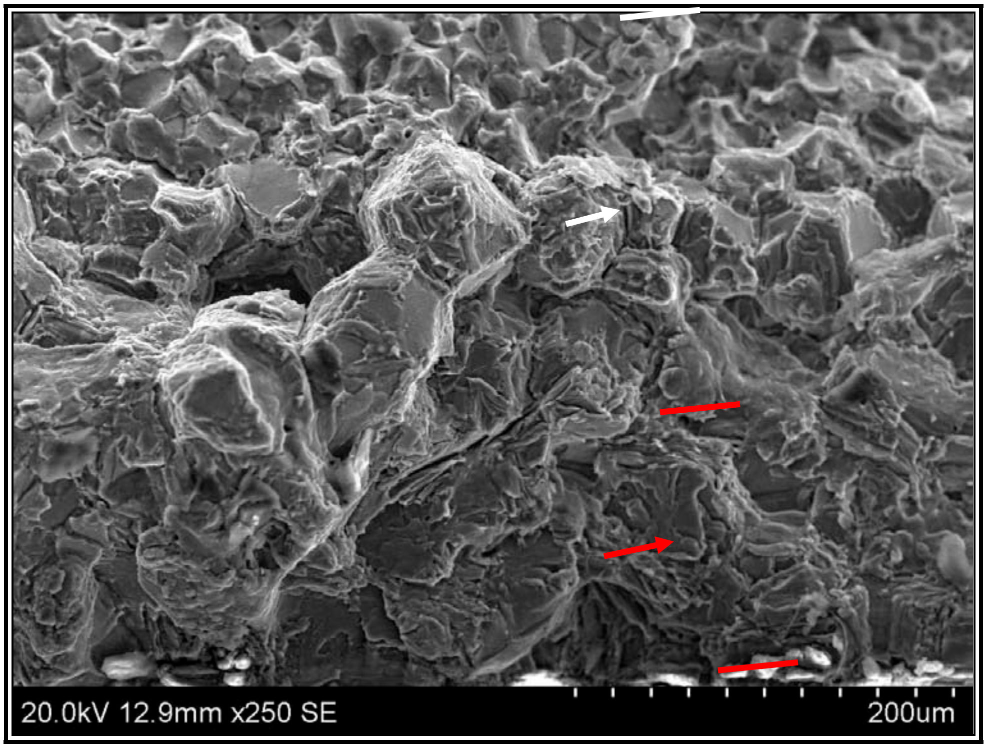
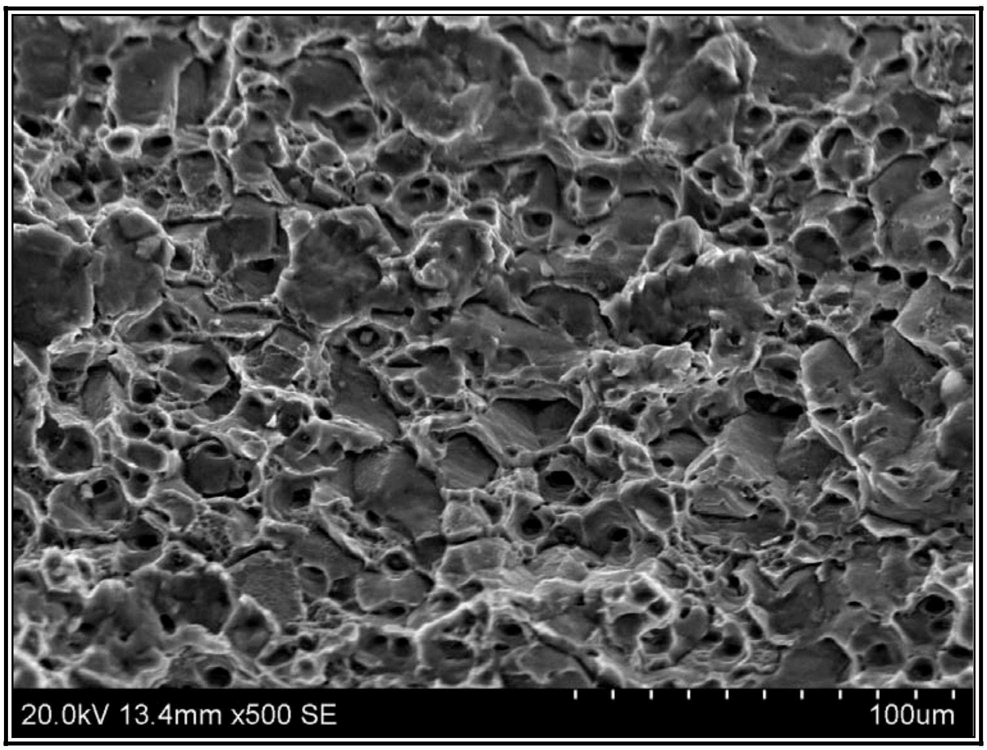


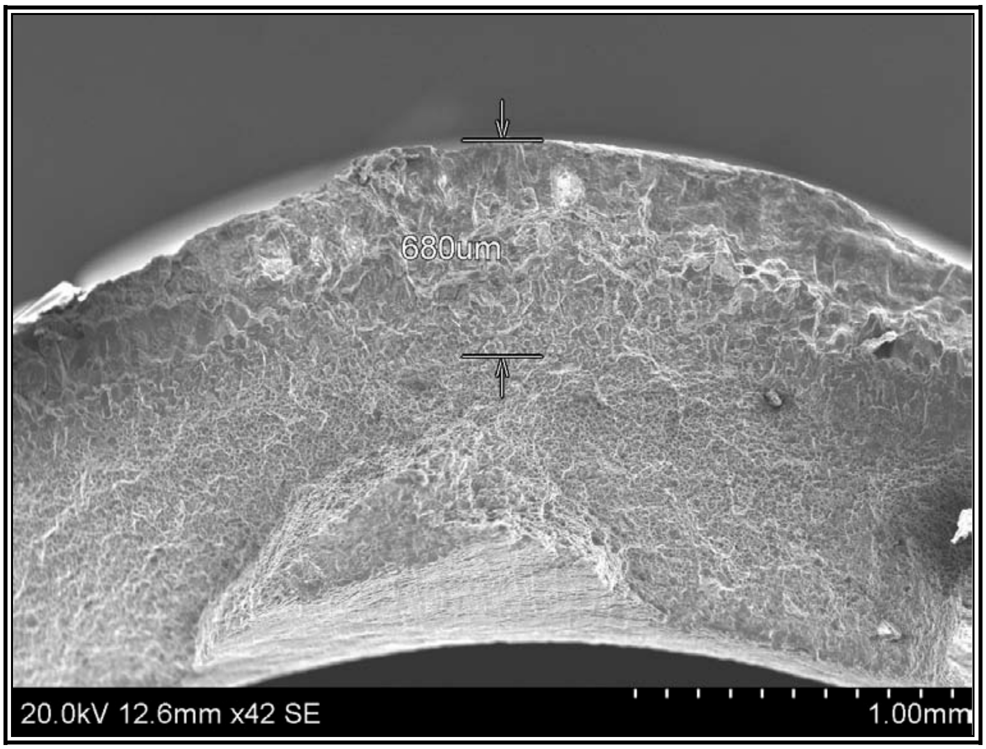
Magnification: 250X

Figure 13: SEM image of the fracture surface exhibiting interdendritic (red arrow) and intergranular (white arrow) areas



Magnification: 500X

Figure 14: SEM image of the fracture surface exhibiting ductile area



Magnification: 42X

Figure 15: SEM image of the lab induced overload fracture surface showing similar features to the service fracture surface

Measured area shows the interdendritic/intergranular area.

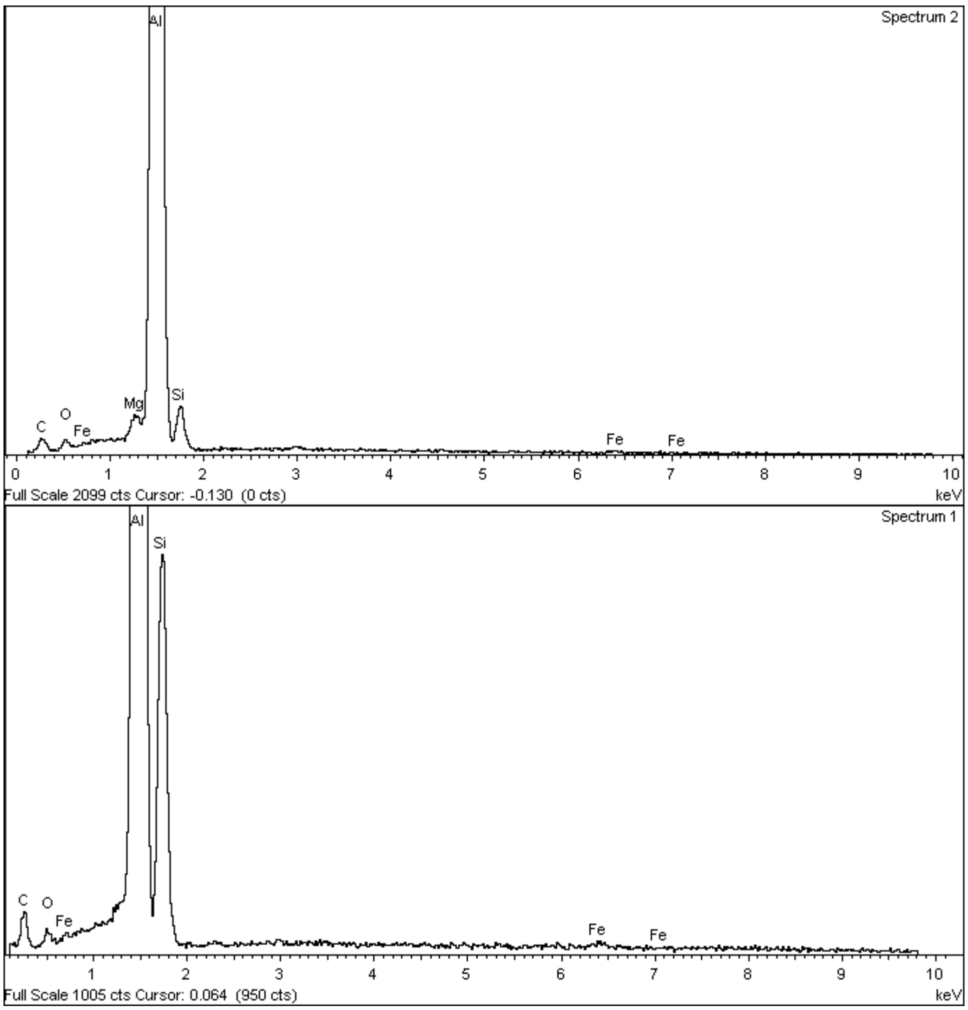
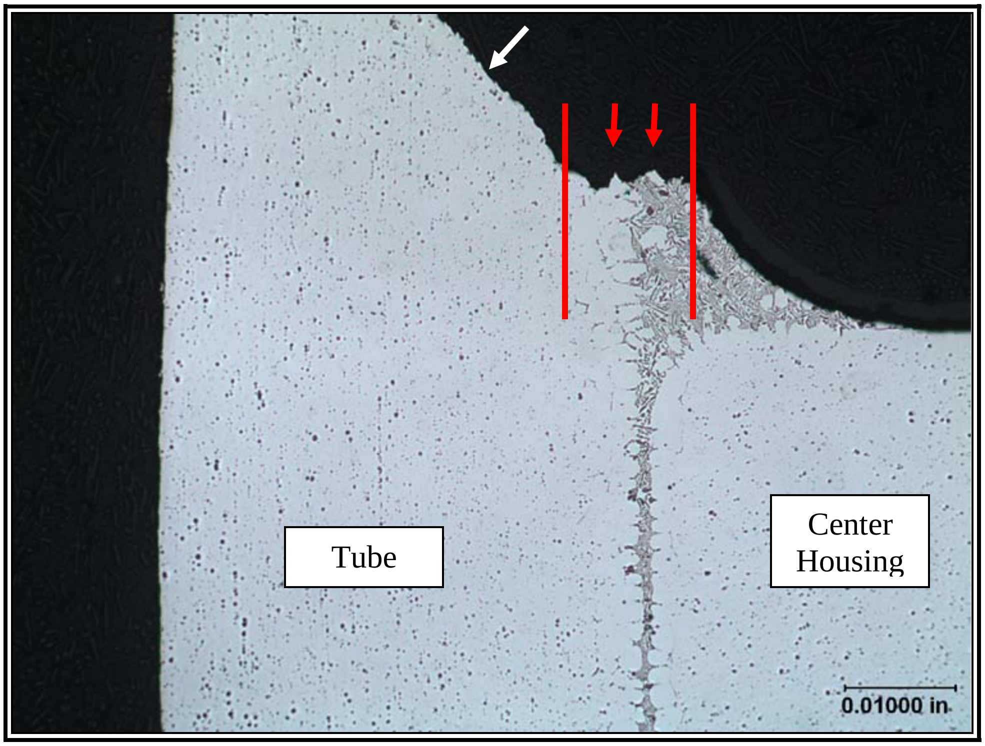


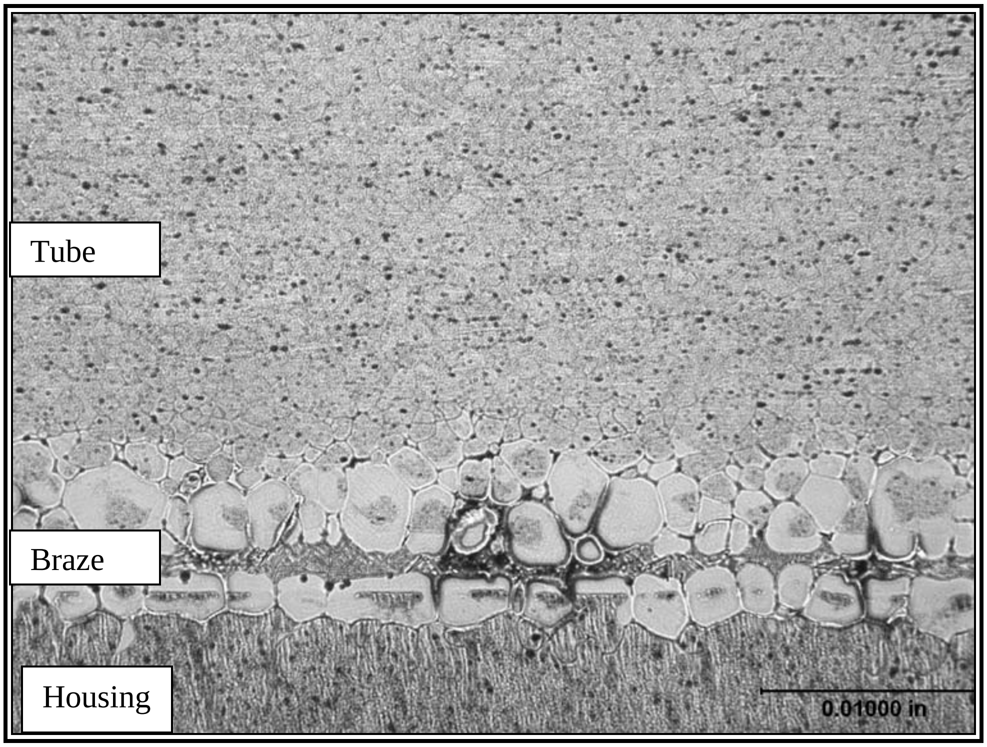
Figure 16: EDS spectra of the ductile (top) and the interdendritic (bottom) areas of the fracture surface

The spectra indicate carbon (C), oxygen (O), iron (Fe), magnesium (Mg), aluminum (Al), and silicon (Si).



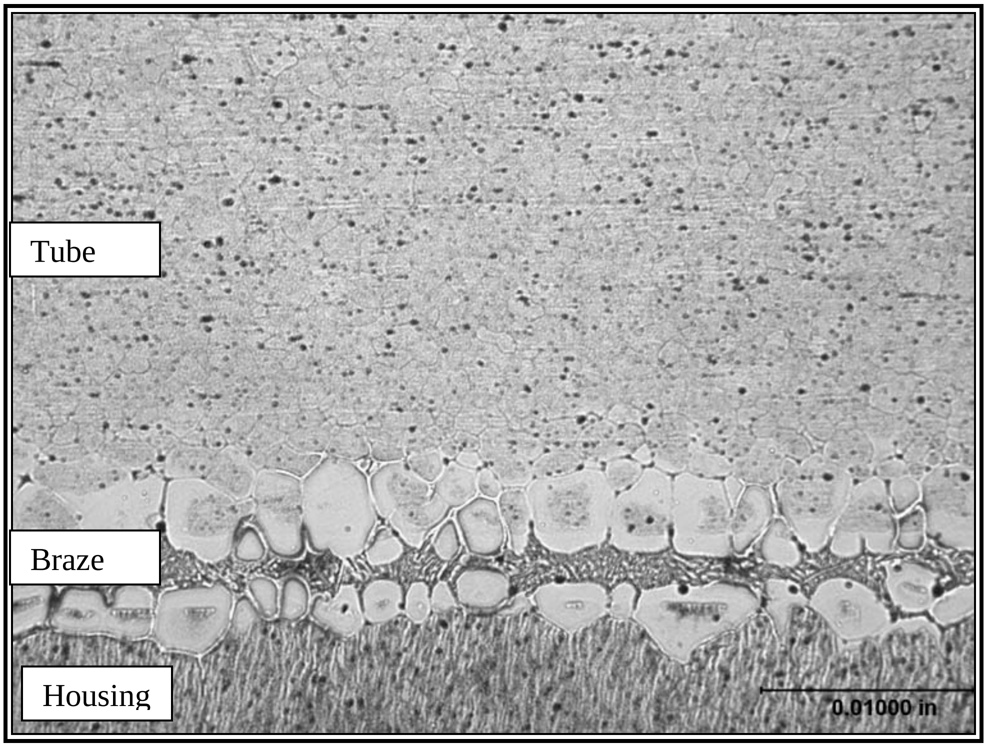
As polished Magnification: 50X

Figure 17: Photomicrograph of the failed tube sample's section showing the fracture origin at the braze fillet (red arrows) and the ductile fracture of the original tube material (white arrow)



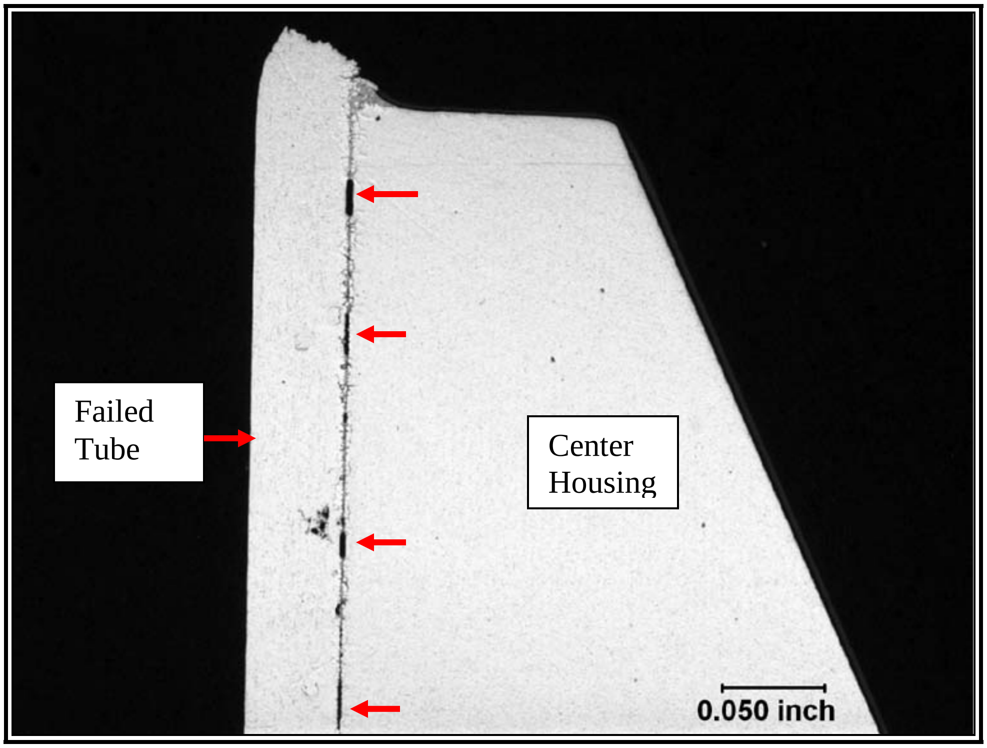
Keller's Reagent Etch Magnification: 100X

Figure 18: Photomicrograph of the failed tube sample's section showing microstructure



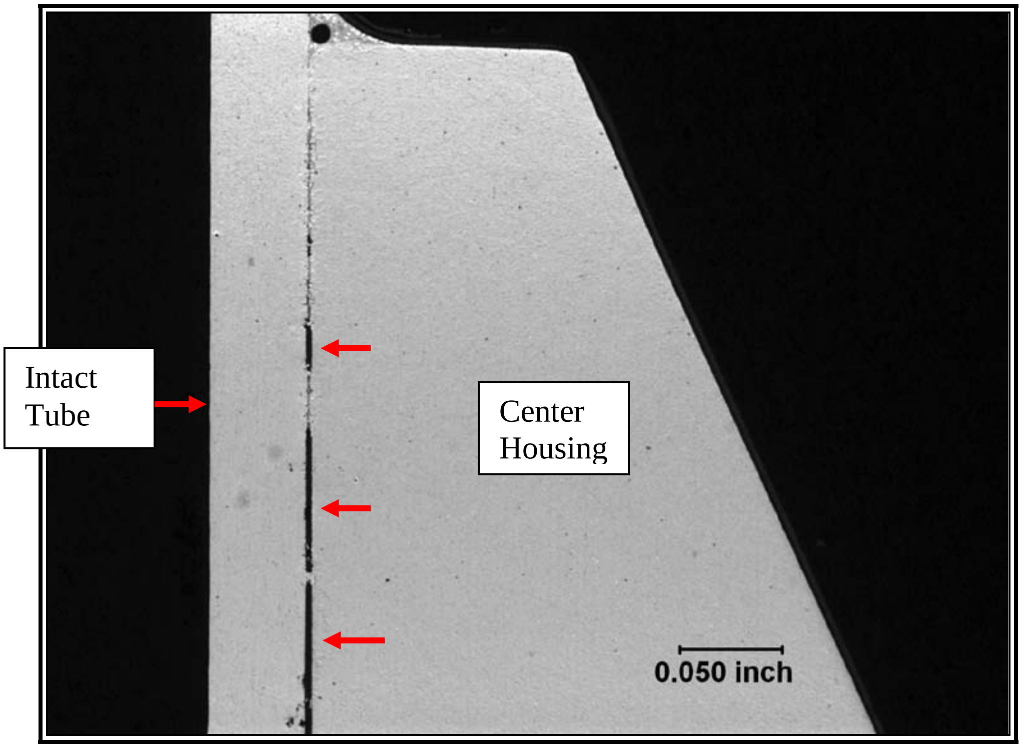
Keller's Reagent Etch Magnification: 100X

Figure 19: Photomicrograph of the intact tube sample's section showing microstructure



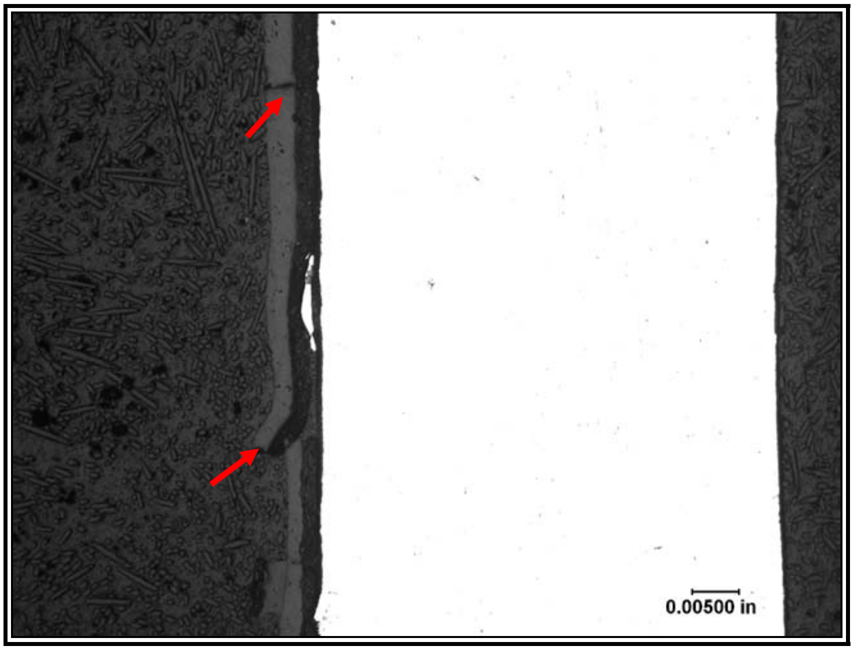
As polished Magnification: 10X

Figure 20: Photomicrograph of the failed tube sample's section showing the areas with lack of braze coverage (arrows)

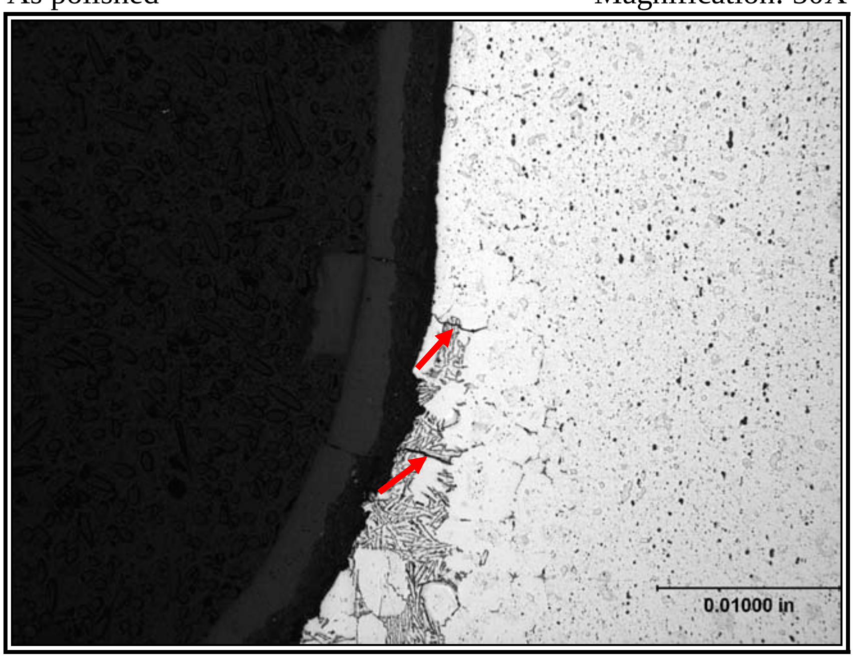


As polished Magnification: 10X

Figure 21: Photomicrograph of the intact tube sample's section showing the areas with lack of braze coverage (arrows)



As polished Magnification: 50X



As polished Magnification: 100X

Figure 22: Photomicrographs of the intact tube sample's section showing the paint cracking (top, arrows) and some cracks in the braze fillet, aligned with paint cracking (bottom, arrows)

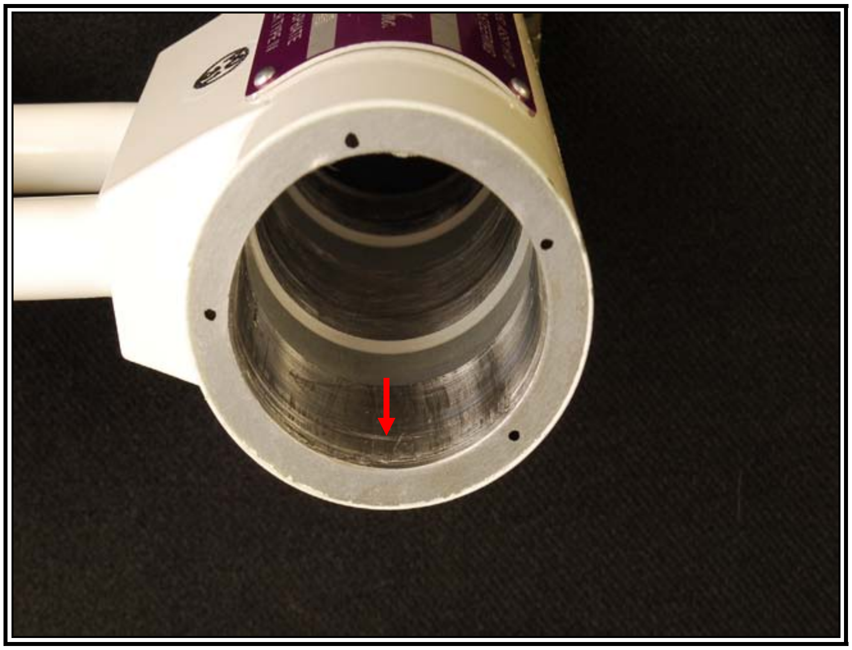


Figure 23: Photographs of the center housing outboard side showing wear (arrows)

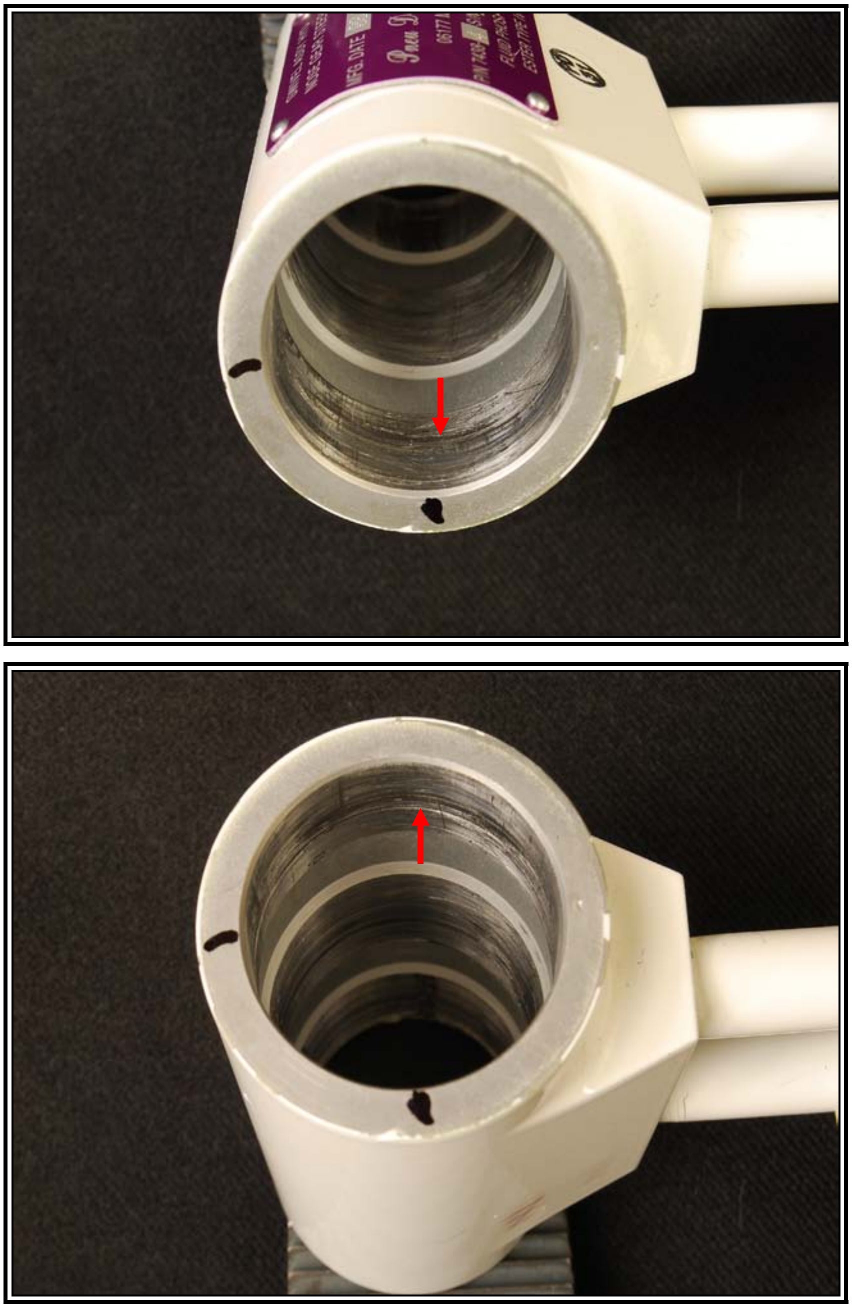


Figure 24: Photographs of the center housing inboard side showing wear (arrows)

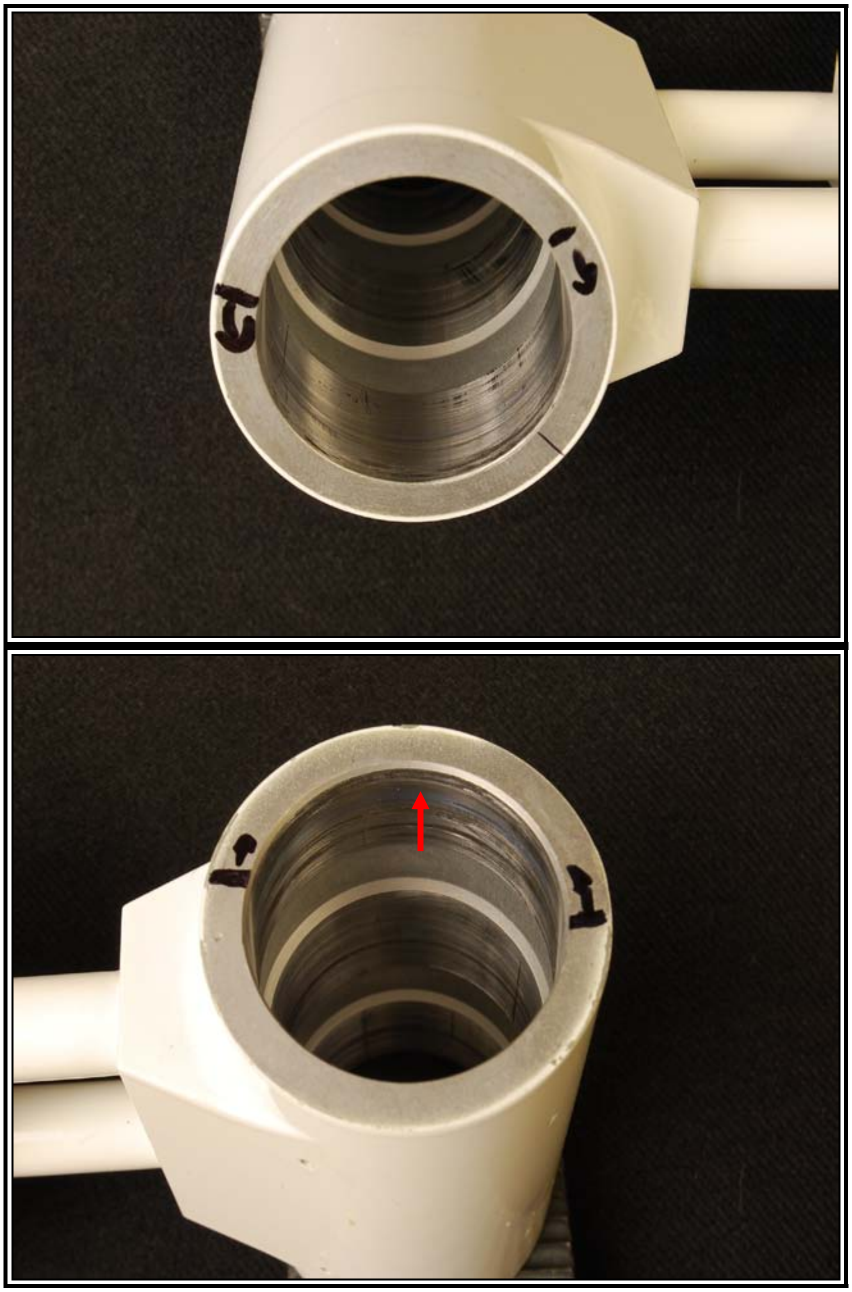


Figure 25: Photographs of the aft housing outboard side showing wear (arrow)

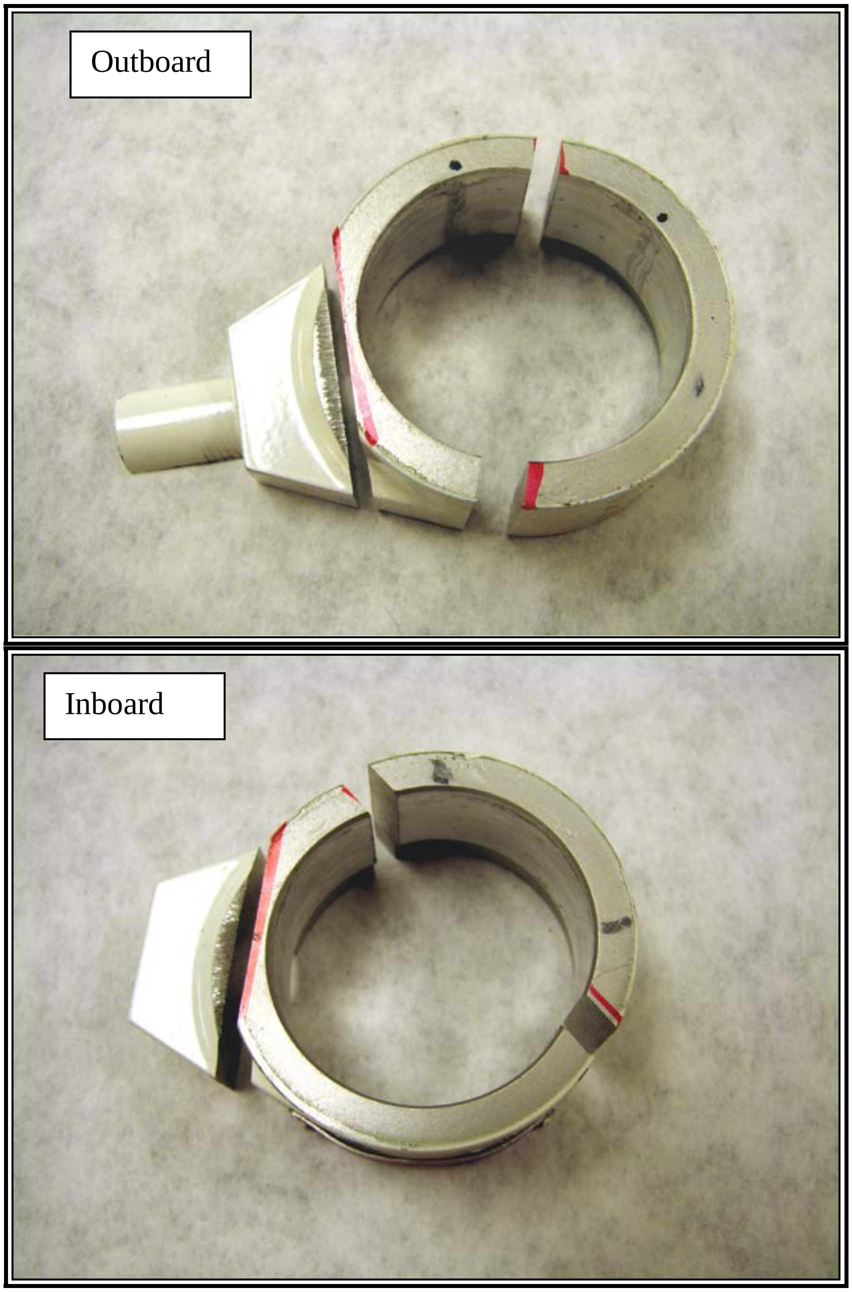


Figure 26: Photographs of the center housing sectioned for analyses

1 inch per grid

Figure 27: Photographs of the aft (top) and forward (bottom) housings sectioned for analyses

1 inch per grid

Figure 28: Photograph of the sectioned center (left) and the forward (right) spools showing wear (arrows)

Figure 29: Photograph of the sectioned aft spool showing wear (arrow)

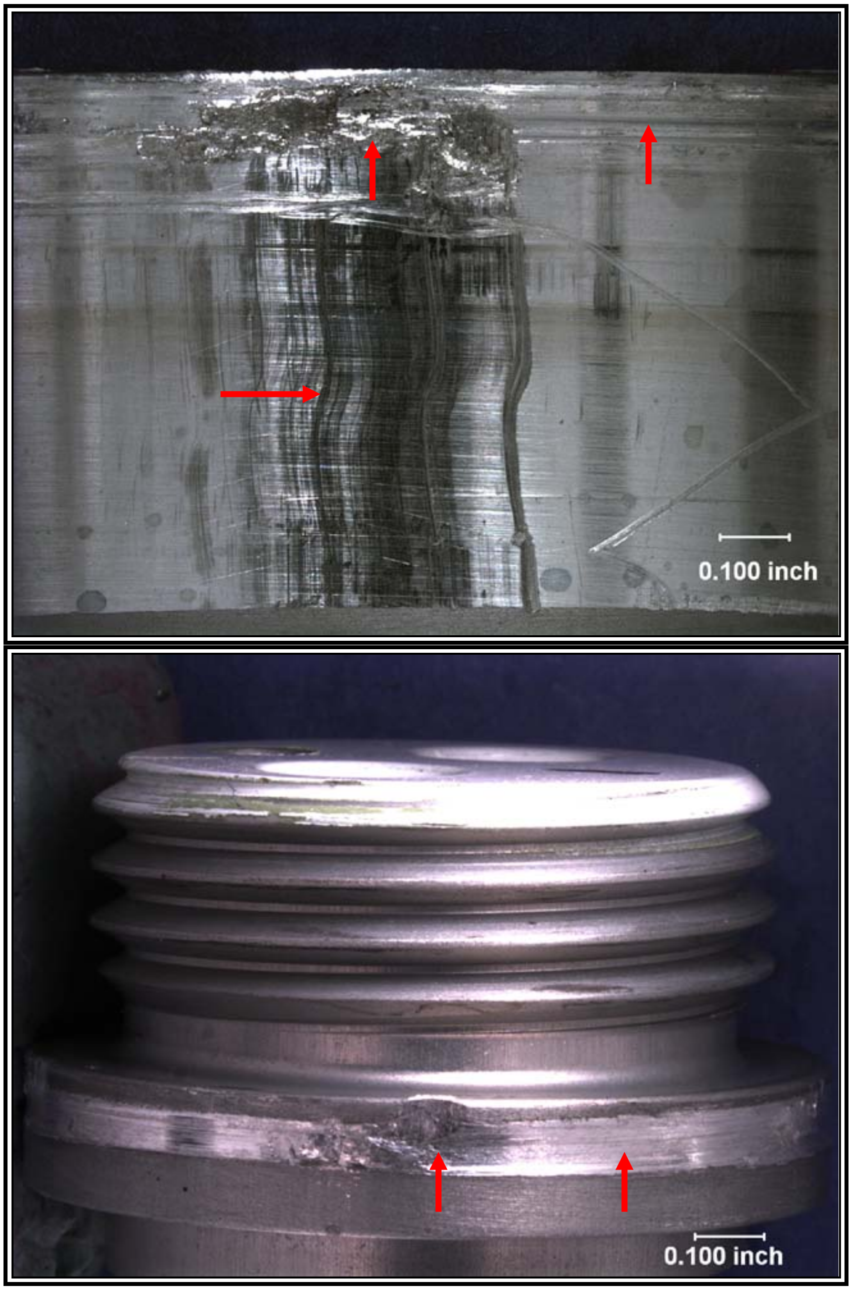


Figure 30: Photomacrographs (4X magnification) of the center housing (top) and the spool (bottom) showing severe wear (arrows)

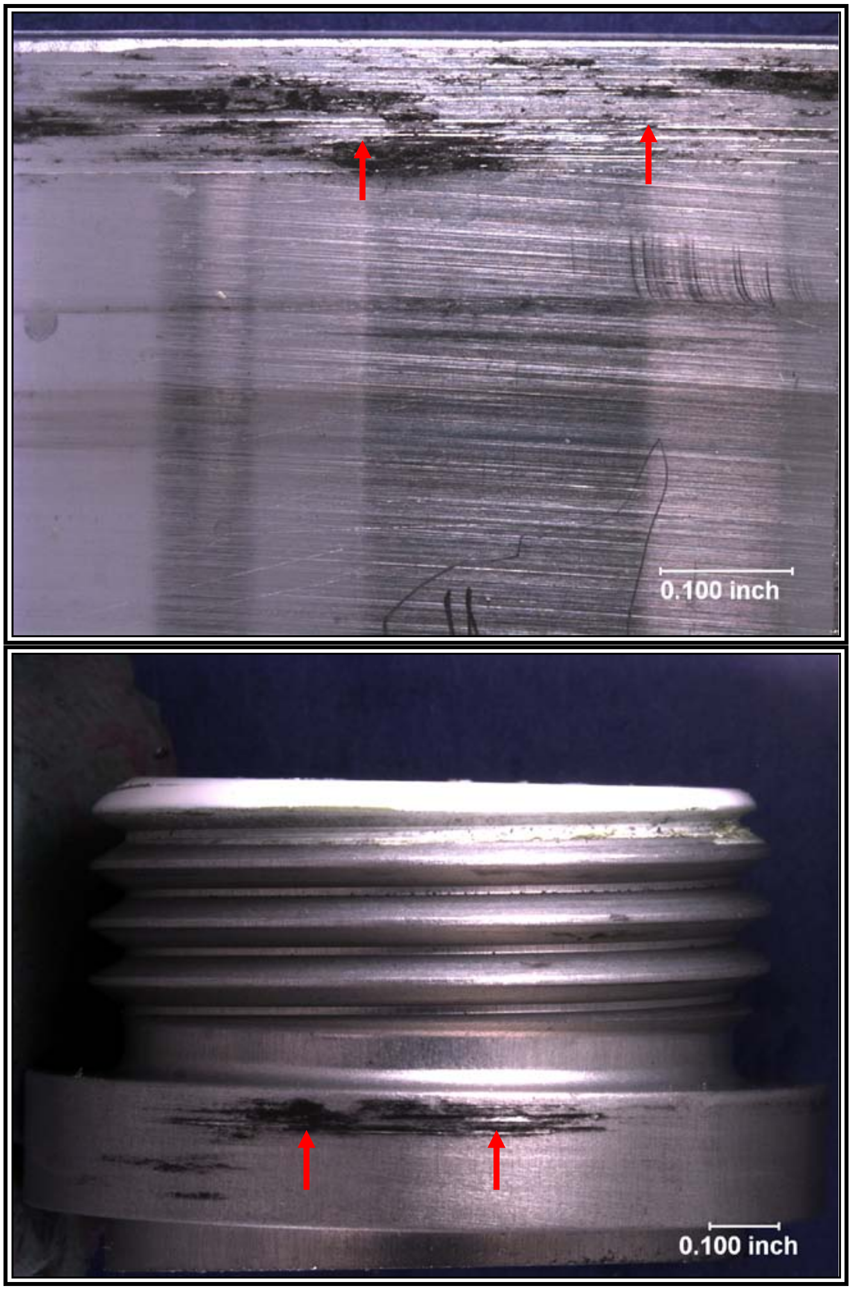


Figure 31: Photomacrographs (4X magnification) of the forward housing (top) and the spool (bottom) showing wear (arrows)

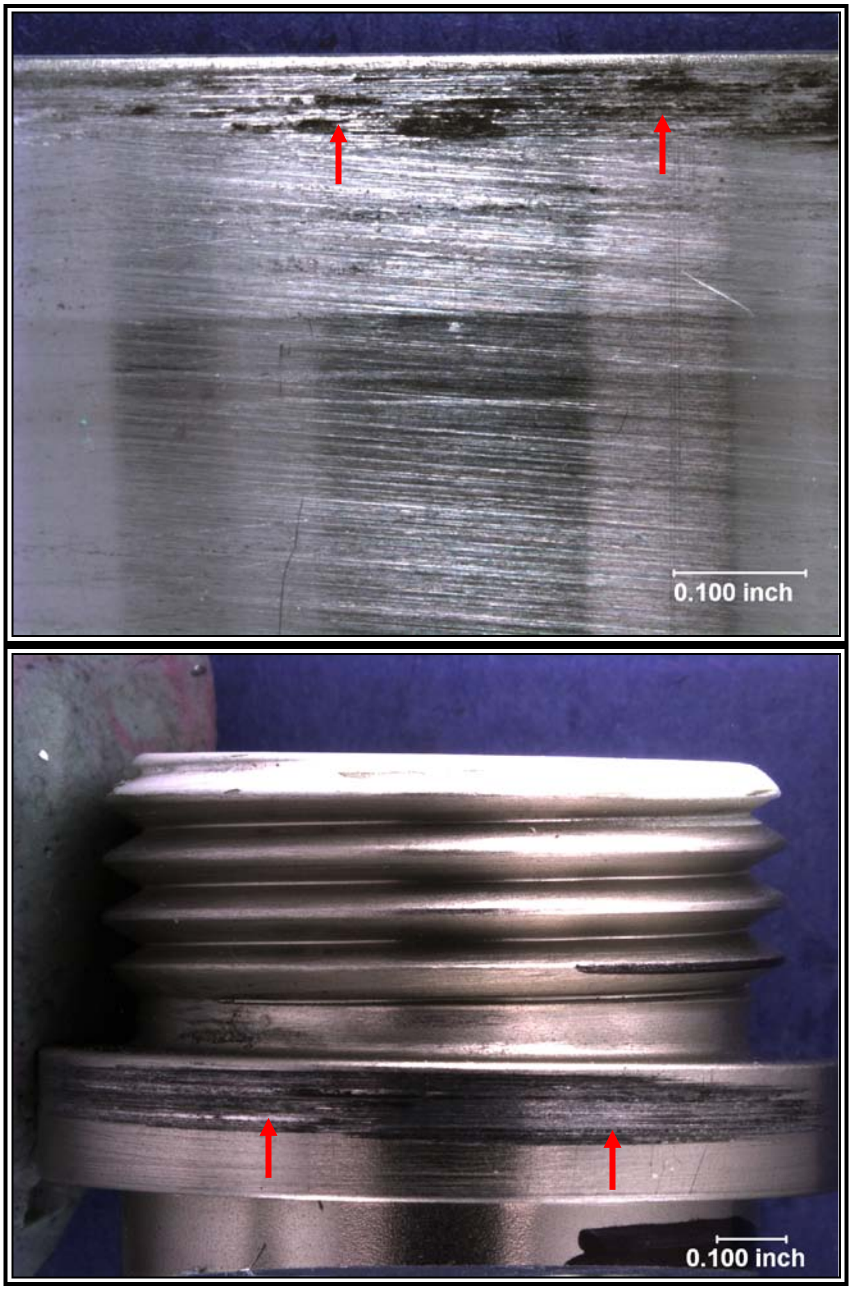


Figure 32: Photomacrographs (4X magnification) of the aft housing (top) and the spool (bottom) showing wear (arrows)

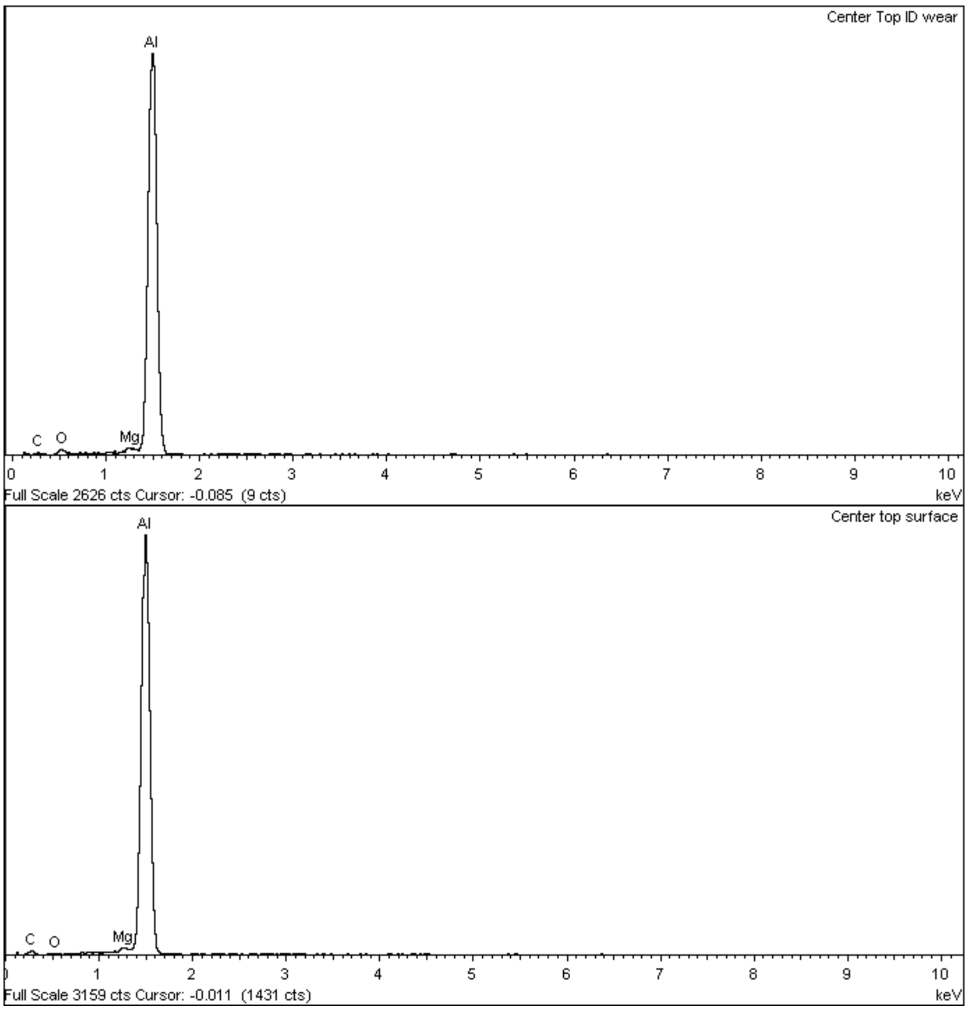


Figure 33: EDS spectra of the center housing worn (top) and the undamaged (bottom) areas

The spectra indicate carbon (C), oxygen (O), magnesium (Mg), and aluminum (Al).

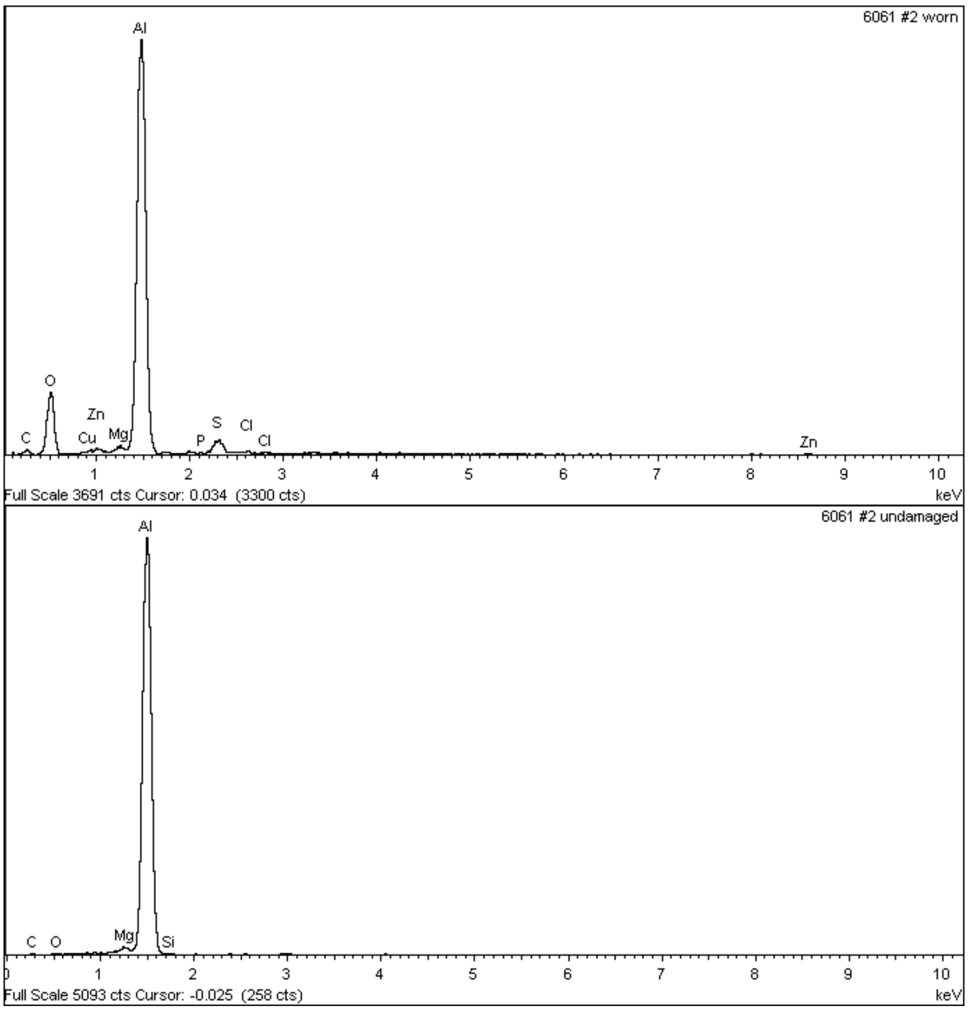


Figure 34: EDS spectra of the aft housing worn (top) and the undamaged (bottom) areas

The spectra indicate carbon (C), oxygen (O), copper (Cu), zinc (Zn), phosphorus (P), sulfur (S), chlorine (Cl), magnesium (Mg), and aluminum (Al).

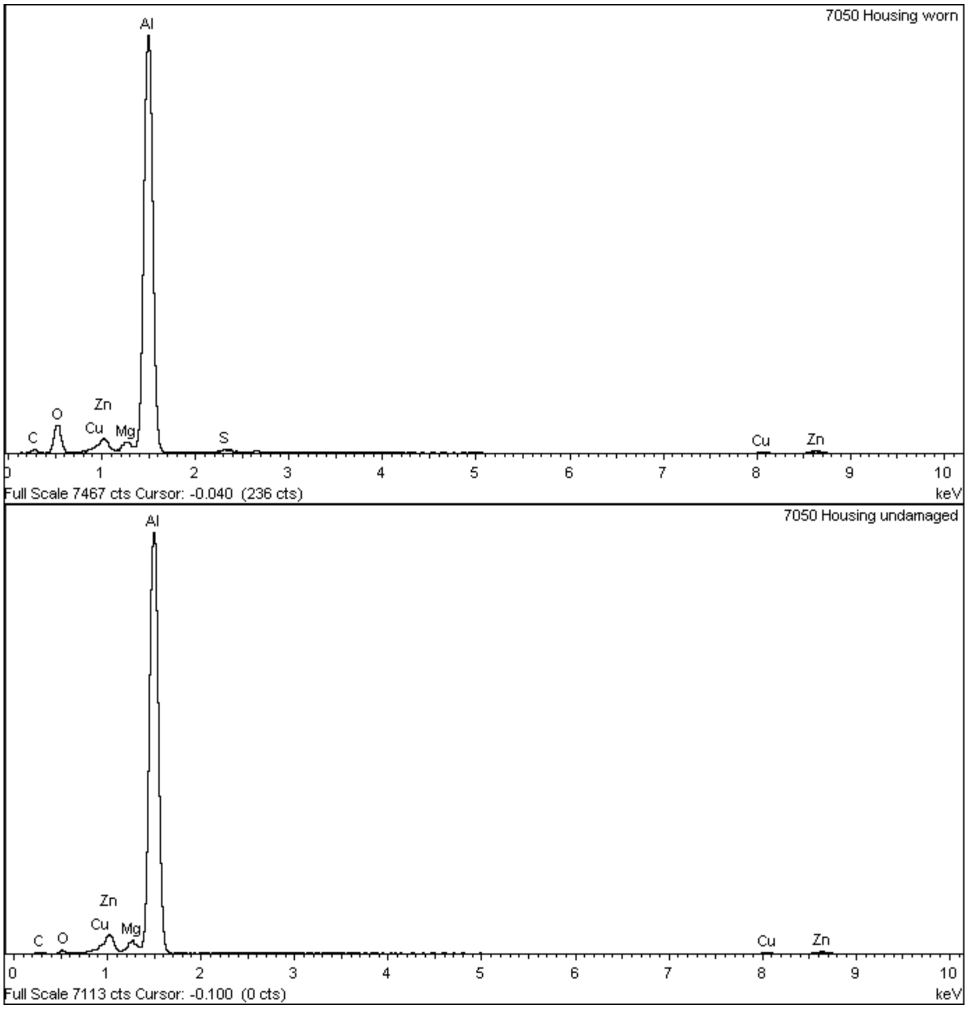


Figure 35: EDS spectra of the forward housing worn (top) and the undamaged (bottom) areas

The spectra indicate carbon (C), oxygen (O), copper (Cu), zinc (Zn), sulfur (S), magnesium (Mg), and aluminum (Al).

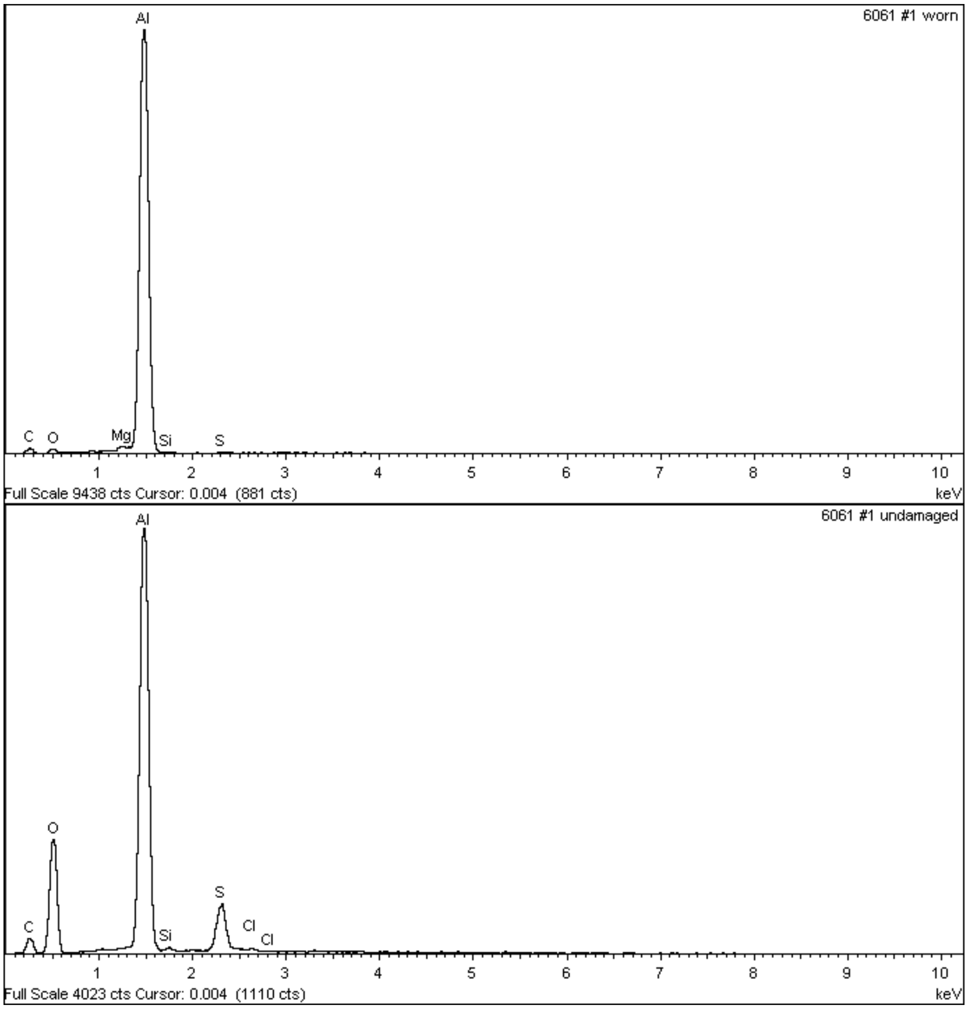


Figure 36: EDS spectra of the center spool worn (top) and the undamaged (bottom) areas

The spectra indicate carbon (C), oxygen (O), silicon (Si), sulfur (S), chlorine (Cl), magnesium (Mg), and aluminum (Al).

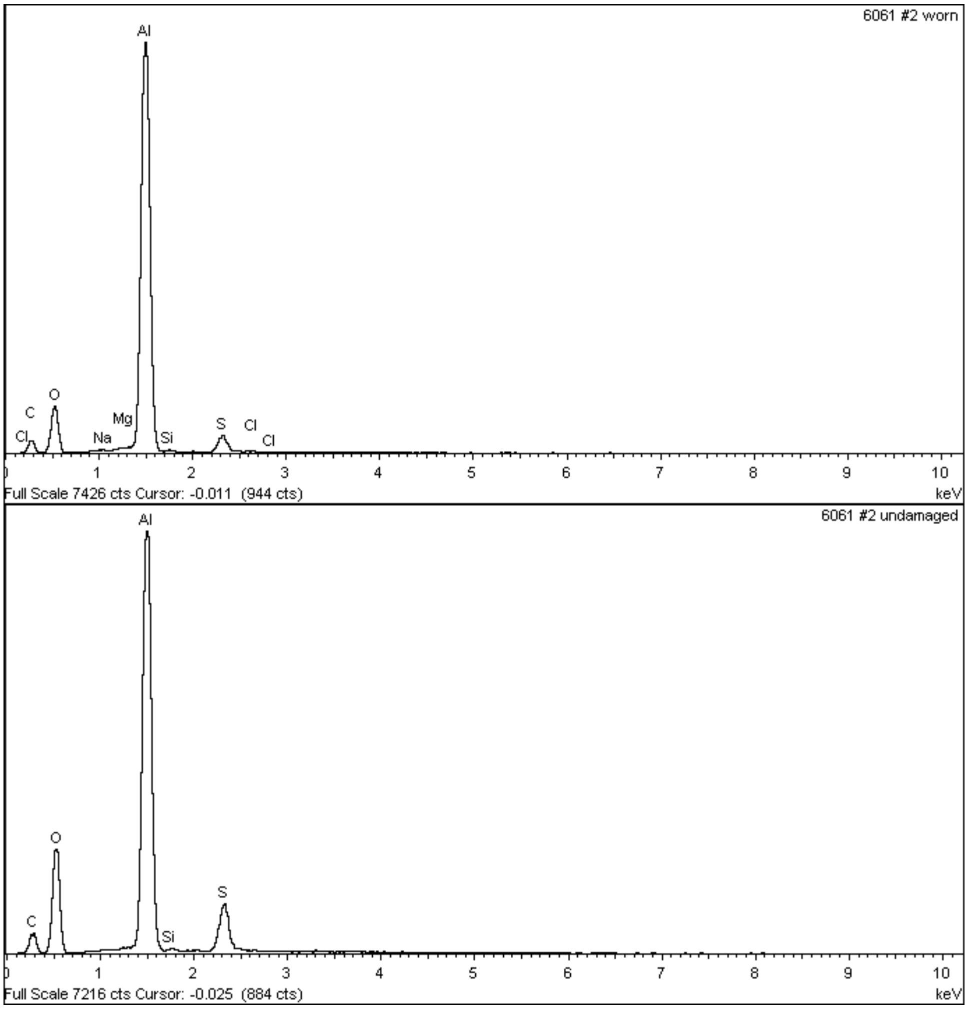


Figure 37: EDS spectra of the forward spool worn (top) and the undamaged (bottom) areas

The spectra indicate carbon (C), oxygen (O), silicon (Si), sulfur (S), chlorine (Cl), sodium (Na), magnesium (Mg), and aluminum (Al).

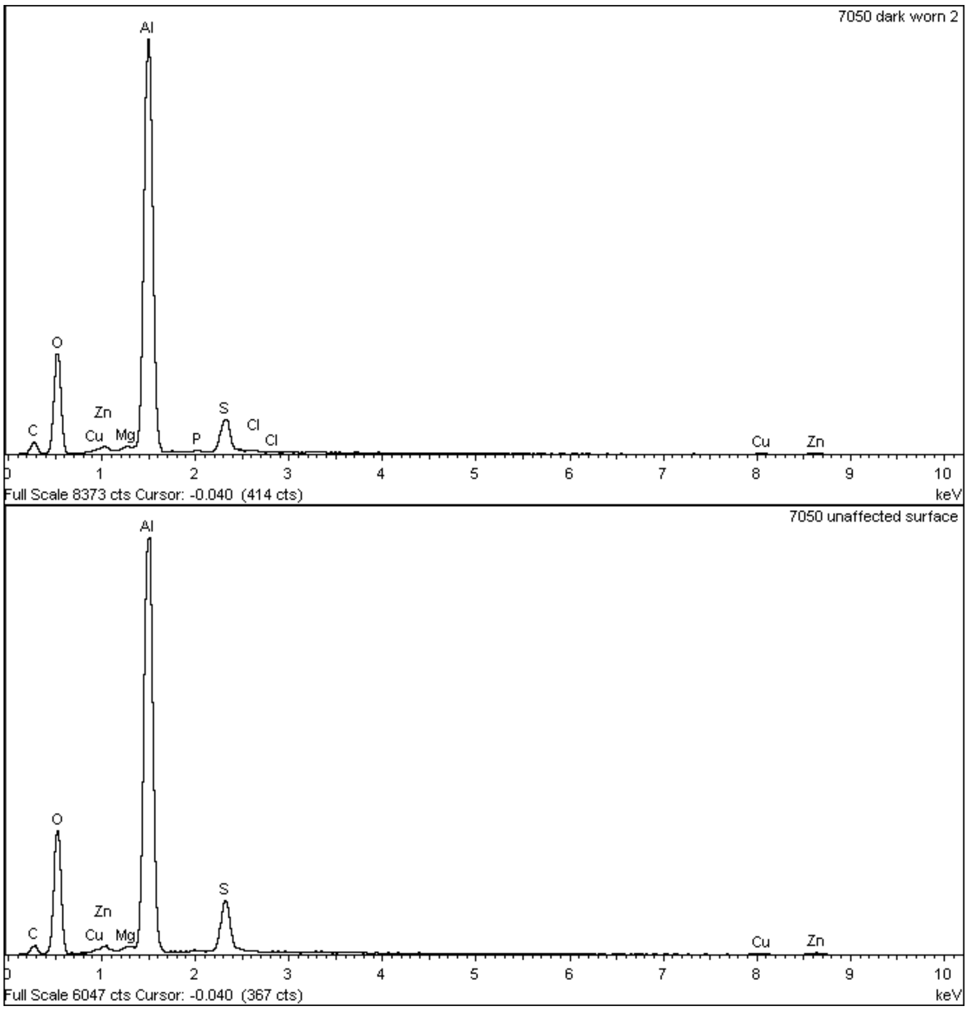


Figure 38: EDS spectra of the aft spool worn (top) and the undamaged (bottom) areas

The spectra indicate carbon (C), oxygen (O), zinc (Zn), copper (Cu), sulfur (S), chlorine (Cl), phosphorus (P), magnesium (Mg), and aluminum (Al).

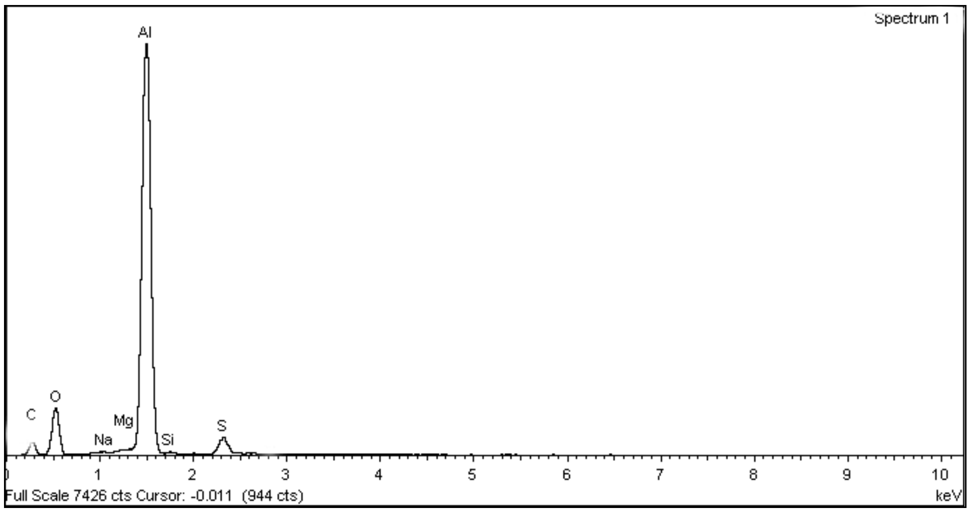
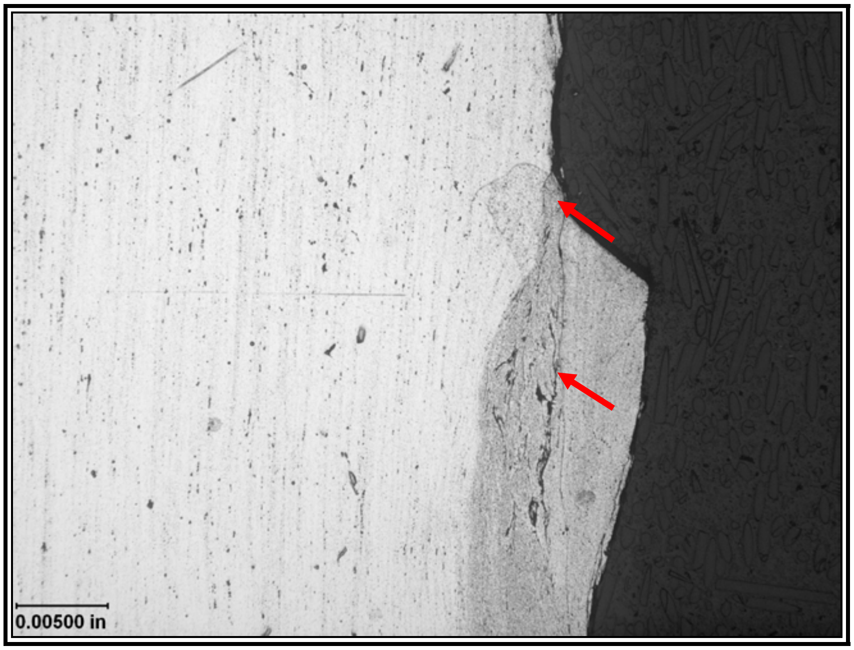


Figure 39: Representative EDS spectrum of a housing recessed area

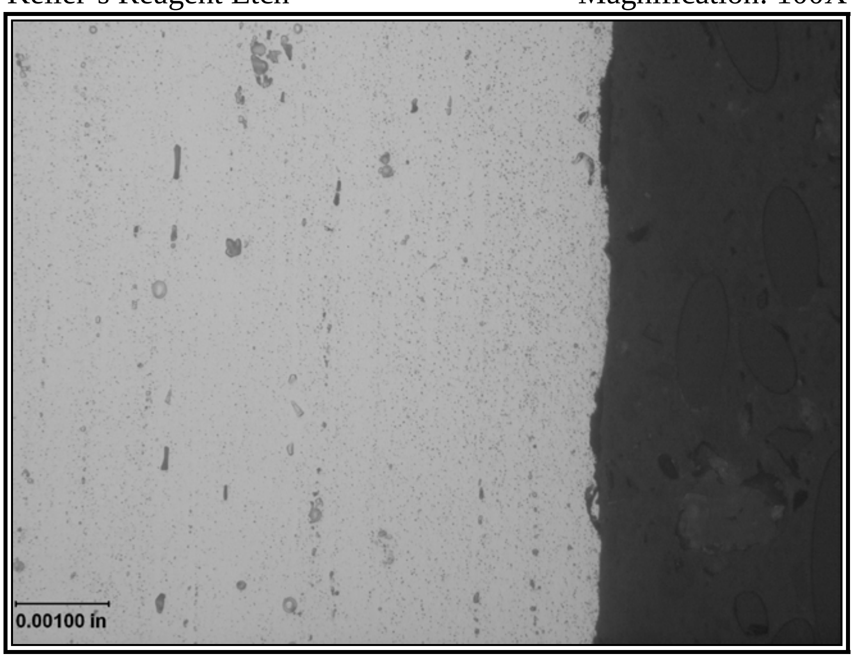
The spectra indicate carbon (C), oxygen (O), sodium (Na), sulfur (S), magnesium (Mg), silicon (Si), and aluminum (Al).

1 inch per grid

Figure 40: Photograph of a representative sectioned housing sample section showing the areas with anodizing (red arrows) and with no anodizing (black arrows) areas

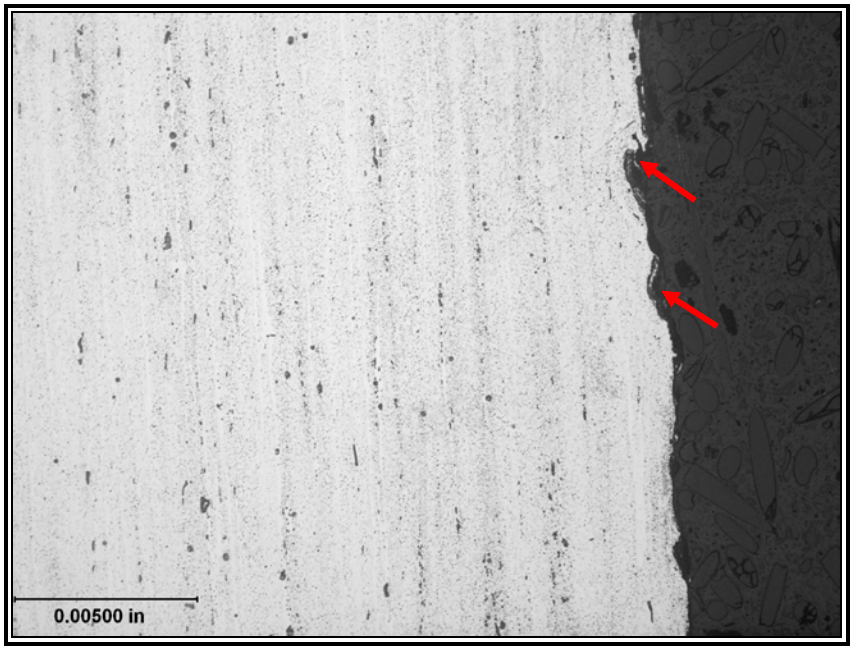


Keller's Reagent Etch Magnification: 100X

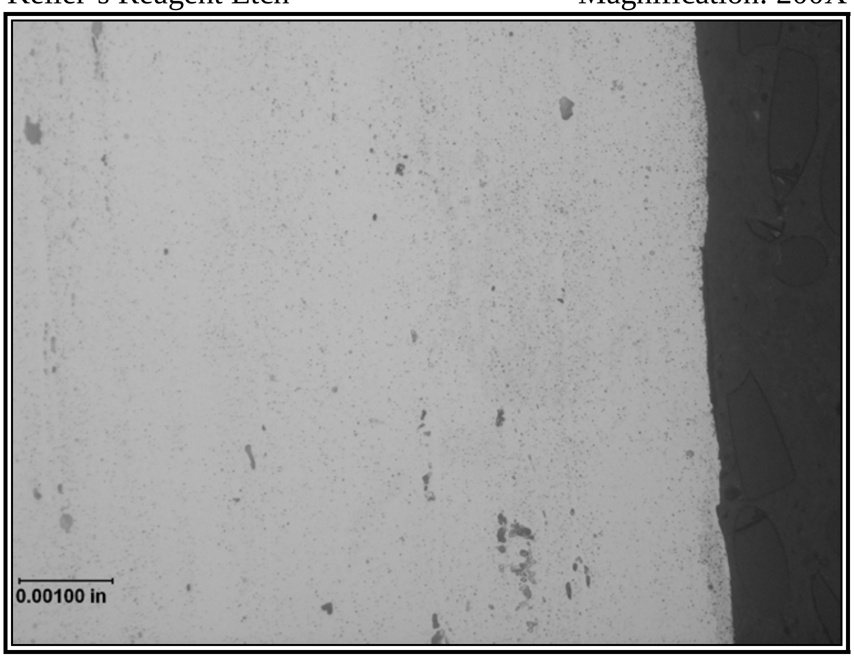


Keller's Reagent Etch Magnification: 500X

Figure 41: Photomicrographs of the center housing sample's section showing the damaged (top, arrows) and unaffected (bottom) areas

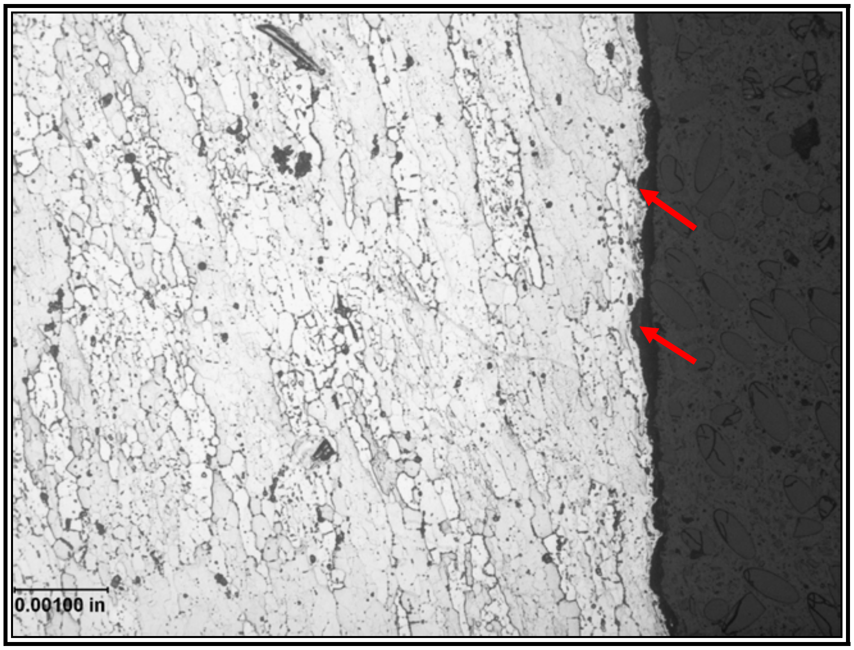


Keller's Reagent Etch Magnification: 200X



Keller's Reagent Etch Magnification: 500X

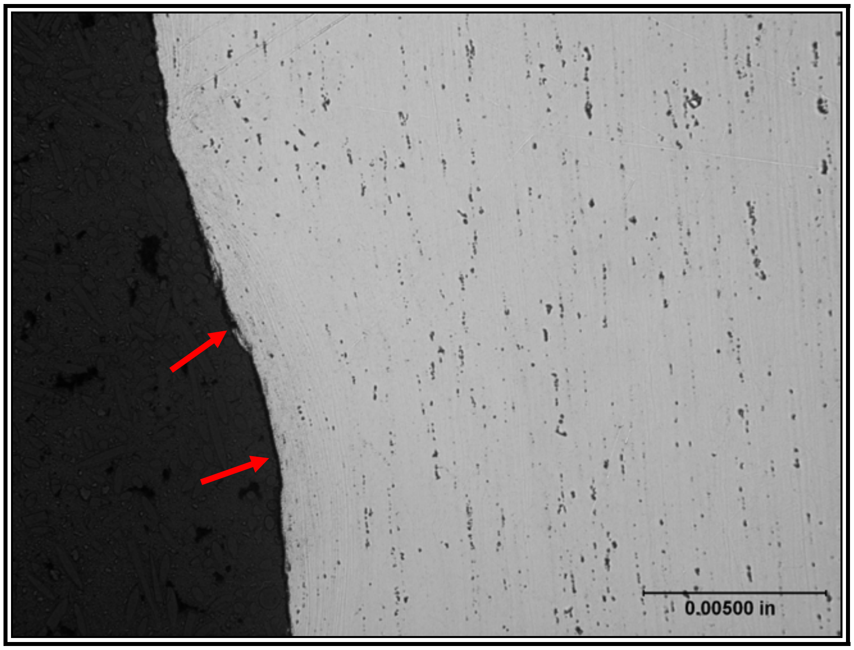
Figure 42: Photomicrographs of the aft housing sample's section showing the damaged (top, arrows) and unaffected (bottom) areas



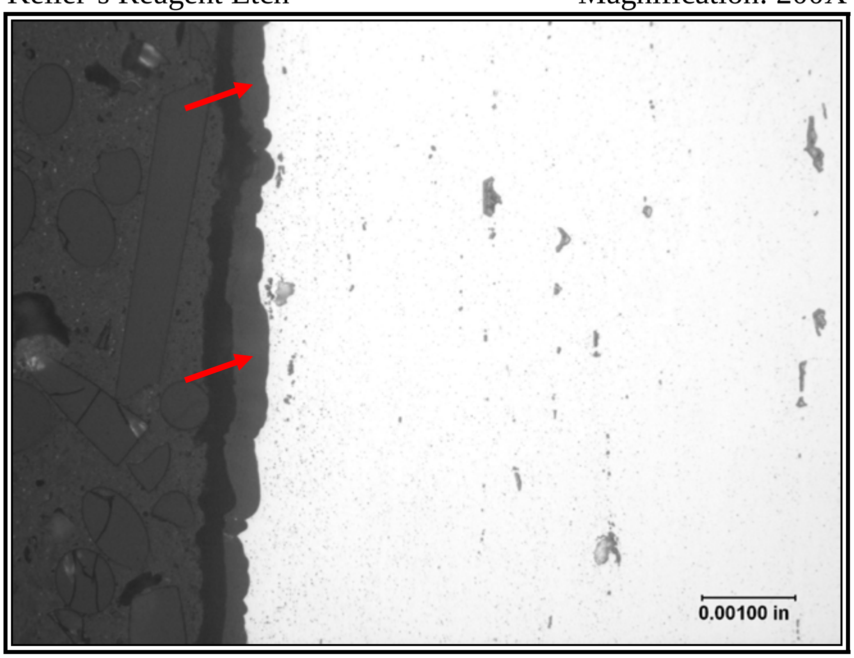
Keller's Reagent Etch Magnification: 500X

Keller's Reagent Etch Magnification: 500X

Figure 43: Photomicrographs of the forward housing sample's section showing the damaged (top, arrows) and unaffected (bottom) areas

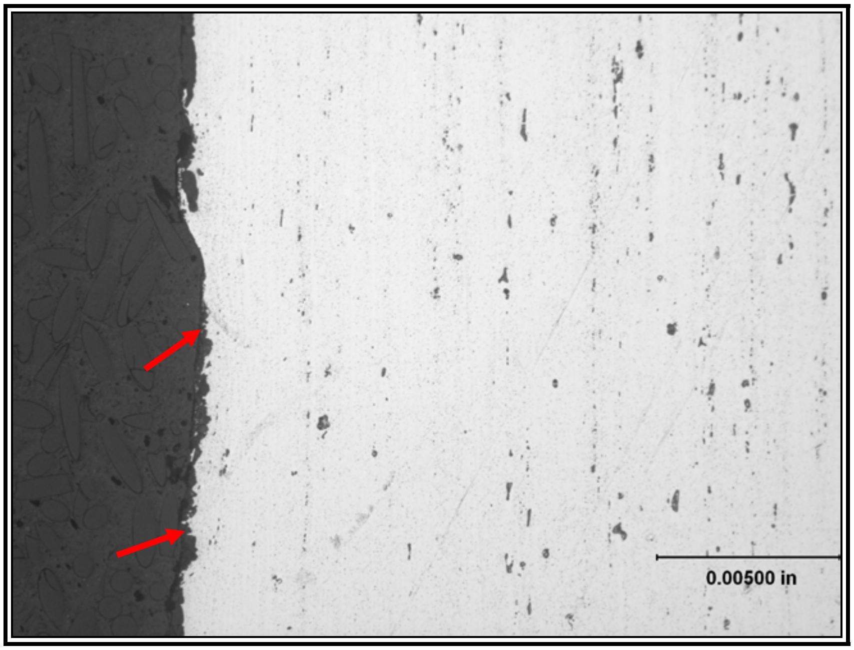


Keller's Reagent Etch Magnification: 200X

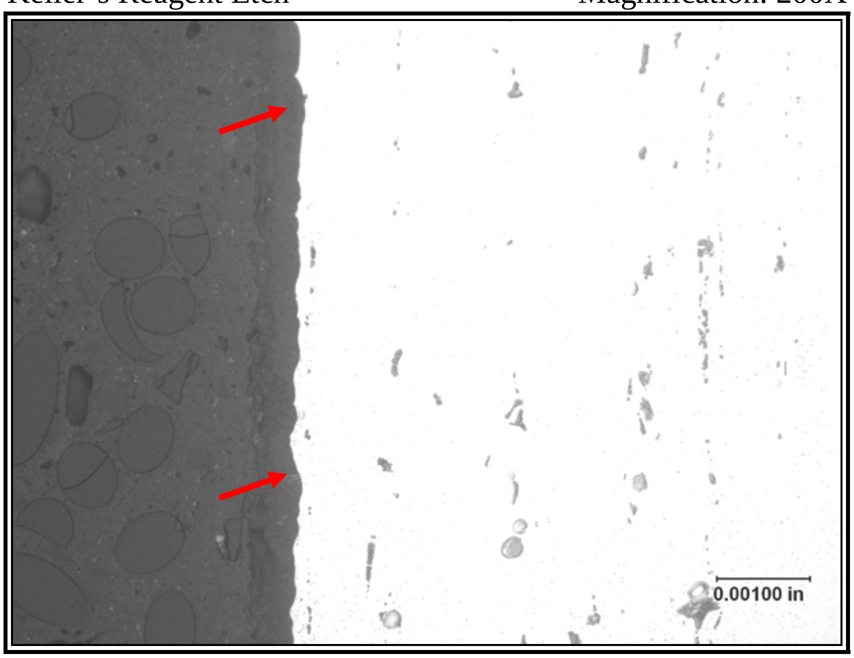


Keller's Reagent Etch Magnification: 500X

Figure 44: Photomicrographs of the center spool sample's section showing the damaged (top, arrows) and unaffected (bottom) areas
Note the anodizing in the unaffected areas (bottom, arrows)

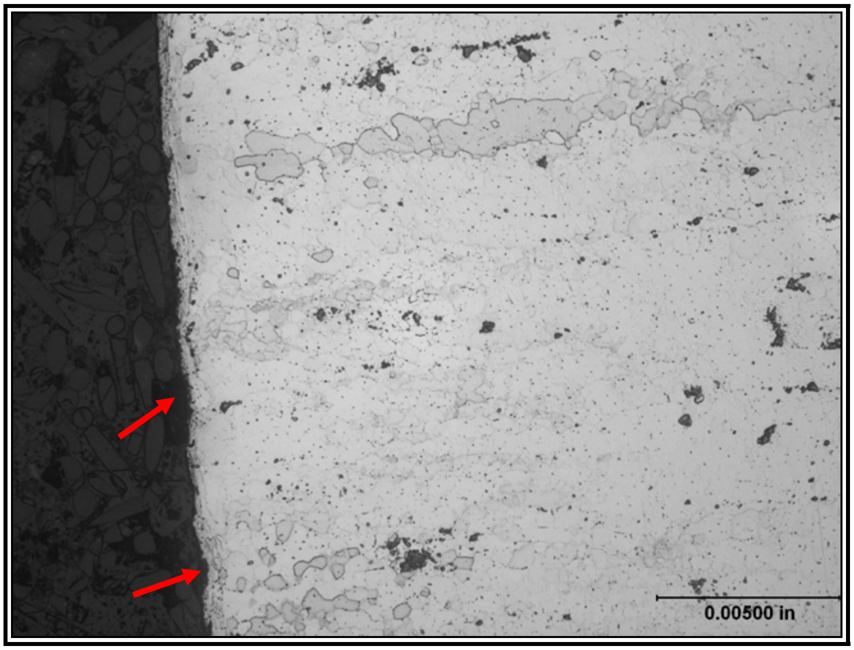


Keller's Reagent Etch Magnification: 200X

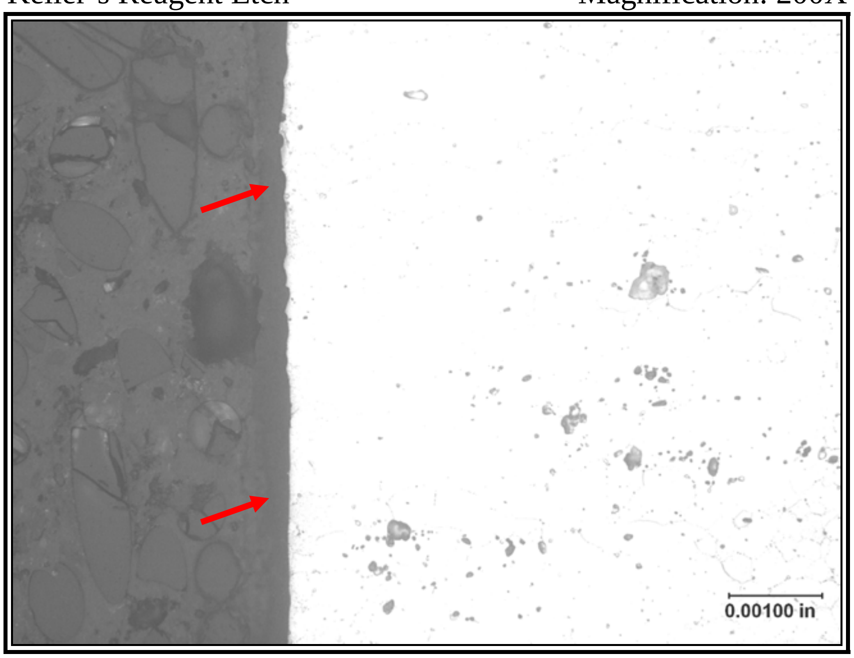


Keller's Reagent Etch Magnification: 500X

Figure 45: Photomicrographs of the forward spool sample's section showing the damaged (top, arrows) and unaffected (bottom) areas
Note the anodizing in the unaffected areas (bottom, arrows)



Keller's Reagent Etch Magnification: 200X



Keller's Reagent Etch Magnification: 500X

Figure 46: Photomicrographs of the aft spool sample's section showing the damaged (top, arrows) and unaffected (bottom) areas
Note the anodizing in the unaffected areas (bottom, arrows)

Figure 47: Photograph of the container with the analyzed particles

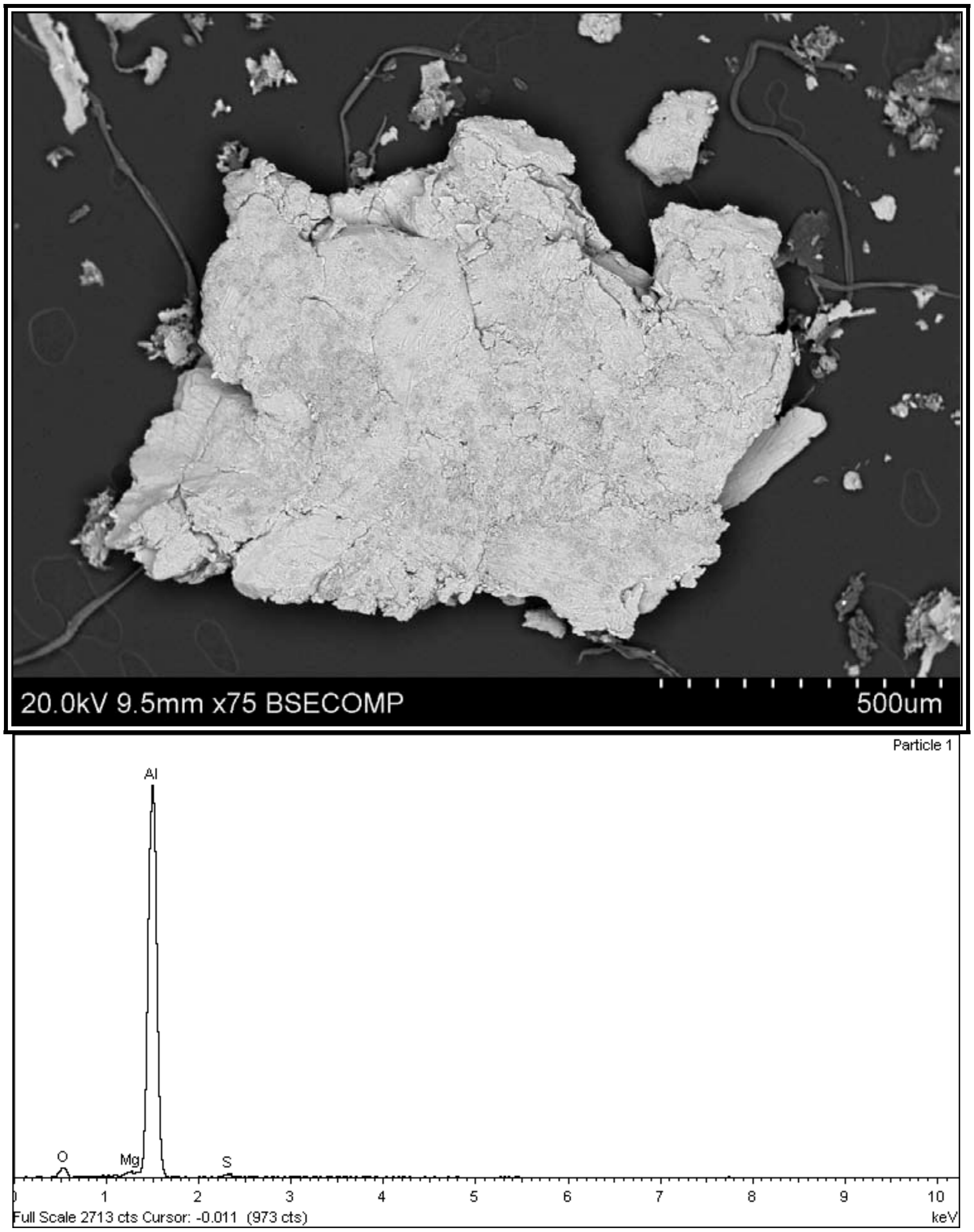


Figure 48: Back-scattered electron image (top) and EDS spectrum (bottom) of a particle

The spectra indicate oxygen (O), sulfur (S), magnesium (Mg), and aluminum (Al).

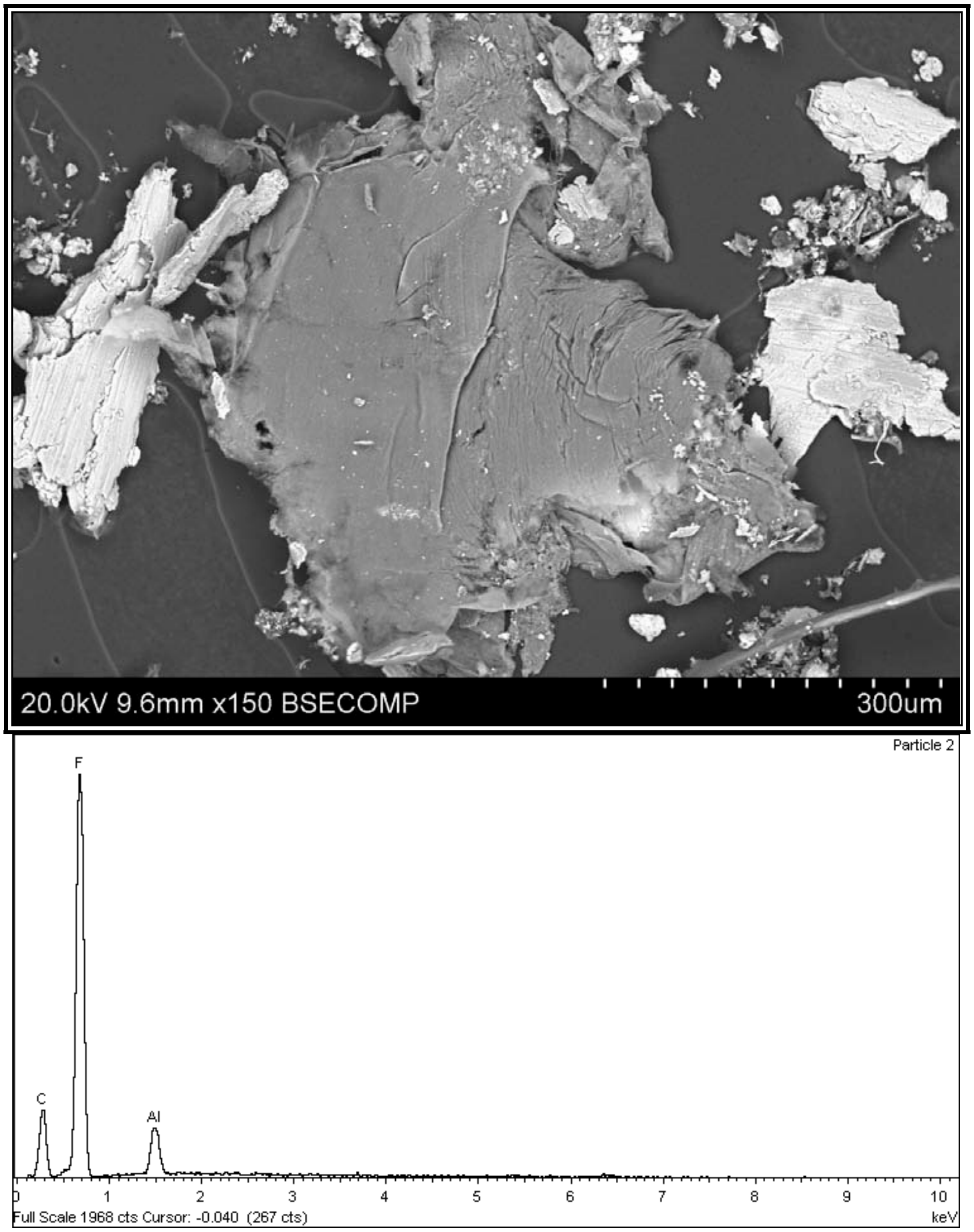


Figure 49: Back-scattered electron image (top) and EDS spectrum (bottom) of a particle

The spectra indicate carbon (C), fluorine (F), and aluminum (Al), consistent with Teflon.

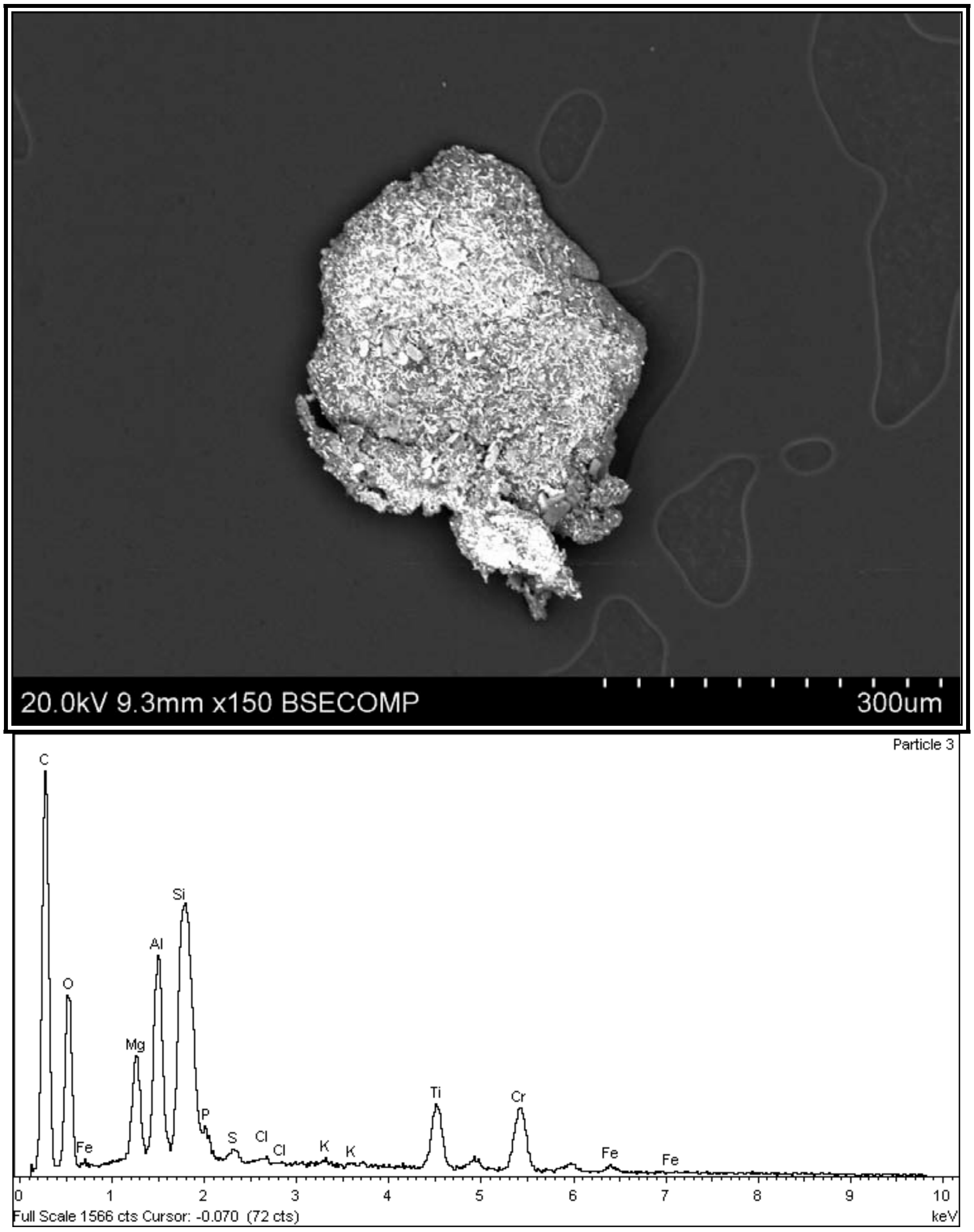


Figure 50: Back-scattered electron image (top) and EDS spectrum (bottom) of a particle
The spectra indicate carbon (C), oxygen (O), iron (Fe), sulfur (S), silicon (Si), phosphorus (P), chlorine (Cl), potassium (K), titanium (Ti), chromium (Cr), magnesium (Mg), and aluminum (Al), consistent with paint and base material.

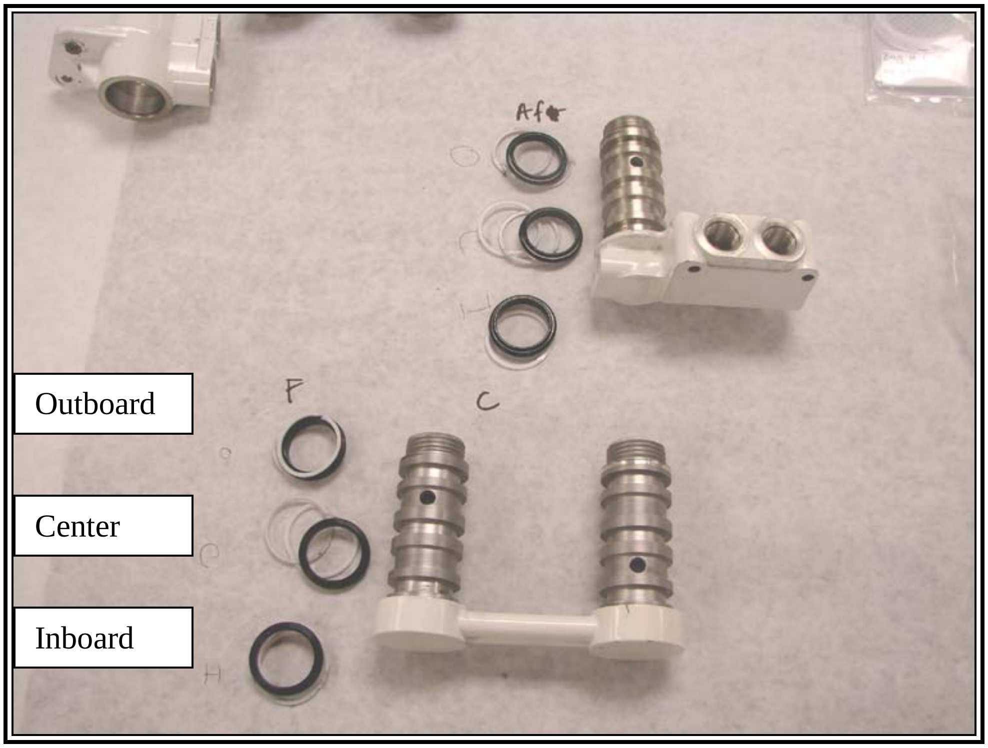


Figure 51: Photograph showing the removed t-seals (black) and backing rings (white)

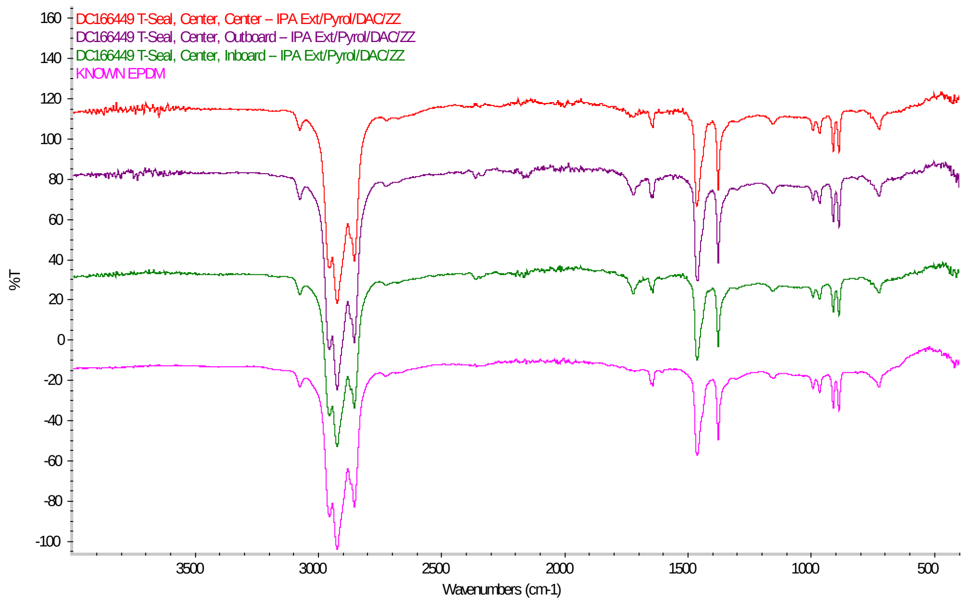


Figure 52: FT-IR spectra of t-seals of the center spool

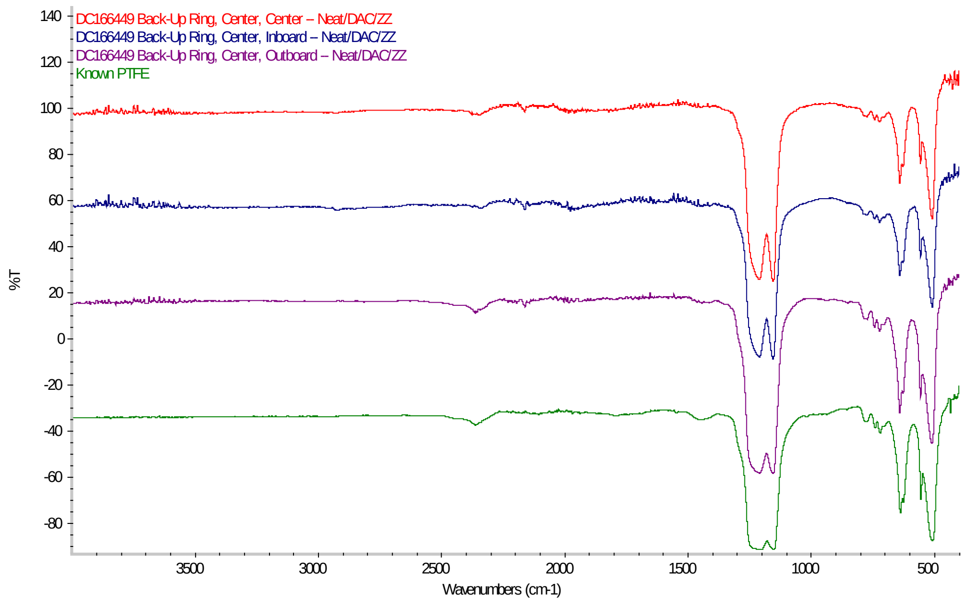


Figure 53: FT-IR spectra of backing rings of the center spool

APPENDIX A

SIGN-IN SHEET (ATTENDEE LIST)

SIGN-IN SHEET

Date: 4-26-2011

ATS Ref. No. D166449

Name	Employer	Associated Law Firm	Represented Party
Walter Young II	Gulfstream Aerospace Co.	—	—
BRANKO STROPNIK	GULFSTREAM AEROSPACE	—	—
JOSE VECIANA	GULFSTREAM	—	—
ED MALINOWSKI	NTSB	—	—
Craig Yates	FAA	—	—
GERRY LOFTIS	PNEU DRAULICS	—	—
Ben Evans	Goodrich	—	—
Gary Wechsler	FAA	—	—

APPENDIX B

DIMENSIONAL DATA AND DRAWINGS

APPLIED TECHNICAL SERVICES, INCORPORATED

1049 Triad Court , Marietta, Georgia 30062 • (770) 423-1400

CERTIFICATE OF INSPECTION

Ref. DM16649 **Date** April 27, 2011 **Page** 1 **of** 1

Purchase Order: TBA

Gulfstream
500 Gulfstream Road
Savannah, GA 31408

Subject

Dimensional Inspection of sub-assemblies; 7438, 72738, 72737, 72749, 73123, 72740 & 72741 per highlighted drawings.

Results

Results are reported on the following pages.

Inspection performed in accordance with ASME Y14.5M-1994. Inspection data is "as found" unless otherwise noted. Applied Technical Services, Inc., certifies that the above named parts have been inspected by comparison to laboratory standards traceable to the National Institute of Standards and Technology. All measurements are based on the International Inch (1.00 Inch = 25.4 mm) and are performed at a measuring temperature of 68°F ± 5° (20°C) and 10% to 65% relative humidity.

Equipment Used

ATS- 0509 CMM Calibration Due: 09-08-2011

Prepared by Tommy Mills
Tommy Mills

	PART NAME : 72738B_72737C	April 27, 2011	09:17
	REV NUMBER : B/C	SER NUMBER :	STATS COUNT : 1

REFERENCE DRAWING 72738 FOR LOCATION OF THE FOLLOWING

SHAFT # 1 DATA

⌖	IN	ITEM 1A - CIRA				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1756	0.0001	0.0000

⌖	IN	ITEM 1B - CIRB				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1753	-0.0002	0.0000

⌖	IN	ITEM 1C - CIRC				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1754	-0.0001	0.0000

⌖	IN	ITEM 1D - CIRD				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1756	0.0001	0.0000

⌖	IN	ITEM 1E - CIRE				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1754	-0.0001	0.0000

⌖	IN	ITME 1F - CIRF				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1752	-0.0003	0.0000

⌖	IN	ITEM 2A - CIR2A				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	0.9340	0.0010	0.0010	0.9341	0.0001	0.0000

⌖	IN	ITME 2B - CIR2B				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	0.9340	0.0010	0.0010	0.9344	0.0004	0.0000

⌖	IN	ITEM 2C - CIR2C				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	0.9340	0.0010	0.0010	0.9343	0.0003	0.0000

◎	IN	ITEM 3A - CIR2A TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0020	0.0000	0.0006	0.0006	0.0000

◎	IN	ITEM 3B - CIR2B TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0020	0.0000	0.0007	0.0007	0.0000

◎	IN	ITEM 3C - CIR2C TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0020	0.0000	0.0006	0.0006	0.0000

↔	IN	ITEM 4 A-B - PNT6 TO PNT5 (ZAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.2400	0.0050	0.0050	0.2382	-0.0018	0.0000

↔	IN	ITEM 4 C-D - PNT4 TO PNT3 (ZAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.2400	0.0050	0.0050	0.2388	-0.0012	0.0000

↔	IN	ITEM 4 E-F - PNT2 TO PNT1 (ZAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.2400	0.0050	0.0050	0.2384	-0.0016	0.0000

SHAFT # 2 DATA

⌖	IN	ITEM_1A - CIR_A				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1757	0.0002	0.0000

⌖	IN	ITEM_1B - CIR_B				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1751	-0.0004	0.0000

⌖	IN	ITEM_1C - CIR_C				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1751	-0.0004	0.0000

⌖	IN	ITEM_1D - CIR_D				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1754	-0.0001	0.0000

⌖	IN	ITEM_1E - CIR_E				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1755	0.0000	0.0000

⌖	IN	ITEM_1F - CIR_F				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1753	-0.0002	0.0000

⌖	IN	ITEM_2A - CIR_2A				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	0.9340	0.0010	0.0010	0.9344	0.0004	0.0000

⌖	IN	ITEM_2B - CIR_2B				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	0.9340	0.0010	0.0010	0.9346	0.0006	0.0000

⌖	IN	ITEM_2C - CIR_2C				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	0.9340	0.0010	0.0010	0.9345	0.0005	0.0000

◎	IN	ITEM_3A - CIR_2A TO CYL2				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0020	0.0000	0.0008	0.0008	0.0000

◎	IN	ITEM_3B - CIR_2B TO CYL2				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0020	0.0000	0.0011	0.0011	0.0000

◎	IN	ITEM_3C - CIR_2C TO CYL2				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0020	0.0000	0.0008	0.0008	0.0000

↔	IN	ITEM_4A - PNT13 TO PNT12 (ZAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.2400	0.0050	0.0050	0.2383	-0.0017	0.0000

↔	IN	ITE_4B - PNT11 TO PNT10 (ZAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.2400	0.0050	0.0050	0.2389	-0.0011	0.0000

↔	IN	ITEM_4C - PNT9 TO PNT8 (ZAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.2400	0.0050	0.0050	0.2388	-0.0012	0.0000

REFERENCE DRAWING 72737 FOR LOCATION OF THE FOLLOWING

↔	IN	ITEM 5_A - CIR_A TO CIRA (YAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	3.3750	0.0200	0.0200	3.3737	-0.0013	0.0000

↔	IN	ITEM 5_B - CIR_B TO CIRB (YAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	3.3750	0.0200	0.0200	3.3768	0.0018	0.0000

↔	IN	ITEM 5_C - CIR_C TO CIRC (YAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	3.3750	0.0200	0.0200	3.3806	0.0056	0.0000

↔	IN	ITEM 5_D - CIR_D TO CIRD (YAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	3.3750	0.0200	0.0200	3.3838	0.0088	0.0000

↔	IN	ITEM 5_E - CIR_E TO CIRE (YAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	3.3750	0.0200	0.0200	3.3872	0.0122	0.0000

↔	IN	ITEM 5_F - CIR_F TO CIRF (YAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	3.3750	0.0200	0.0200	3.3897	0.0147	0.0000

//	IN	ITEM 6 - CYL2 TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0400	0	0.0165	0.0165	0.0000

	PART NAME : 72741D / 72740F		November 30, 2011	11:20
	REV NUMBER : D (ATS-2)	SER NUMBER : 0748	STATS COUNT : 1	

BARSTOCK HOUSING 72741 WITH LABEL

⊥	IN	ITEM 1 - PLN3 TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0050	0	0.0004	0.0004	0.0000

⊥	IN	ITEM 2 - PLN2 TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0050	0	0.0011	0.0011	0.0000

↔	IN	ITEM 3 - PNT1 TO PNT2 (XAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	2.4450	0.0000	0.0050	2.4421	-0.0029	0.0000

ITEM 4A,4B,4C REMOVED FROM THIS REPORT AT CUSTOMER REQUEST

◎	IN	ITEM 5 - CYL1 TO CIR8				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0150	0.0000	0.0016	0.0016	0.0000

BARSTOCK HOUSING 72741 WITHOUT LABEL

⊥	IN	ITEM_1 - PLN6 TO CYL2				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0050	0	0.0008	0.0008	0.0000

⊥	IN	ITEM_2 - PLN5 TO CYL2				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0050	0	0.0004	0.0004	0.0000

↔	IN	ITEM_3 - PNT3 TO PNT4 (XAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	2.4450	0.0000	0.0050	2.4424	-0.0026	0.0000

ITEM 4A,4B,4C REMOVED FROM THIS REPORT AT CUSTOMER REQUEST

◎	IN	ITEM _5 - CYL2 TO CIR9				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0150	0.0000	0.0010	0.0010	0.0000

↔	IN	ITEM_1 AT A - CIR2 TO CIR5 (YAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	3.2500	0.0200	0.0200	3.2638	0.0138	0.0000

↔	IN	ITEM_1 AT B - CIR3 TO CIR6 (YAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	3.2500	0.0200	0.0200	3.2737	0.0237	0.0037

↔	IN	ITEM_1 AT C - CIR7 TO CIR4 (YAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	3.2500	0.0200	0.0200	3.2852	0.0352	0.0152

⌖	IN	ITEM 2A RIGHT - CIR4				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1795	0.0005	0.0000

⌖	IN	ITEM 2B RIGHT - CIR3				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1795	0.0005	0.0000

⌖	IN	ITEM 2C RIGHT - CIR2				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1796	0.0006	0.0000

⌖	IN	ITEM 2A LEFT - CIR5				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1794	0.0004	0.0000

⌖	IN	ITEM 2B LEFT - CIR6				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1794	0.0004	0.0000

⌖	IN	ITEM 2C LEFT - CIR7				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1794	0.0004	0.0000

//	IN	ITEM __3 - CYL1 TO CYL2				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0400	0	0.0356	0.0356	0.0000

	PART NAME : 72749	April 26, 2011	11:47
REV NUMBER : E	SER NUMBER : 1	STATS COUNT : 1	

⊥	IN	ITEM 1 - PLN4 TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0050	0	0.0003	0.0003	0.0000

⊥	IN	ITEM 2 - PLN2 TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0050	0	0.0016	0.0016	0.0000

↔	IN	ITEM 3 - PNT1 TO PNT2 (XAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	2.4450	0.0000	0.0050	2.4445	-0.0005	0.0000

⌖	IN	ITEM 4 - PLN3				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
X	1.0950	0.0050	0.0050	1.1028	0.0078	0.0028

⌖	IN	ITEM 5A - CIR4				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1799	0.0009	0.0000

⌖	IN	ITEM 5B - CIR3				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1800	0.0010	0.0000

⌖	IN	ITEM 5C - CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1799	0.0009	0.0000

◎	IN	ITEM 6 - CYL1 TO CIR5				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0150	0.0000	0.0093	0.0093	0.0000

	PART NAME : 73123		April 27, 2011	12:53
	REV NUMBER : B	SER NUMBER :	STATS COUNT : 1	

REFERENCE DRAWING 73123 FOR LOCATION OF THE FOLLOWING...

⌖	IN	ITEM 1A - CIRA				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1765	0.0010	0.0005

⌖	IN	ITEM 1B - CIRB				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1763	0.0008	0.0003

⌖	IN	ITEM 1C - CIRC				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1762	0.0007	0.0002

⌖	IN	ITEM 1D - CIRD				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1762	0.0007	0.0002

⌖	IN	ITEM 1E - CIRE				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1762	0.0007	0.0002

⌖	IN	ITEM 1F - CIRF				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1755	0.0005	0.0005	1.1763	0.0008	0.0003

⌖	IN	ITEM 2A - CIR_A				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	0.9340	0.0010	0.0010	0.9325	-0.0015	0.0005

⌖	IN	ITEM 2B - CIR_B				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	0.9340	0.0010	0.0010	0.9333	-0.0007	0.0000

⌖	IN	ITEM 2C - CIR_C				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	0.9340	0.0010	0.0010	0.9342	0.0002	0.0000

◎	IN	ITEM 3A - CIR_A TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0020	0.0000	0.0006	0.0006	0.0000

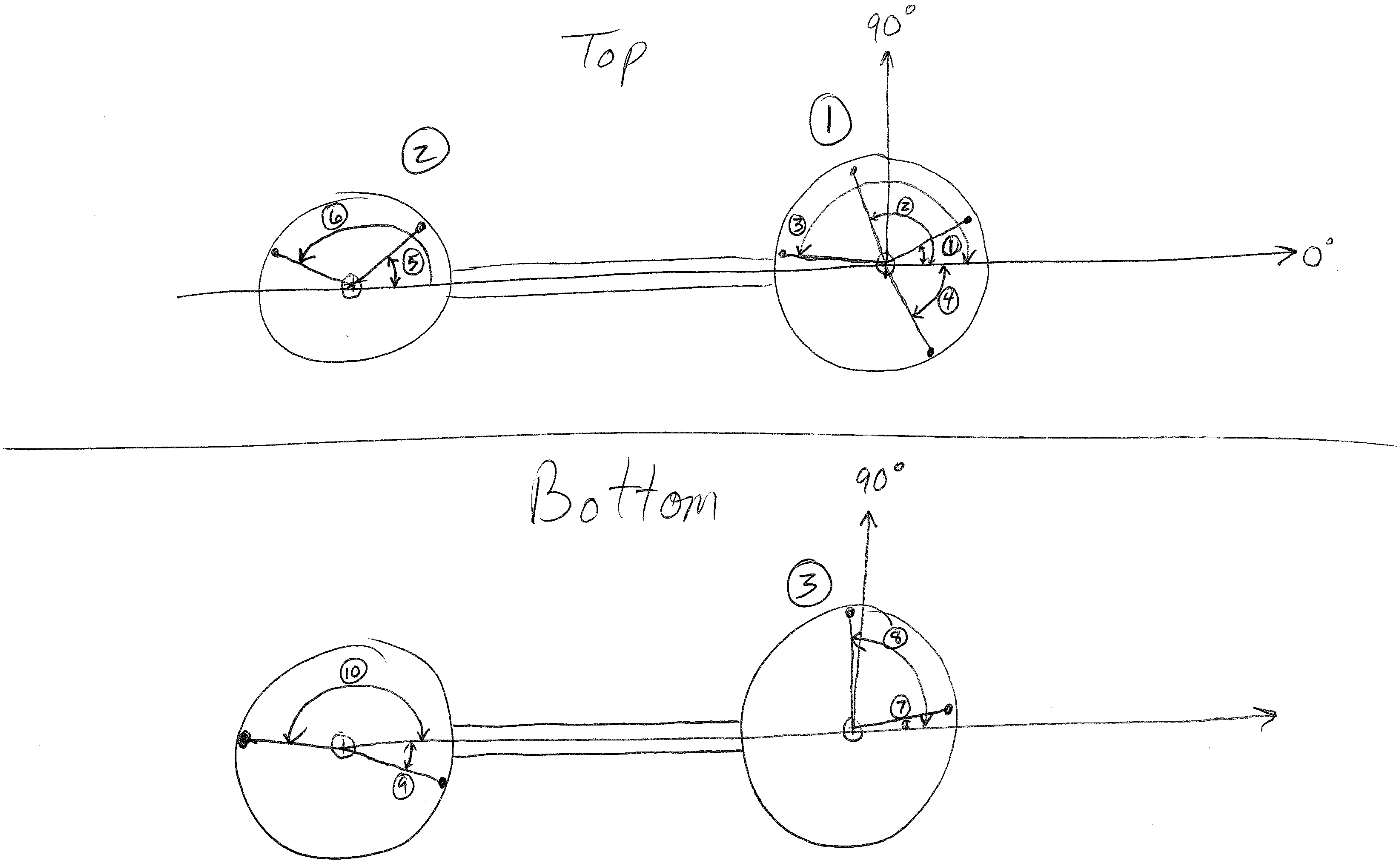
◎	IN	ITEM 3B - CIR_B TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0020	0.0000	0.0003	0.0003	0.0000

◎	IN	ITEM 3C - CIR_C TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0020	0.0000	0.0003	0.0003	0.0000

↔	IN	ITEM 4 A-B - PNT5 TO PNT6 (ZAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.2400	0.0050	0.0050	0.2384	-0.0016	0.0000

↔	IN	ITEM 4 C-D - PNT3 TO PNT4 (ZAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.2400	0.0050	0.0050	0.2387	-0.0013	0.0000

↔	IN	ITEM 4 E-F - PNT1 TO PNT2 (ZAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.2400	0.0050	0.0050	0.2386	-0.0014	0.0000


Top
90°
0°
1
2
1
2
3
4
5
6
Bottom
90°
3
7
8
9
10

THESE ARE ANGLES REQUESTED BY DOTS ON PART

REFERENCE SKETCH FOR LOCATION OF THE FOLLOWING ANGLES

#1

∠	DEG	ANGL1 - LIN1 TO LIN2
AX		MEAS
A		23.727

∠	DEG	ANGL2 - LIN1 TO LIN3
AX		MEAS
A		98.568

∠	DEG	ANGL3 - LIN1 TO LIN4
AX		MEAS
A		175.050

∠	DEG	ANGL4 - LIN1 TO LIN5
AX		MEAS
A		-45.540

#2

∠	DEG	ANGL5 - LIN1 TO LIN6
AX		MEAS
A		35.439

∠	DEG	ANGL6 - LIN1 TO LIN7
AX		MEAS
A		164.777

REFERENCE SKETCH BOTTOM VIEW FOR LOCATION OF THE FOLLOWING ANGLES

#3

⦤	DEG	ANGL7 - LIN8 TO LIN9
AX		MEAS
A		3.946

⦤	DEG	ANGL8 - LIN8 TO LIN10
AX		MEAS
A		93.030

#4

⦤	DEG	ANGL9 - LIN8 TO LIN11
AX		MEAS
A		-14.359

⦤	DEG	ANGL10 - LIN8 TO LIN12
AX		MEAS
A		175.497

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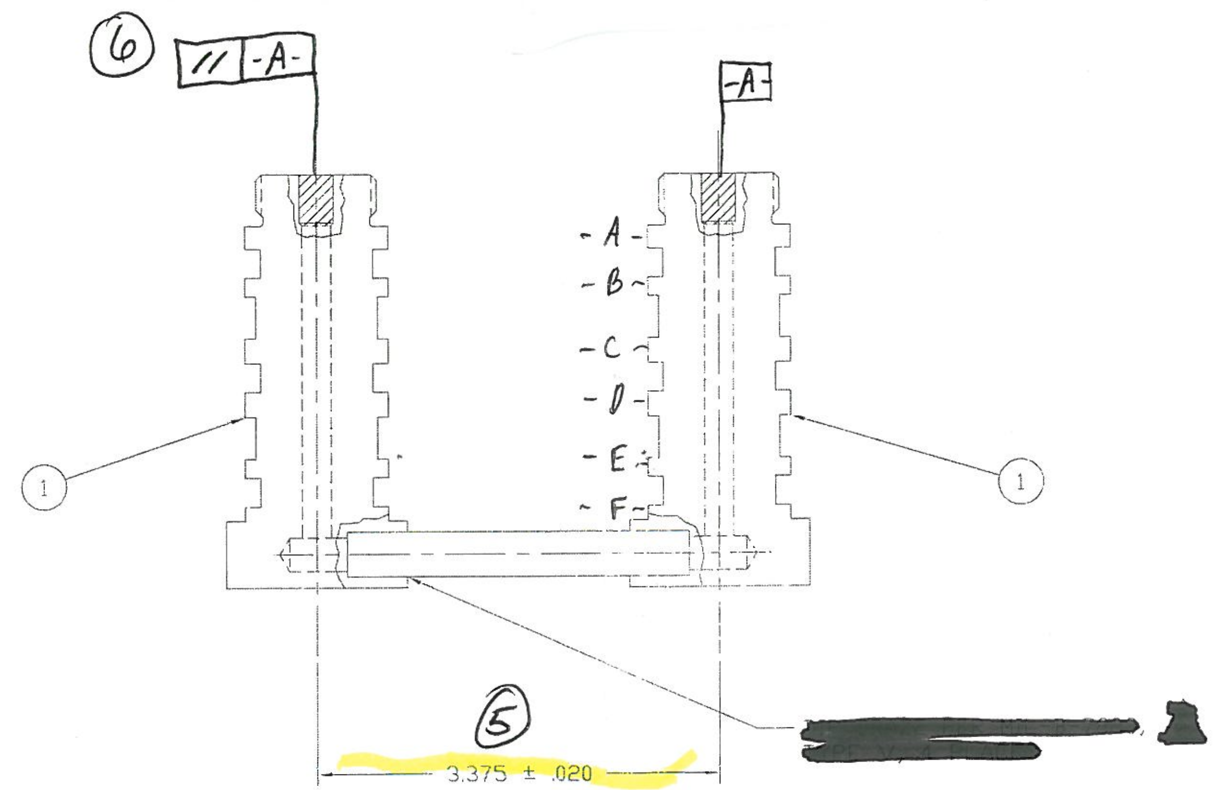
REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	SEE DCN 13599	8/1/95	WSJ
	B	SEE DCN 16031	5/23/01	CW
	C	SEE DCN 19280	8/21/08	MS



QTY REQD	FIND NO.	PART OR IDENTIFYING NUMBER	DESCRIPTION OR NOMENCLATURE	MATERIAL/SPEC	HEAT TREAT	FINISH
4	4	PLGA2811010	PIN PLUG	THE LEE CO		
	3					△
2	2	72739	CONNECTING TUBE	D6061-T6 AL ALY		△
2	1	72738	SHAFT	6061-T651 AL ALY		

LIST OF MATERIALS OR PARTS LIST

REQ	NEXT ASSY	USED ON
1		7438-3

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES

TOLERANCES ON
.X ±
.XX ± .01
.XXX ± .005
ANGLES ± 0° 30'

SYMBOLS ANSI-Y14.5
STRAIGHTNESS
FLATNESS
ANGULARITY
PERPENDICULARITY
PARALLELISM
POSITION
CONCENTRICITY

DIMS TO BE MET AFTER PLATING
BREAK SHARP EDGES .005/.010
125 MACHINE SURFACES
.015/.035 MACHINED FILLETS
SURFACE SYMBOL PER ANSI-B46.1
THREADS PER HANDBOOK H-28

DRAWN	JEFFERSON	3/10/95
CHECKED		
PROJECT ENGINEER		
CONTRACT NO.		
DESIGN ACTIVITY APPROVAL	C. WHEELER	4/10/95

Pneu Draulics Inc. 8575 HELMS AVENUE RANCHO CUCAMONGA, CA

SHAFT ASSEMBLY

SIZE	FSCM NO.	
C	06177	72737
SCALE 1/1	WEIGHT	SHEET 1 OF 1

72737 C

prtd. 04/06/2011. Verify current revision on CRADL prior to use.

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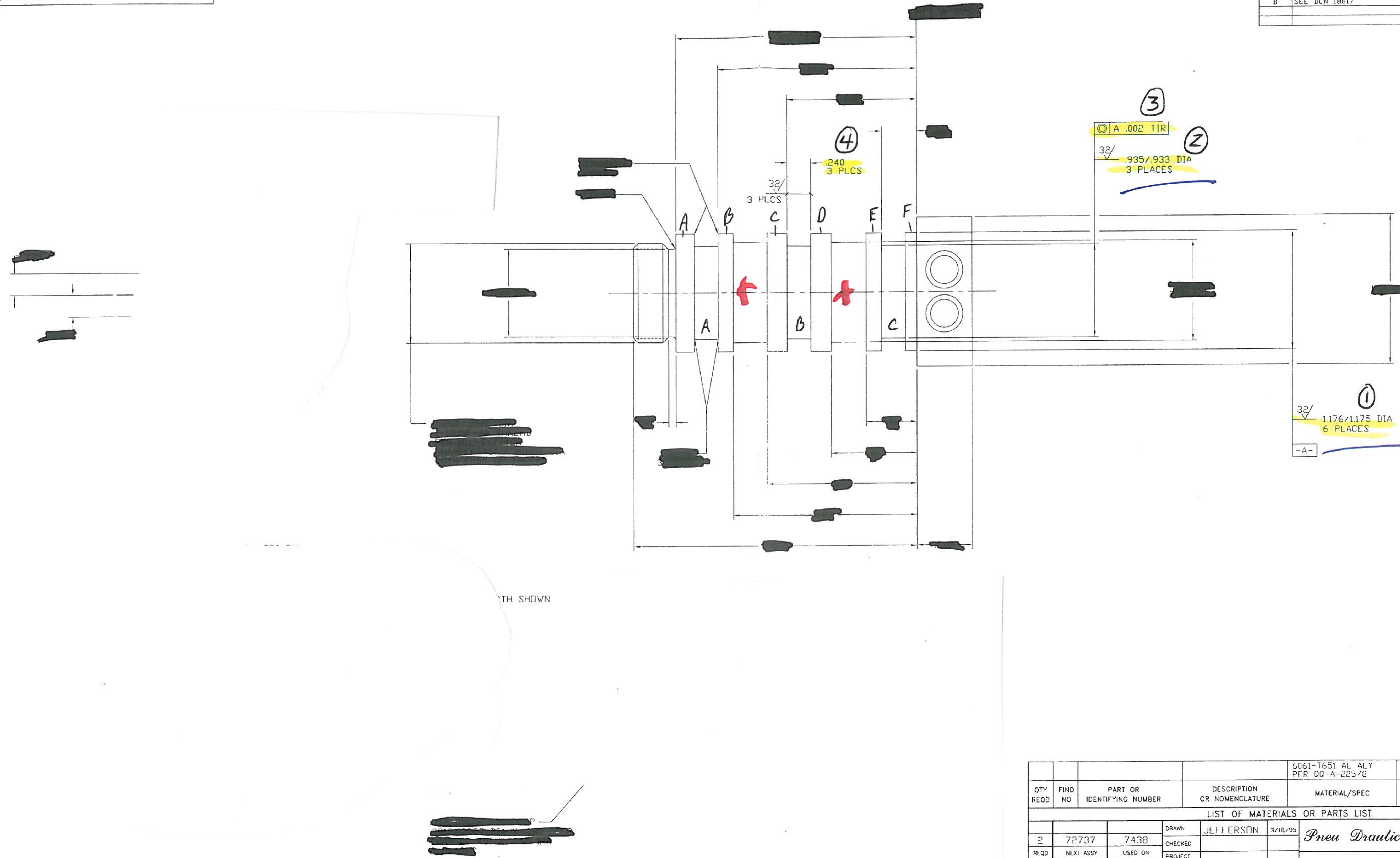
REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	SEE DCN 13810	2/9/96	WSJ
	B	SEE DCN 18617	5-3-07	TRUJILLO



[redacted]

SECTION B-B

QTY REQD	FIND NO	PART OR IDENTIFYING NUMBER	DESCRIPTION OR NOMENCLATURE	MATERIAL/SPEC	HEAT TREAT	FINISH
				6061-T651 AL ALY PER QQ-A-225/8		

LIST OF MATERIALS OR PARTS LIST

REQD	NEXT ASSY	USED ON
2	72737	7438

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES
TOLERANCES ON
.X ±
.XX ± .01
.XXX ± .005
ANGLES ± 0° 30'

SYMBOLS ANSI-Y14.5
— STRAIGHTNESS
▱ FLATNESS
∠ ANGULARITY
⊥ PERPENDICULARITY
// PARALLELISM
⌖ POSITION
◎ CONCENTRICITY

DIMENSIONS TO BE MET AFTER PLATING
BREAK SHARP EDGES .005/.010
125 √ MACHINE SURFACES
.015/.035 MACHINED FILLETS
SURFACE SYMBOL PER ANSI-B46.1
THREADS PER HANDBOOK H-28

DRAWN	JEFFERSON	3/18/95
CHECKED		
PROJECT ENGINEER		
CONTRACT NO		
DESIGN ACTIVITY APPROVAL	C WHEELER	4/10/95

Pneu Draulics Inc — 8575 HELMS AVENUE RANCHO CUCAMONGA, CA

SHAFT

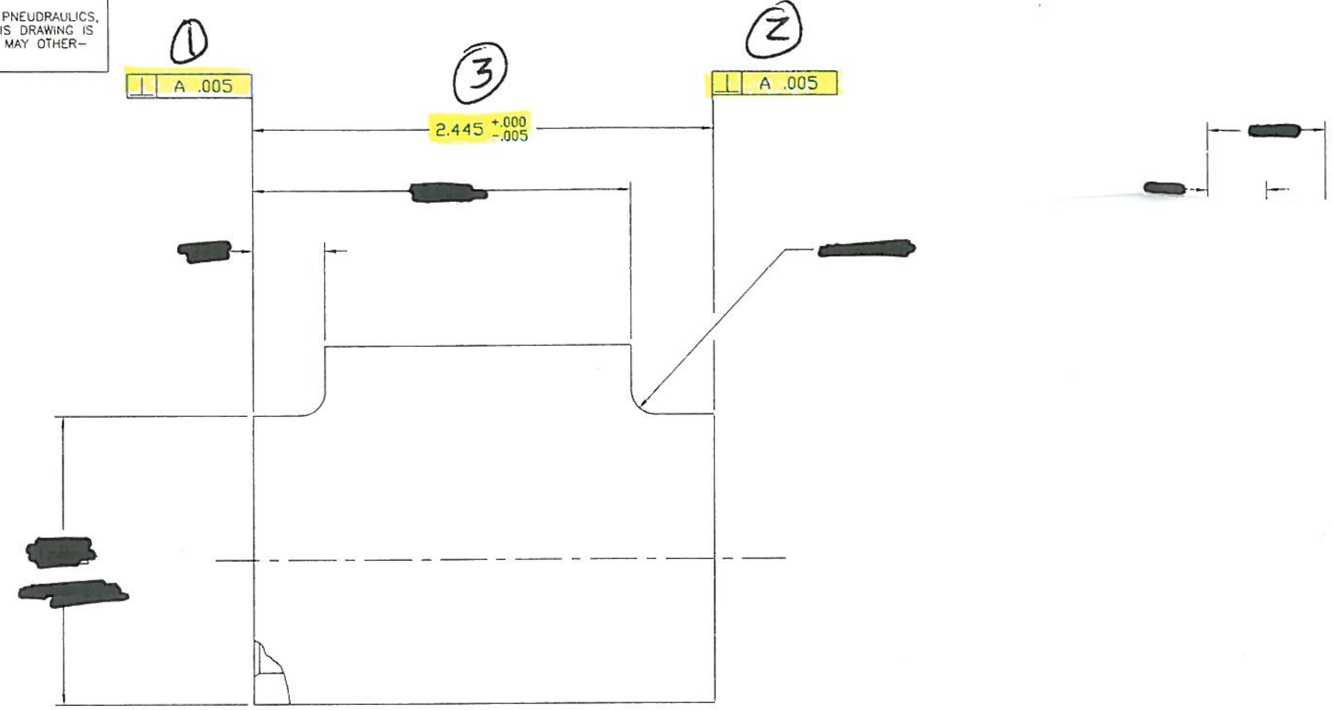
SIZE	CAGE CODE	
D	06177	72738

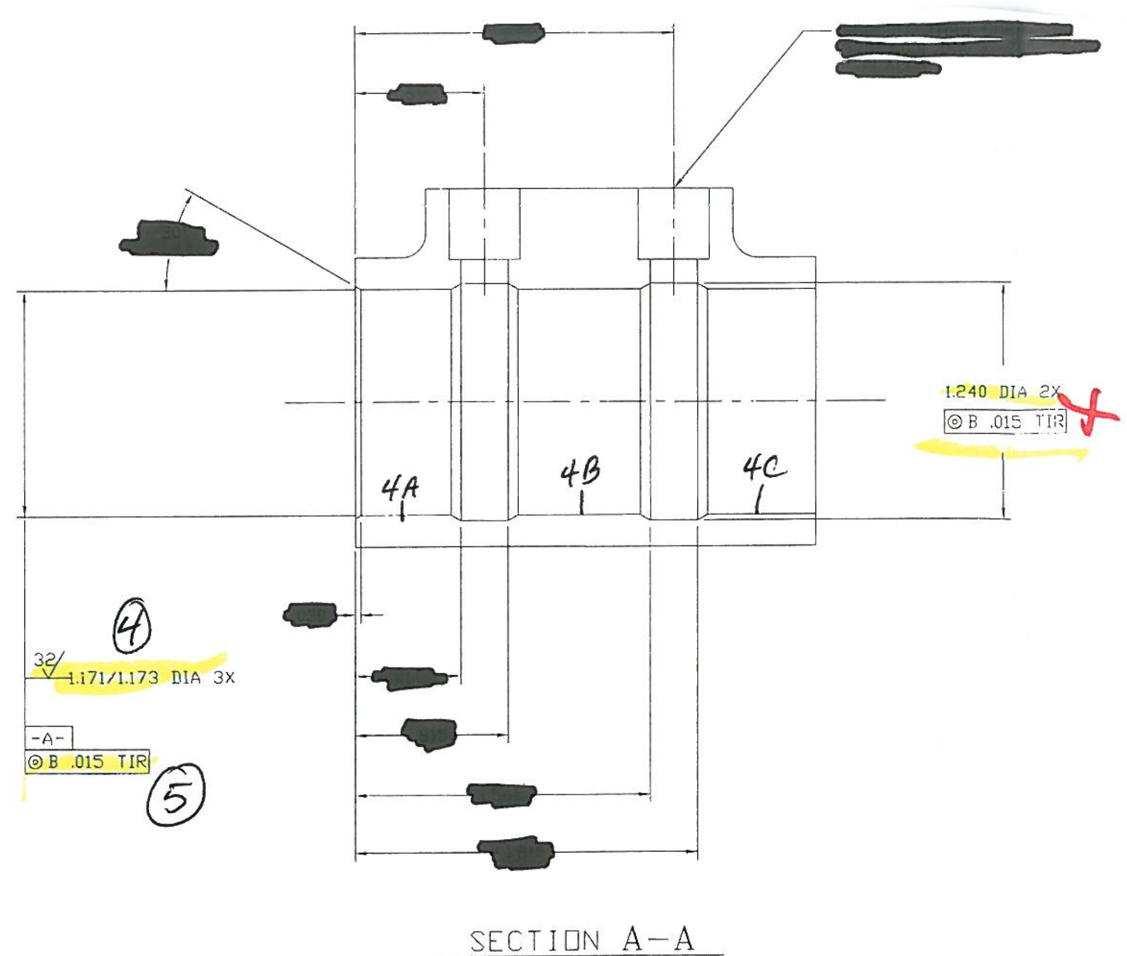
SCALE 2/1 | WEIGHT | SHEET 1 OF 1

72738 B

prtd 04/06/2011. Verify current revision on CRADL prior to use.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	SEE DCN 13575	6/21/95	WSJ
	B	SEE DCN 15676	6/05/00	TRUJILLO
	C	SEE DCN 15837	11/13/00	TRUJILLO
	D	SEE DCN 16376	3/4/02	TRUJILLO





72741 D

QTY REQD	FIND NO	PART OR IDENTIFYING NUMBER	DESCRIPTION OR NOMENCLATURE	MATERIAL/SPEC	HEAT TREAT	FINISH
				6061-T651 AL ALY PER QQ-A-225/8		

LIST OF MATERIALS OR PARTS LIST

REQD	NEXT ASSY	USED ON
2	72740	7438-1

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES
TOLERANCES ON
.X ±
.XX ± .01
.XXX ± .005
ANGLES ± 0° 30'

SYMBOLS ANSI-Y14.5
— STRAIGHTNESS
▱ FLATNESS
∠ ANGULARITY
⊥ PERPENDICULARITY
// PARALLELISM
⌖ POSITION
◎ CONCENTRICITY

DIMENSIONS TO BE MET AFTER PLATING
BREAK SHARP EDGES .005/.010
125 √ MACHINE SURFACES
.015/.035 MACHINED FILLETS
SURFACE SYMBOL PER ANSI-B46.1
THREADS PER HANDBOOK H-28

DRAWN	JEFFERSON	3/11/95
CHECKED		
PROJECT ENGINEER		
CONTRACT NO		
DESIGN ACTIVITY APPROVAL	WHEELER	3/11/95

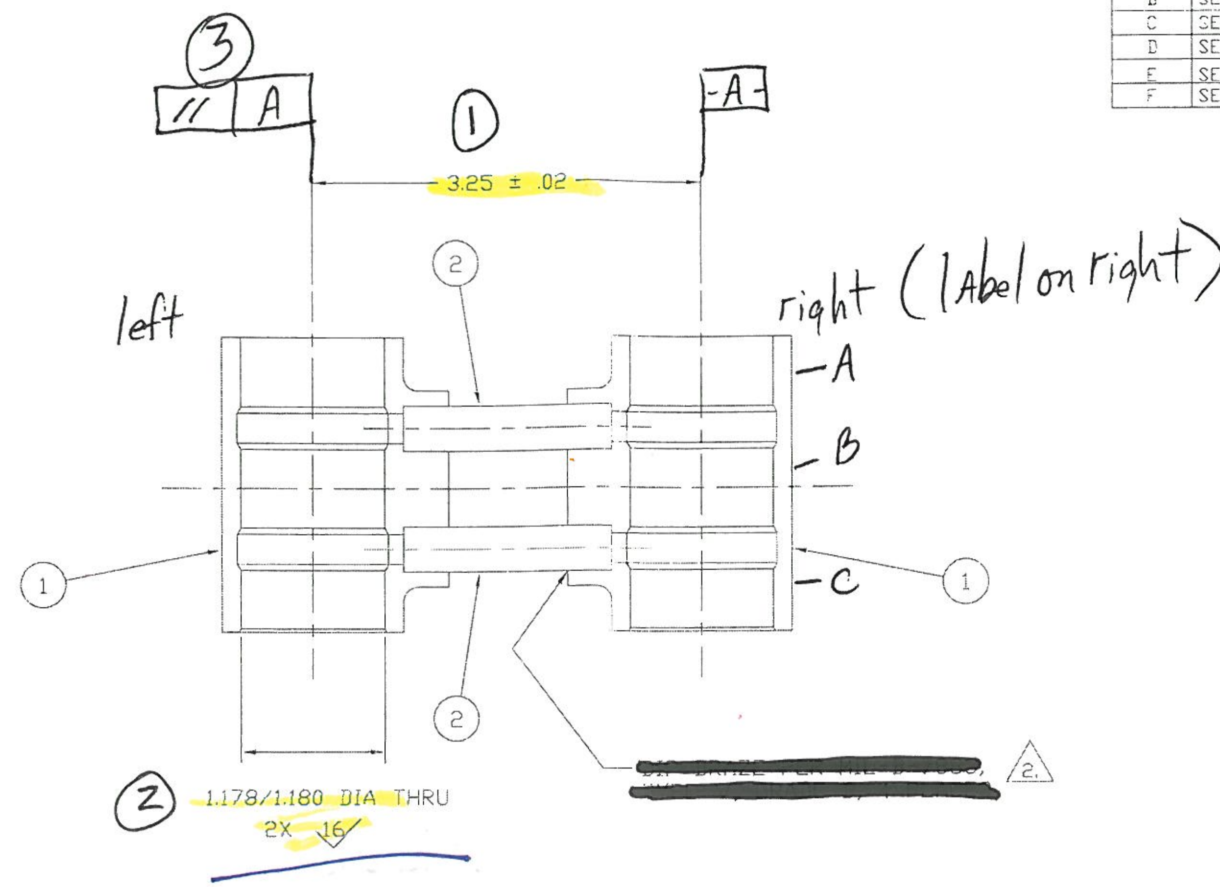
Pneu Draulics Inc 8575 HELMS AVENUE RANCHO CUCAMONGA, CA

HOUSING-BARSTOCK

SIZE	CAGE CODE	
D	06177	72741
SCALE 2/1	WEIGHT	SHEET 1 OF 1

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	SEE DCN 13574	6/21/95	WSJ
	B	SEE DCN 15675	6/02/00	TRUJILLO
	C	SEE DCN 15742	7/31/00	CW
	D	SEE DCN 16032	5/23/01	CW
	E	SEE DCN 16375	3/4/02	TRUJILLO
	F	SEE DCN 19526	1-26-09	CL



2	2	72742	CONNECTING TUBE	D6061-T6 AL ALY		1.
2	1	72741	HOUSING	6061-T651 AL ALY		1.
QTY REQD	FIND NO	PART OR IDENTIFYING NUMBER	DESCRIPTION OR NOMENCLATURE	MATERIAL/SPEC	HEAT TREAT	FINISH

LIST OF MATERIALS OR PARTS LIST

REQD	NEXT ASSY	USED ON
1		7438-1

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES

TOLERANCES ON
.X ±
.XX ± .01
.XXX ± .005
ANGLES ± 0° 30'

SYMBOLS ANSI-Y14.5
— STRAIGHTNESS
▱ FLATNESS
∠ ANGULARITY
⊥ PERPENDICULARITY
// PARALLELISM
⌖ POSITION
○ CONCENTRICITY

DIMENSIONS TO BE MET AFTER PLATING
BREAK SHARP EDGES .005/.010
125 √ MACHINE SURFACES
.015/.035 MACHINED FILLETS
SURFACE SYMBOL PER ANSI-B46.1
THREADS PER HANDBOOK H-28

DRAWN	JEFFERSON	3/19/95
CHECKED		
PROJECT ENGINEER		
CONTRACT NO		
DESIGN ACTIVITY APPROVAL	WHEELER	3/19/95

Pneu Draulics Inc 8575 HELMS AVENUE RANCHO CUCAMONGA, CA

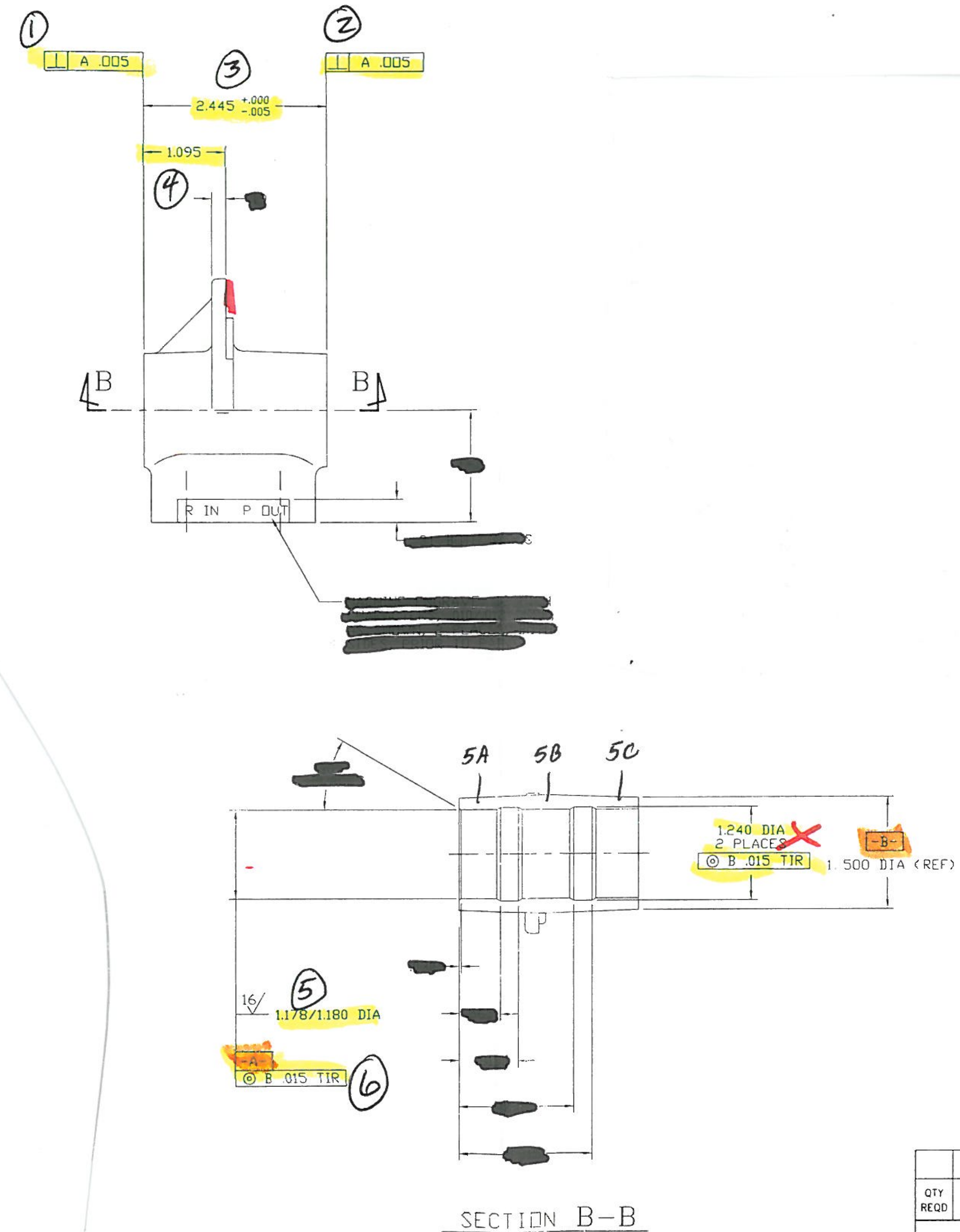
HOUSING ASSEMBLY

SIZE	CAGE CODE	
C	06177	72740
SCALE 1/1	WEIGHT	SHEET 1 OF 1

72740 F

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	SEE DCN 13602	8/1/95	WSJ
	B	SEE DCN 13695	10/25/95	WSJ
	C	SEE DCN 15659	5/24/00	TRUJILLO
	D	SEE DCN 16066	6/14/01	GL
	E	SEE DCN 19276	8/20/08	MS



			M/F 72748 FORGING	7050-T74 AL ALY PER AMS 4107		△1
QTY REQD	FIND NO	PART OR IDENTIFYING NUMBER	DESCRIPTION OR NOMENCLATURE	MATERIAL/SPEC	HEAT TREAT	FINISH

LIST OF MATERIALS OR PARTS LIST

1		7438
REQD	NEXT ASSY	USED ON

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES
TOLERANCES ON
.X ±
.XX ± .01
.XXX ± .005
ANGLES ± 0° 30'

SYMBOLS ANSI-Y14.5
— STRAIGHTNESS
▱ FLATNESS
∠ ANGULARITY
⊥ PERPENDICULARITY
// PARALLELISM
⌖ POSITION
○ CONCENTRICITY

DIMENSIONS TO BE MET AFTER PLATING
BREAK SHARP EDGES .005/.010
125√ MACHINE SURFACES
.015/.035 MACHINED FILLETS
SURFACE SYMBOL PER ANSI-B46.1
THREADS PER HANDBOOK H-28

DRAWN	JEFFERSON	3/24/95
CHECKED		
PROJECT ENGINEER		
CONTRACT NO		
DESIGN ACTIVITY APPROVAL	C. WHEELER	4/10/95

Pneu Draulics Inc 8575 HELMS AVENUE RANCHO CUCAMONGA, CA

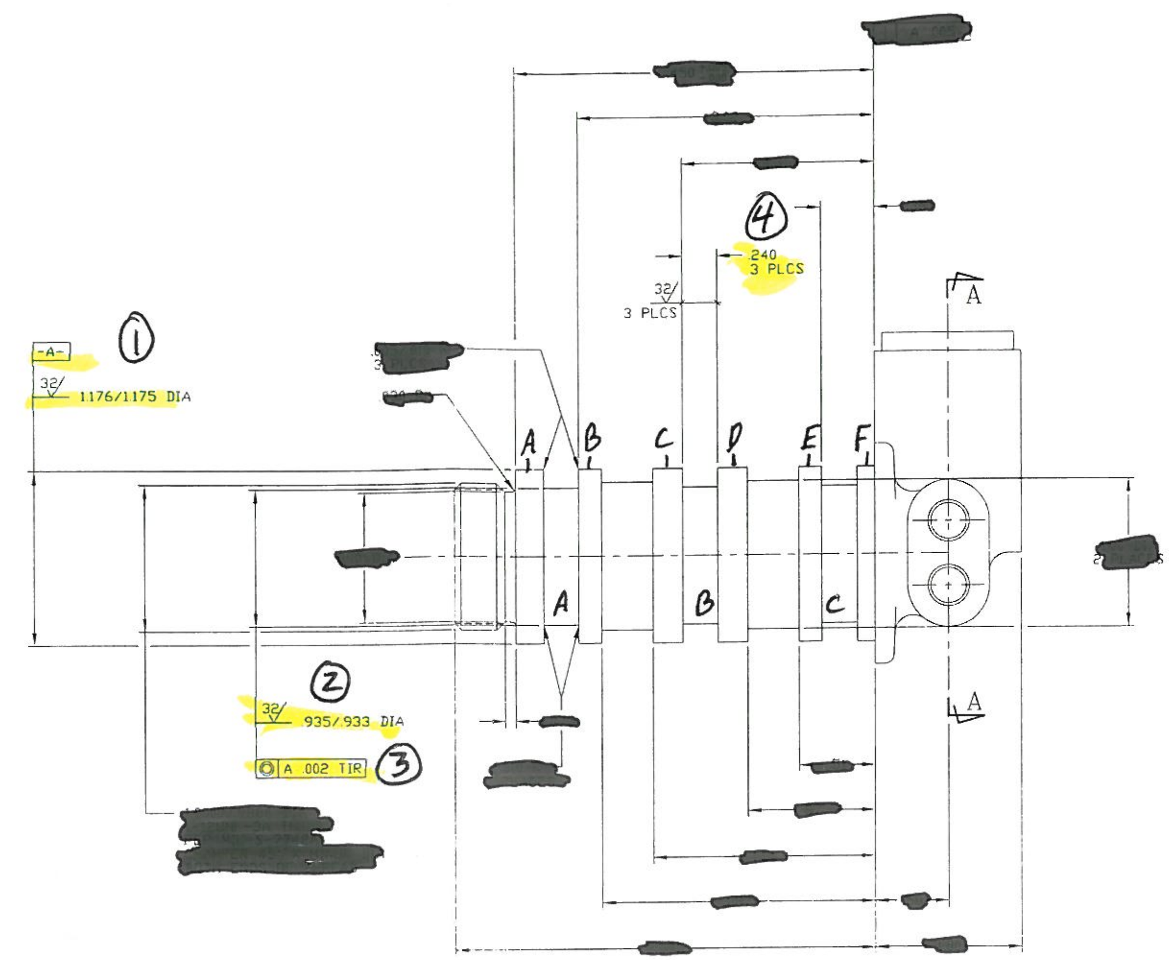
HOUSING-MACHINED

SIZE	CAGE CODE	
D	06177	72749
SCALE 1/1	WEIGHT	SHEET 1 OF 1

72749 E

prtd. 04/06/2011. Verify current revision on CRADL prior to use.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	SEE DCN 16380	3/5/02	TRUJILLO
	B	SEE DCN 18616	5-3-07	TRUJILLO
	-	-	-	-



			M/F 72752 FORGING	7050-T74 AL ALY PER AMS 4107		2
QTY REQD	FIND NO	PART OR IDENTIFYING NUMBER	DESCRIPTION OR NOMENCLATURE	MATERIAL/SPEC	HEAT TREAT	FINISH

LIST OF MATERIALS OR PARTS LIST

1	73122	7438-4
REQD	NEXT ASSY	USED ON

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES
TOLERANCES ON
.X ±
.XX ± .01
.XXX ± .005
ANGLES ± 0° 30'

SYMBOLS ANSI-Y14.5
— STRAIGHTNESS
FLATNESS
ANGULARITY
⊥ PERPENDICULARITY
// PARALLELISM
⌖ POSITION
○ CONCENTRICITY

DIMENSIONS TO BE MET AFTER PLATING
BREAK SHARP EDGES .005/.010
125√ MACHINE SURFACES
.015/.035 MACHINED FILLETS
SURFACE SYMBOL PER ANS-B46.1
THREADS PER HANDBOOK H-28

DRAWN	D.TRUJILLO	10/9/01
CHECKED		
PROJECT ENGINEER		
CONTRACT NO		
DESIGN ACTIVITY APPROVAL	WHEELER	10/9/01

Pneu Draulics Inc 8575 HELMS AVENUE RANCHO CUCAMONGA, CA

SHAFT-MACHINED

SIZE	CAGE CODE	
F	06177	73123
SCALE 2/1	WEIGHT	SHEET 1 OF 1

73123 B

APPLIED TECHNICAL SERVICES, INCORPORATED

1049 Triad Court, Marietta, Georgia 30062 • (770) 423-1400 Fax (770) 424-6415

APPENDIX C

INITIAL WORK SCOPE SUBMITTED BY GULFSTREAM

From: branko.stropnik@gulfstream.com
To: Burak Akyuz
Subject: RE: Swivel Investigation - NTSB
Date: Tuesday, April 19, 2011 10:43:39 AM

Heres the proposed itinerary, let me know hat additional information you may need

DAY 1
1) Dimensional analysis of all subassemblies before destructive testing.
   a) Document location, length of wear/damage features

DAY 2-3

2) Determine surface finish, presence of coatings, coating thickness on all parts.

3)Examine external spool surfaces with SEM/EDS to detect any presence of embedded/smeared FOD in surfaces. Evaluate the "galling/wear" characteristics of the surfaces.
   a) Cross section and make a metallographic mounts of the area .
   b) Conduct microhardness/microstructure evaluation

4)Examine internal housing surfaces with SEM/EDS to detect any presence of embedded/smeared FOD in surfaces. Evaluate the "galling/wear" characteristics of the surfaces.
   a) Cross section and make a metallographic mounts of the area .
   b) Conduct microhardness/microstructure evaluation

5) Section damaged tube and determine failure mode , fatigue, overload, tensile, compressive failure
   a) Conduct hardness on the various detail parts of the assembly
   b) Open up the fracture, and document the fracture surface with photographs
   c) Cross section the failed tube and make a metallographic mounts of the area at or near the crack and away from the crack
   d) Cross section and mount on of the other tubes for microstructure comparison
   e) Conduct micro-hardness on the mounts to determine if there is any difference in hardness in the area of the crack versus away from the crack or in the cracked tube versus another tube
   f) Examine the fracture surface under SEM and conduct EDS elemental scan to determine if alloy is 6061 and compare with other tube in assembly

Branko Stropnik
Principal Engineer
Service Engineering
Gulfstream Aerospace
MS SW7
Phone: 912-965-3620
Fax: 912-965-4725
Cell: 912-658-0645

From: Branko Stropnik/SAV/GAC

APPLIED TECHNICAL SERVICES, INCORPORATED

1049 Triad Court, Marietta, Georgia 30062 • (770) 423-1400 Fax (770) 424-6415

APPENDIX D

REVISION 1 MODIFICATIONS

APPLIED TECHNICAL SERVICES, INCORPORATED

1049 Triad Court, Marietta, Georgia 30062 • (770) 423-1400 Fax (770) 424-6415

Section/Page	Location	Modification
1	1st Paragraph	Fourth sentence revised to state “The aircraft had accumulated 10.4 flight hours and 5 landings at the time of failure.”
3	4th Paragraph	Added a sentence “Pneudralics personnel reported that these longitudinal marks may have been due to post-incident disassembly.”
2	2nd Paragraph	Added a sentence “It should be noted that the dimensional analysis was conducted on the failed/used parts.”
4	4th Paragraph	Added a sentence “The samples met the drawing requirements of 16 µin for the housings and 32 µin for the spools.”
48	–	Added Figure 40 to clarify anodizing verification results
Appendix B	3rd Page	Removed some dimensional measurements. See next page for removed data and the drawing explaining the reasons for this change.

PART NAME : 72741D / 72740F		April 27, 2011	13:00
REV NUMBER : D	SER NUMBER : 0748	STATS COUNT : 1	

BARSTOCK HOUSING 72741 WITH LABEL

⊥	IN	ITEM 1 - PLN3 TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0050	0	0.0004	0.0004	0.0000

⊥	IN	ITEM 2 - PLN2 TO CYL1				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0050	0	0.0011	0.0011	0.0000

↔	IN	ITEM 3 - PNT1 TO PNT2 (XAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	2.4450	0.0000	0.0050	[illegible]	029	0.0000

⌖	IN	ITEM 4A - CIR4				
AX	NOMINAL	+TOL	-TOL	[illegible]	EV	OUTTOL
D	1.1720	0.0010	0.0010	[illegible]	075	0.0065

⌖	IN	ITEM 4B - CIR3				
AX	NOMINAL	+TOL	-TOL	[illegible]	EV	OUTTOL
D	1.1720	0.0010	0.0010	[illegible]	075	0.0065

⌖	IN	ITEM 4C - CIR2				
AX	NOMINAL	+TOL	-TOL	[illegible]	EV	OUTTOL
D	1.1720	0.0010	0.0010	[illegible]	076	0.0066

The issue with these dimensions is that the bore was machined to 1.178-1.180 on next assy drawing 72740. I think its best to delete these and indicate that these are unobtaineable as they are altered at assembly dwg 72740. The dimensions were taken of the 72740 IDs and are recorded properly on the following sheet 3 of 3

◎	IN	ITEM 5 - CYL1 TO CIR8				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0150	0.0000	0.0016	0.0016	0.0000

BARSTOCK HOUSING 72741 WITHOUT LABEL

⊥	IN	ITEM_1 - PLN6 TO CYL2				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0050	0	0.0008	0.0008	0.0000

⊥	IN	ITEM_2 - PLN5 TO CYL2				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0050	0	0.0004	0.0004	0.0000

↔	IN	ITEM_3 - PNT3 TO PNT4 (XAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	2.4450	0.0000	[illegible]	[illegible]	-0.0026	0.0000

⌖	IN	ITEM_4A - CIR7				
AX	NOMINAL	+TOL	[illegible]	[illegible]	DEV	OUTTOL
D	1.1720	0.0010	[illegible]	[illegible]	0.0074	0.0064

⌖	IN	ITEM_4B - CIR6				
AX	NOMINAL	+TOL	[illegible]	[illegible]	DEV	OUTTOL
D	1.1720	0.0010	[illegible]	[illegible]	0.0074	0.0064

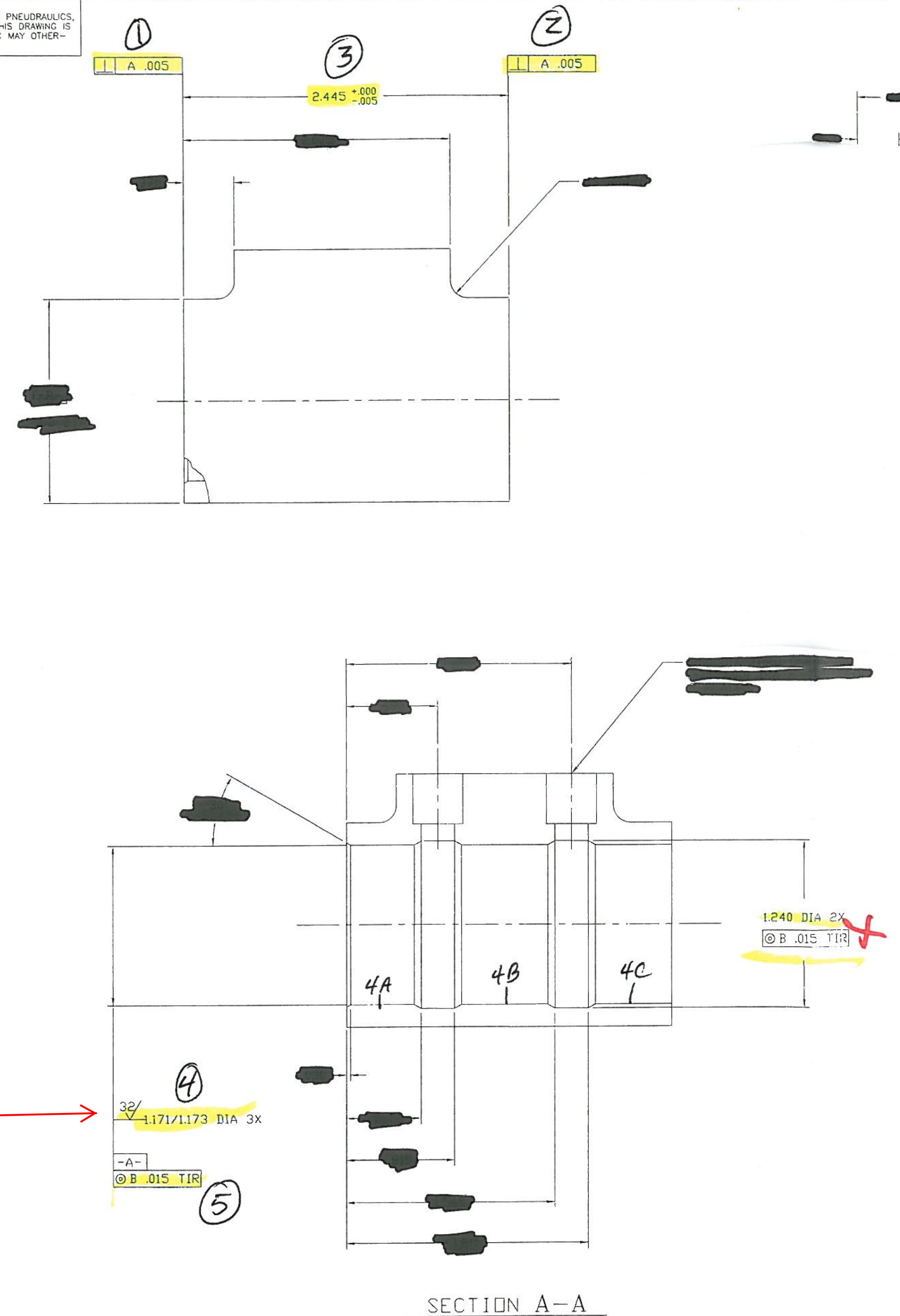
⌖	IN	ITEM _4C - CIR5				
AX	NOMINAL	+TOL	[illegible]	[illegible]	DEV	OUTTOL
D	1.1720	0.0010	[illegible]	[illegible]	0.0074	0.0064

The issue with these dimensions is that the bore was machined to 1.178-1.180 on next assy drawing 72740. I think its best to delete these and indicate that these are unobtaineable as they are altered at assembly dwg 72740. The dimensions were taken of the 72740 IDs and are recorded properly on the following sheet 3 of 3

◎	IN	ITEM _5 - CYL2 TO CIR9				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0.0000	0.0150	0.0000	0.0010	0.0010	0.0000

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	SEE DCN 13575	6/21/95	WSJ
	B	SEE DCN 15676	6/05/00	TRUJILLO
	C	SEE DCN 15837	11/13/00	TRUJILLO
	D	SEE DCN 16376	3/4/02	TRUJILLO



This dimension was unobtainable as the bore is reamed at next assembly

QTY REQD	FIND NO	PART OR IDENTIFYING NUMBER	DESCRIPTION OR NOMENCLATURE	MATERIAL/SPEC	HEAT TREAT	FINISH
				6061-T651 AL ALY PER QQ-A-225/8		

LIST OF MATERIALS OR PARTS LIST

REQD	NEXT ASSY	USED ON
2	72740	7438-1

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES

TOLERANCES ON
.X ±
.XX ± .01
.XXX ± .005
ANGLES ± 0° 30'

SYMBOLS ANSI-Y14.5: — STRAIGHTNESS; ⏥ FLATNESS; ∠ ANGULARITY; ⊥ PERPENDICULARITY; // PARALLELISM; ⌖ POSITION; ◎ CONCENTRICITY

DIMENSIONS TO BE MET AFTER PLATING
BREAK SHARP EDGES .005/.010
125√ MACHINE SURFACES
.015/.035 MACHINED FILLETS
SURFACE SYMBOL PER ANSI-B46.1
THREADS PER HANDBOOK H-28

DRAWN	JEFFERSON	3/11/95
CHECKED		
PROJECT ENGINEER		
CONTRACT NO		
DESIGN ACTIVITY APPROVAL	WHEELER	3/11/95

Pneu Draulics Inc 8575 HELMS AVENUE RANCHO CUCAMONGA, CA

HOUSING-BARSTOCK

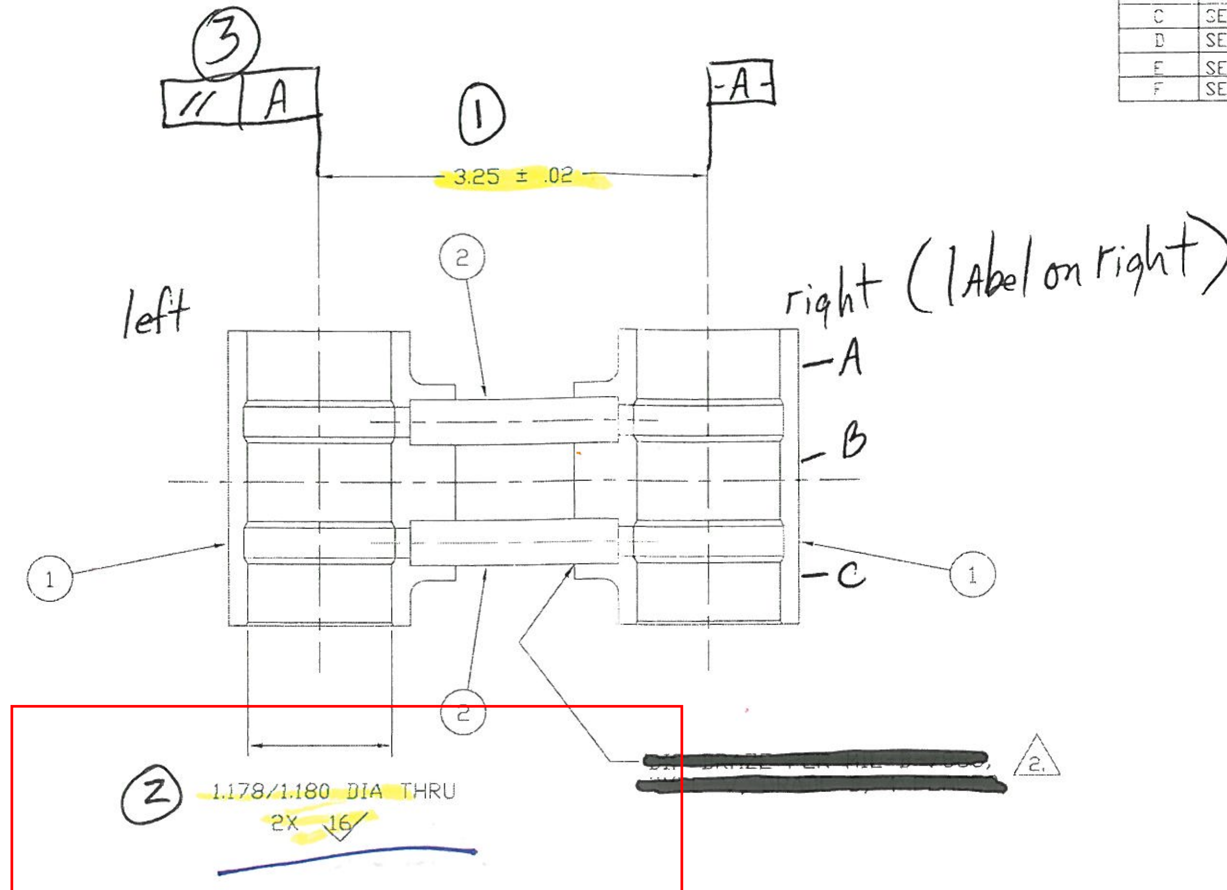
SIZE	CAGE CODE	
D	06177	72741
SCALE 2/1	WEIGHT	SHEET 1 OF 1

72741 D

prtd. 04/06/2011. Verify current revision on CRADL prior to use

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	SEE DCN 13574	6/21/95	WSJ
	B	SEE DCN 15675	6/02/00	TRUJILLO
	C	SEE DCN 15742	7/31/00	CW
	D	SEE DCN 16032	5/23/01	CW
	E	SEE DCN 16375	3/4/02	TRUJILLO
	F	SEE DCN 19526	1-26-09	CL



[redacted] 2

2	2	72742	CONNECTING TUBE	6061-T6 AL ALY		1
2	1	72741	HOUSING	6061-T651 AL ALY		1
QTY REQD	FIND NO	PART OR IDENTIFYING NUMBER	DESCRIPTION OR NOMENCLATURE	MATERIAL/SPEC	HEAT TREAT	FINISH

LIST OF MATERIALS OR PARTS LIST

1		7438-1
REQD	NEXT ASSY	USED ON

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES

TOLERANCES ON
.X ±
.XX ± .01
.XXX ± .005
ANGLES ± 0° 30'

SYMBOLS ANSI-Y14.5: STRAIGHTNESS, FLATNESS, ANGULARITY, PERPENDICULARITY, PARALLELISM, POSITION, CONCENTRICITY

DIMENSIONS TO BE MET AFTER PLATING
BREAK SHARP EDGES .005/.010
125 MACHINE SURFACES
.015/.035 MACHINED FILLETS
SURFACE SYMBOL PER ANS-B46.1
THREADS PER HANDBOOK H-28

DRAWN	JEFFERSON	3/19/95
CHECKED		
PROJECT ENGINEER		
CONTRACT NO		
DESIGN ACTIVITY APPROVAL	WHEELER	3/19/95

Pneu Draulics Inc
8575 HELMS AVENUE
RANCHO CUCAMONGA, CA

HOUSING ASSEMBLY

SIZE	CAGE CODE	DWG NO
C	06177	72740

SCALE 1/1 | WEIGHT | SHEET 1 OF 1

72740 F

↔	IN	ITEM_1 AT A - CIR2 TO CIR5 (YAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	3.2500	0.0200	0.0200	3.2638	0.0138	0.0000

↔	IN	ITEM_1 AT B - CIR3 TO CIR6 (YAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	3.2500	0.0200	0.0200	3.2737	0.0237	0.0037

↔	IN	ITEM_1 AT C - CIR7 TO CIR4 (YAXIS)				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	3.2500	0.0200	0.0200	3.2852	0.0352	0.0152

⌖	IN	ITEM 2A RIGHT - CIR4				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1795	0.0005	0.0000

⌖	IN	ITEM 2B RIGHT - CIR3				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1795	0.0005	0.0000

⌖	IN	ITEM 2C RIGHT - CIR2				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1796	0.0006	0.0000

These are OK

⌖	IN	ITEM 2A LEFT - CIR5				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1794	0.0004	0.0000

⌖	IN	ITEM 2B LEFT - CIR6				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1794	0.0004	0.0000

⌖	IN	ITEM 2C LEFT - CIR7				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
D	1.1790	0.0010	0.0010	1.1794	0.0004	0.0000

//	IN	ITEM __3 - CYL1 TO CYL2				
AX	NOMINAL	+TOL	-TOL	MEAS	DEV	OUTTOL
M	0	0.0400	0	0.0356	0.0356	0.0000