Beechcraft Cessna Hawker

TEXTRON AVIATION

Material & Process Engineering Report

Report Title:	Examination of Fractured Torque Knee, P/N 50-810032-4, from Beechcraft E90 Aircraft A/C LW-76		
Report No.:	19-359-091	**Date:**	08/20/2019
Revision:	A		
EC:	084198		
To:	Henry Soderlund	**Prepared by:**	Grace Bjorland
cc:	Shad Eickbush	**Checked by:**	-
		Approved by:	Bret Vogel
			(see Electronic Signature Sheet)

Summary

A Beechcraft E90 (A/C LW-76) experienced a separation of the lower right main landing gear after takeoff in Fort Worth, Texas. The MLG was found to have broken at the connection between the upper and lower torque knees (50-810032-4, 50-810295-17), and at two other connection points in the upper torque knee. Both torque knees were sent to M&P to investigate the cause of fracture.

The examination resulted in the following findings:

1. The upper torque knee, P/N 50-810032-4, was found to have fractured at all three connection points.
2. Fatigue was identified on Fracture Piece #1, all other fractures occurred through ductile overload.
3. Corrosion was found to have assisted in crack initiation in Fracture Piece #1. The crack propagated through fatigue until a critical crack length was reached. Final fracture region showed evidence of ductile overload.
4. Material chemistry, tensile properties, conductivity, and microstructure of the upper torque link was consistent with aluminum alloy 2014 in the T6 condition.

Examination

LW-76's RH MLG is shown in Figure 1 after fracture was found and assembly was removed from the aircraft. The lower torque knee (P/N 50-810295-17) remains intact and the upper torque knee (P/N 50-810032-4) has fractures at all three connection points. An image from the Illustrated Parts Catalog shows the MLG assembly and the locations of each of the fractures (Figure 2). Due to historical evidence of this occurrence a mandatory service bulletin (SB 32-3134) was released requiring nondestructive inspection of the torque knees at reduced intervals. An additional Service Bulletin (SB 32-3116) was released recommending a steel torque knee replacement for the upper and lower knees.

Figures 3 and 4 show the upper and lower torque knees as received by M&P; pieces from two of the fractures on the upper torqu knee are missing. All fracture surfaces were inspected at higher magnification using optical and scanning electron microscopy (Figures 5-14). Fracture piece #1 showed

evidence of corrosion assisted crack initiation. The material on the outside face of the fracture had begun to separate in layers. This type of layer separation is common in 2xxx series aluminum alloys and is indicative of a corrosive attack on the metal. The crack propagated through fatigue until a critical crack size was reached. Final fracture occurred through ductile overload. The rest of the fracture pieces showed evidence of ductile overload. Fracture piece #1 likely fatigued and fractured first; after fracture the other two connections experienced an increase in loading which caused them to separate from the assembly.

Material Conformity

Table I: Material Conformity Testing

Conformity Check	Results	Table/ Figure
Conductivity	Acceptable	Table 2
Tensile Properties	Acceptable	Table 3
Chemical Composition	Acceptable	Table 4
Microstructure	Acceptable	Figure 15

Table 2: Conductivity Test Results

	Conductivity (%IACS)
P/N 50-810032-4	38.2
2014-T6 per AMS 2658	35.0 - 41.5

Table 3: Tensile Property Results
Arrow Report # e57tg595

	Tensile Strength (ksi)	Yield Strength (ksi)	Elongation (%)
P/N 50-810032-4	70.8	65.9	13
2014-T6 Per AMS-QQ-A-367	65.0 min	56.0 min	6.0 min

Table 4: Chemical Analysis Results
Arrow Report # e57tg595

Element	Chemical Composition (wt. %)	
	P/N 50-810032-4	2014 Aluminum per AMS-QQ-A-367
Silicon	0.73	0.50-1.2
Iron	0.25	0.7 max
Copper	4.3	3.9-5.0
Manganese	0.67	0.40-1.2
Magnesium	0.41	0.20-0.8
Chromium	0.01	0.10 max
Zinc	0.03	0.25 max
Titanium	0.02	0.15 max

Revision History

Letter	Date	Description	By	Approved
A	08/20/19	Removed finding from summary section. Finding stated fracture was outside inspection region in SB32-3134. This is incorrect. SB calls out areas of special attention but calls for inspection of the entire torque knee. Removed Figure 15, Figure 16 changed to Figure 15 Made changes to the Examination paragraph to match requirements stated in SB 32-3134.	See Electronic Signature Sheet	

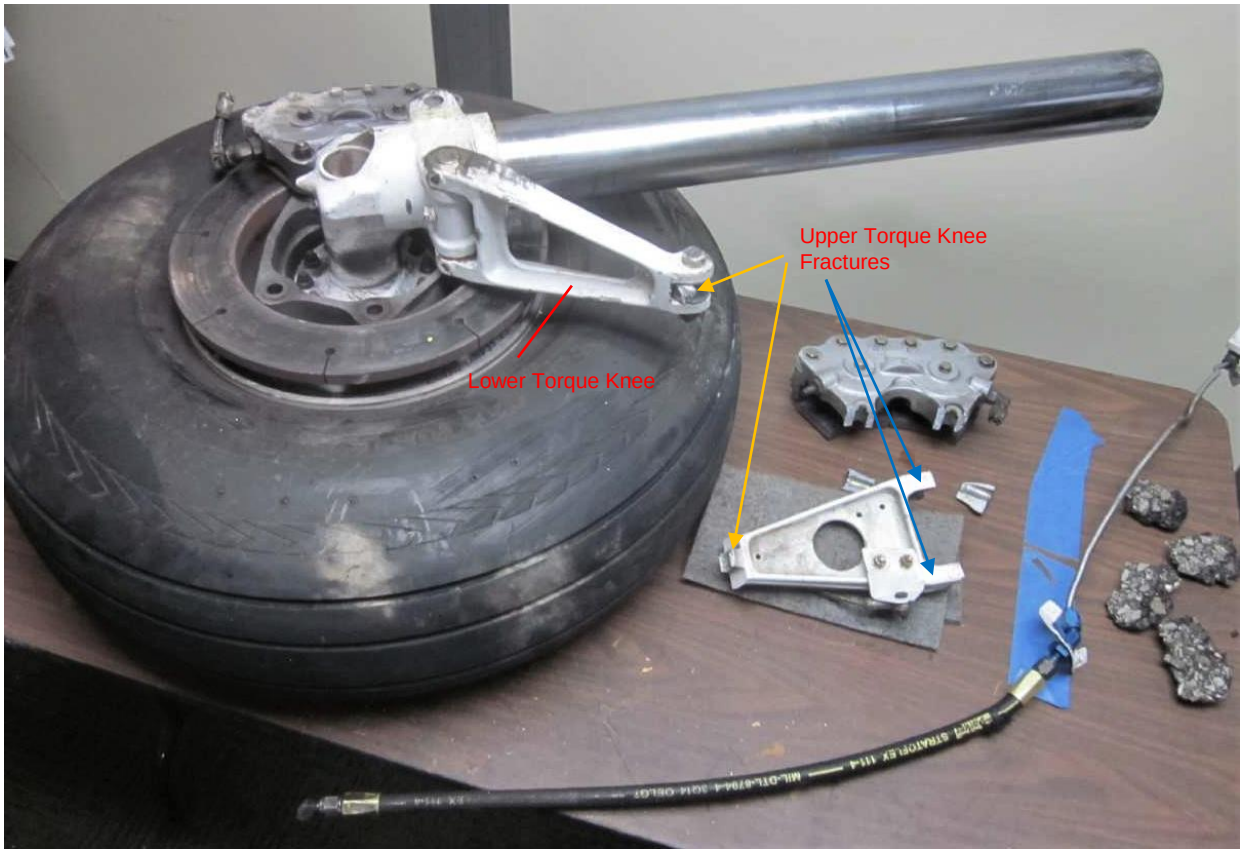


Figure 1: RH main landing gear after fracture was identified and assembly was removed from the aircraft. Lower torque knee (P/N 50-810295-17) remains intact; upper torque knee (50-810032-4) fractured at all connecting points from assembly.

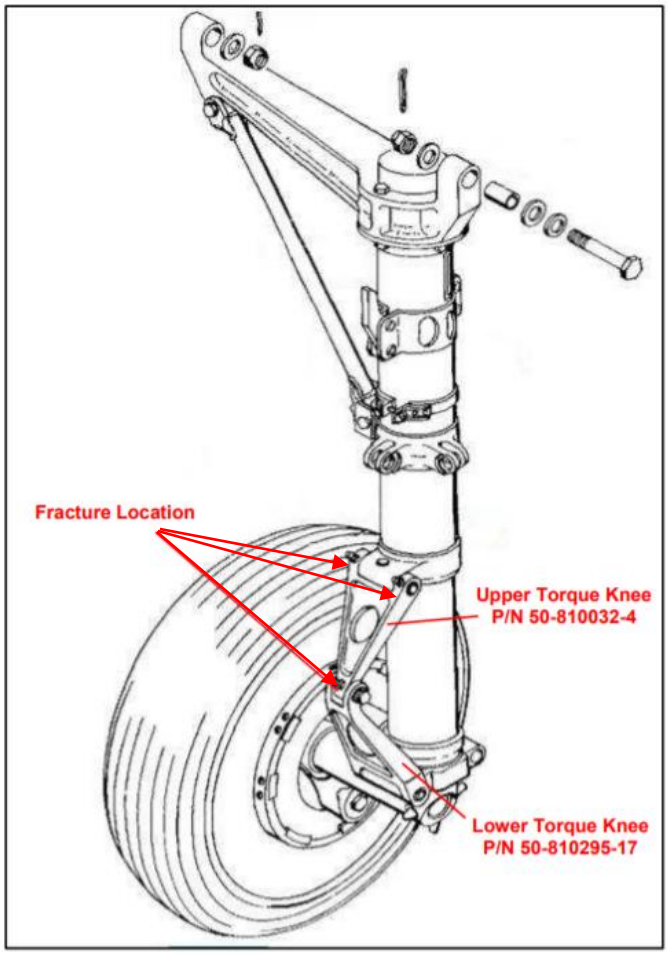


Figure 2: MLG as represented by the Illustrated Parts Catalog.

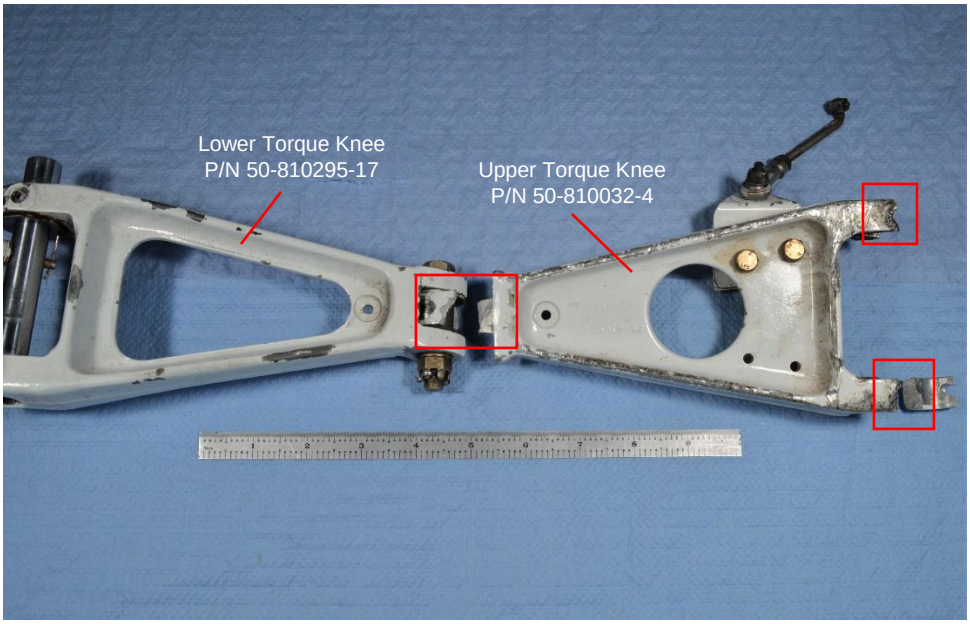
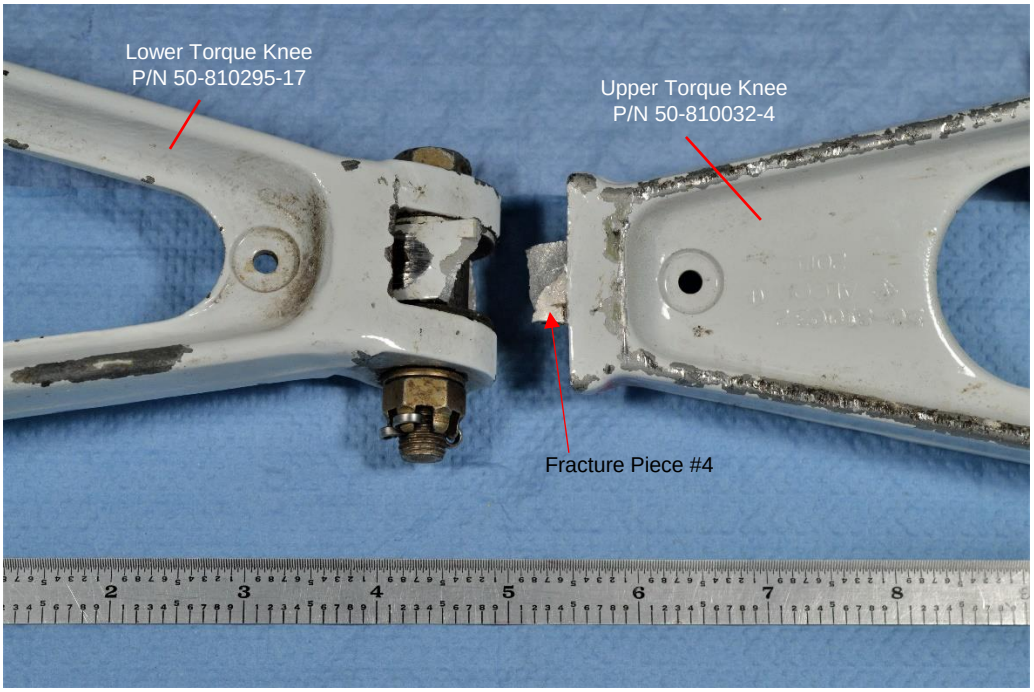


Figure 3: Torque knees as received by M&P. Boxes show fracture locations. Some fracture pieces are missing from the upper torque knee.

a)



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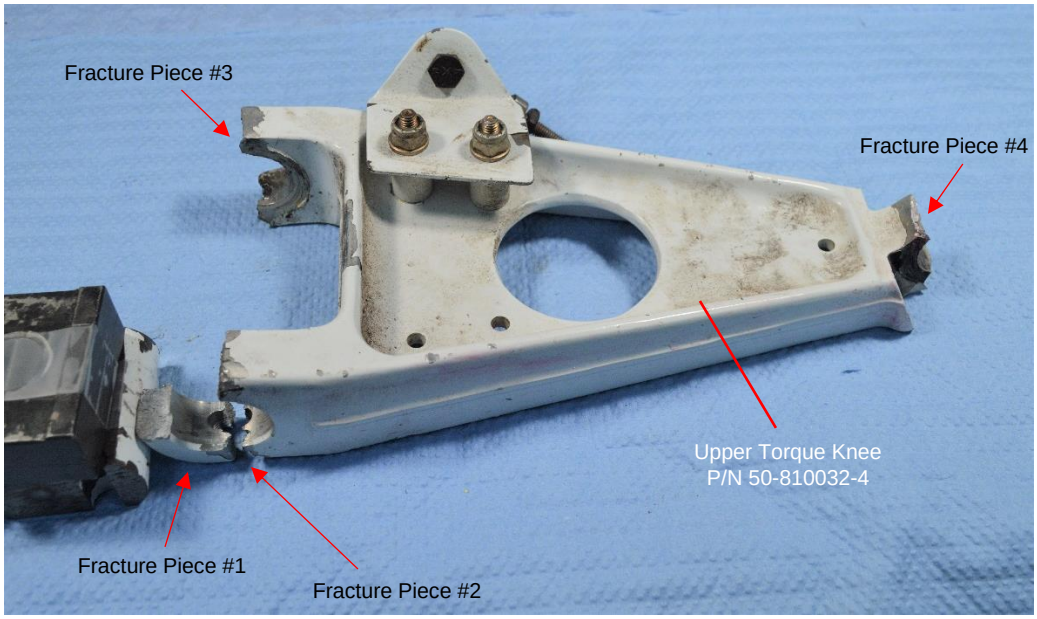
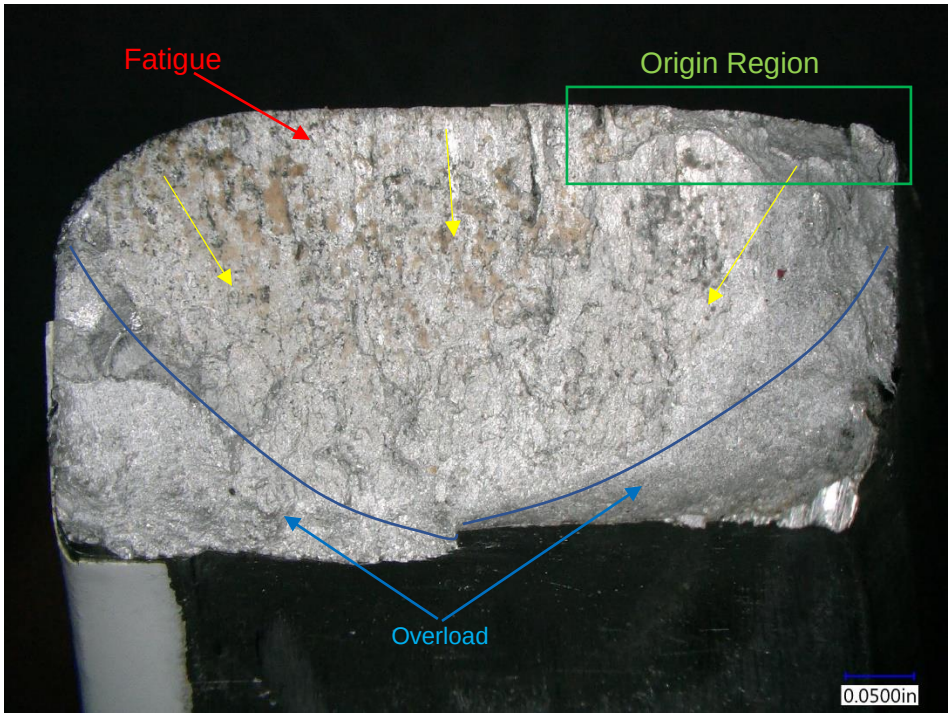


Figure 4: Close-up of fracture areas on the upper torque knee. Fractures are arbitrarily labeled for easy identification during analysis.

a)



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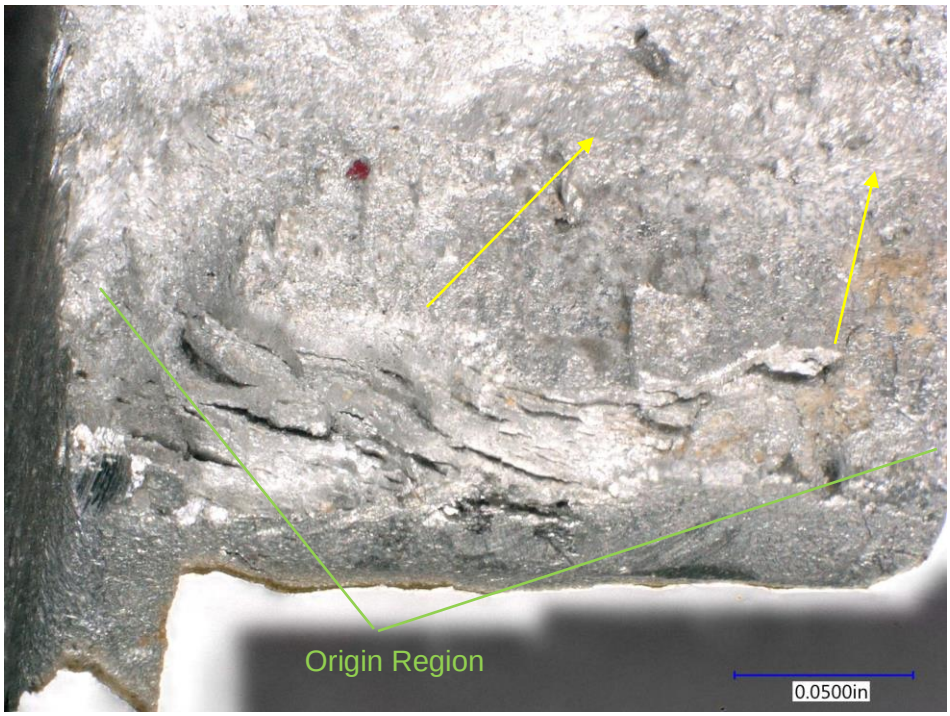
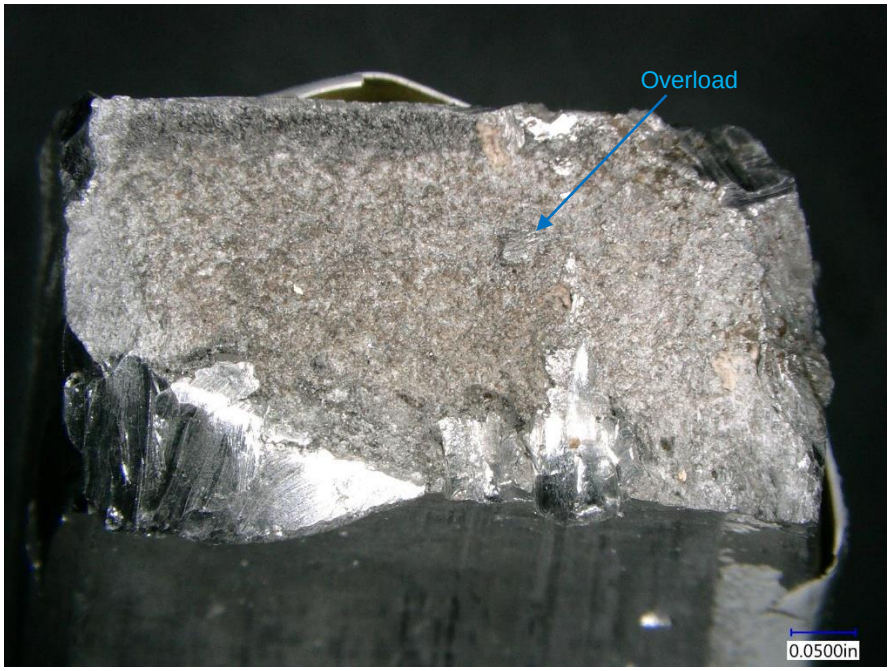


Figure 5: Fracture Piece #1 a) Fracture shows regions of fatigue and overload. Yellow arrows represent the direction of crack propagation, 7x magnification b) Upper right corner of fracture surface shows separation of material layers. Yellow arrows show crack propagation direction, 19x magnification

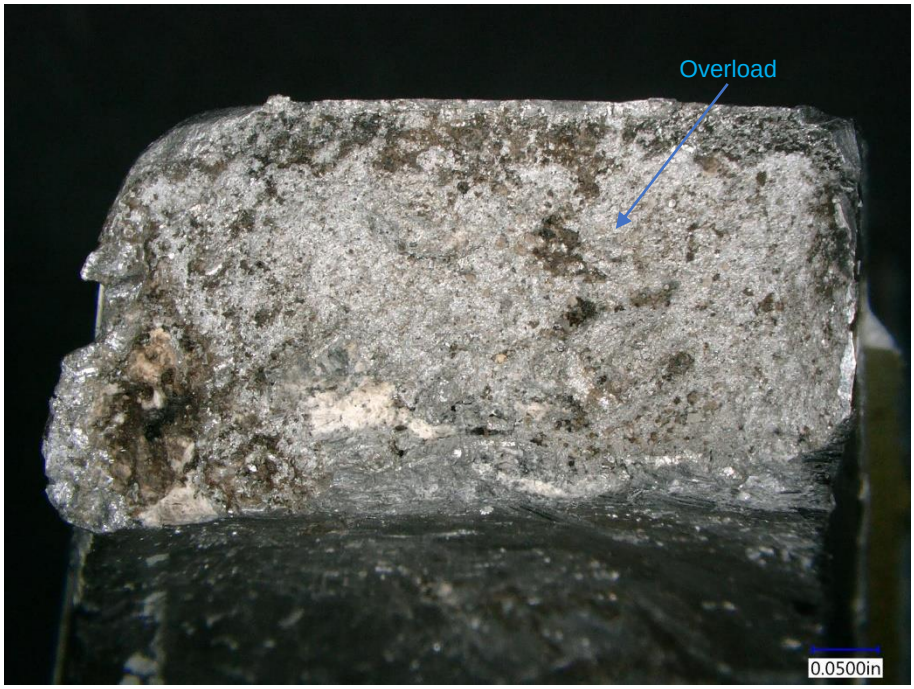
a)



b)

Figure 6: Fracture Piece #2, significant portions of the fracture are damaged or covered in corrosion a) 7x magnification b) 7x magnification

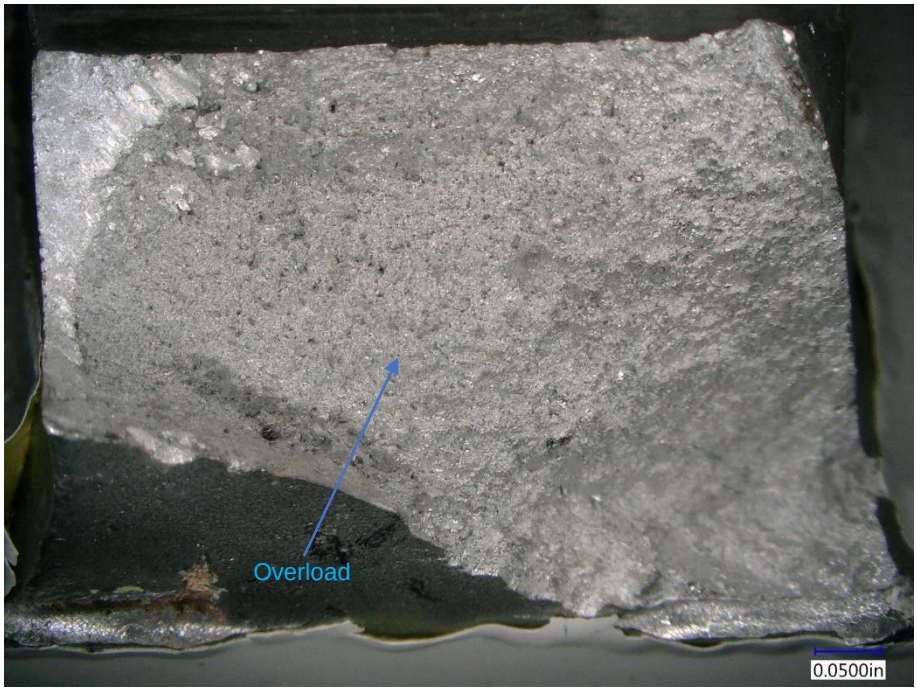
a)



b)

Figure 7: Fracture Piece #3, significant portions of the fracture are damaged or covered in corrosion a) 7x magnification b) 7x magnification

a)



b)

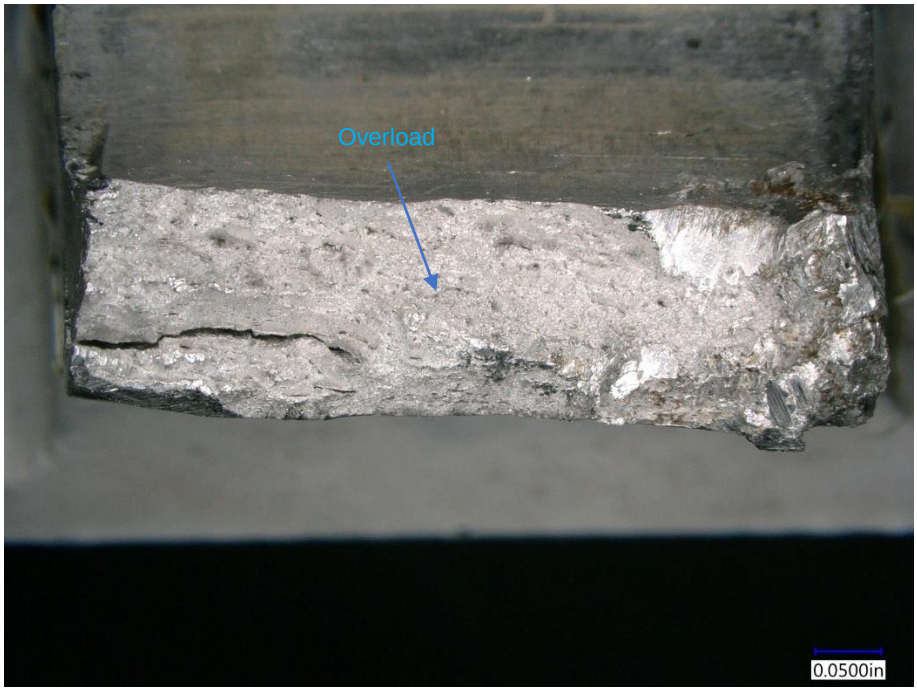
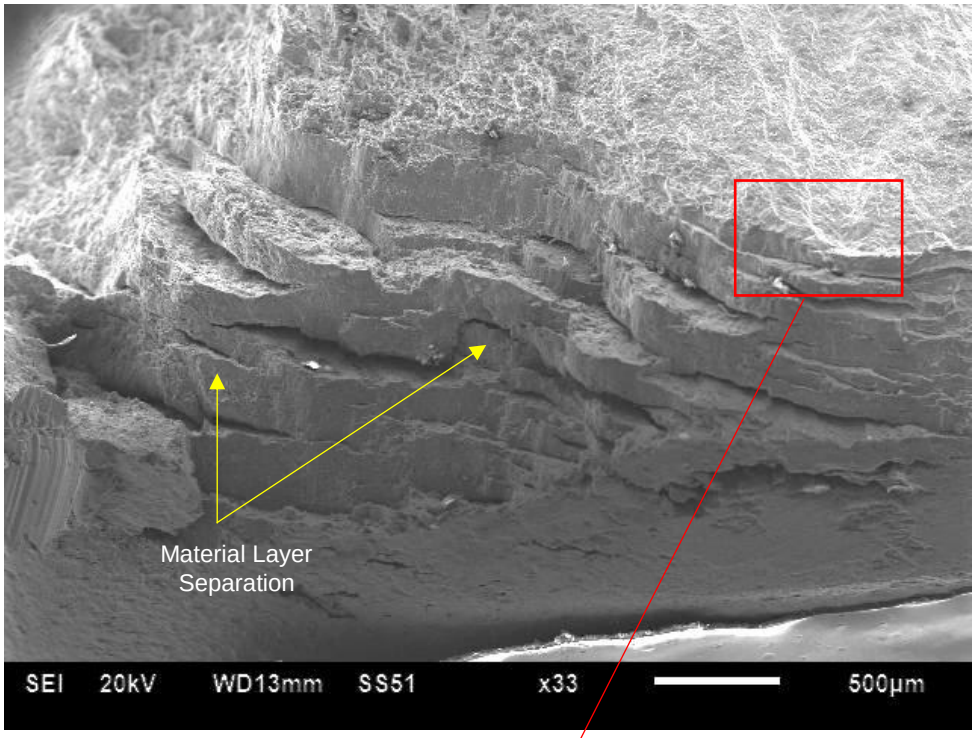


Figure 8: Fracture Piece #4, connection piece between upper and lower torque knees. a) 7x magnification b) 7x magnification

a)



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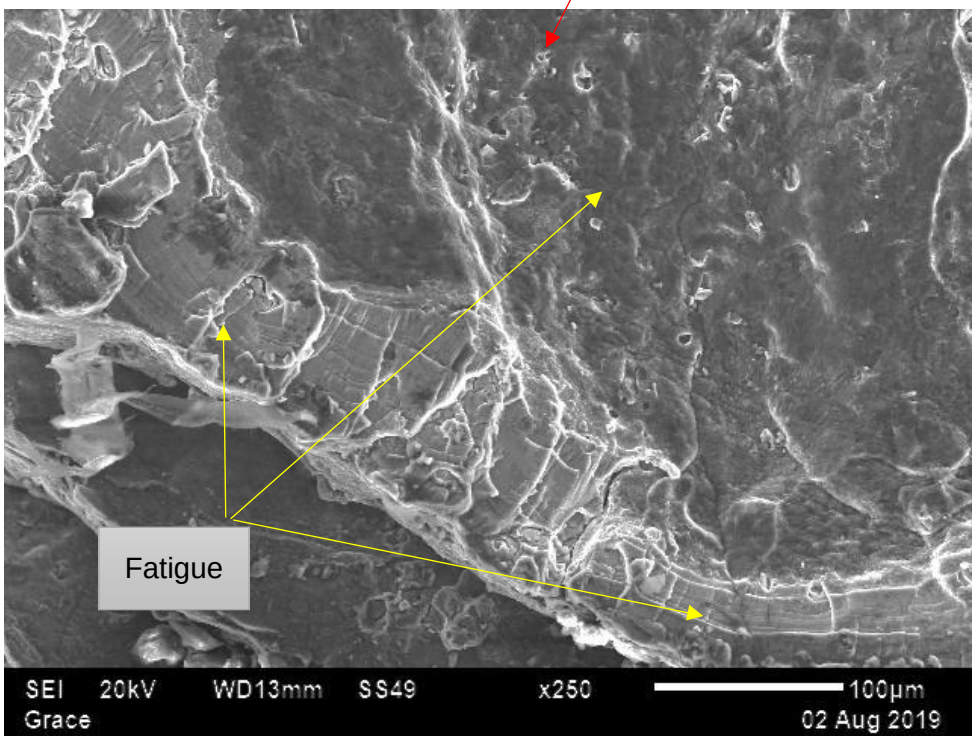
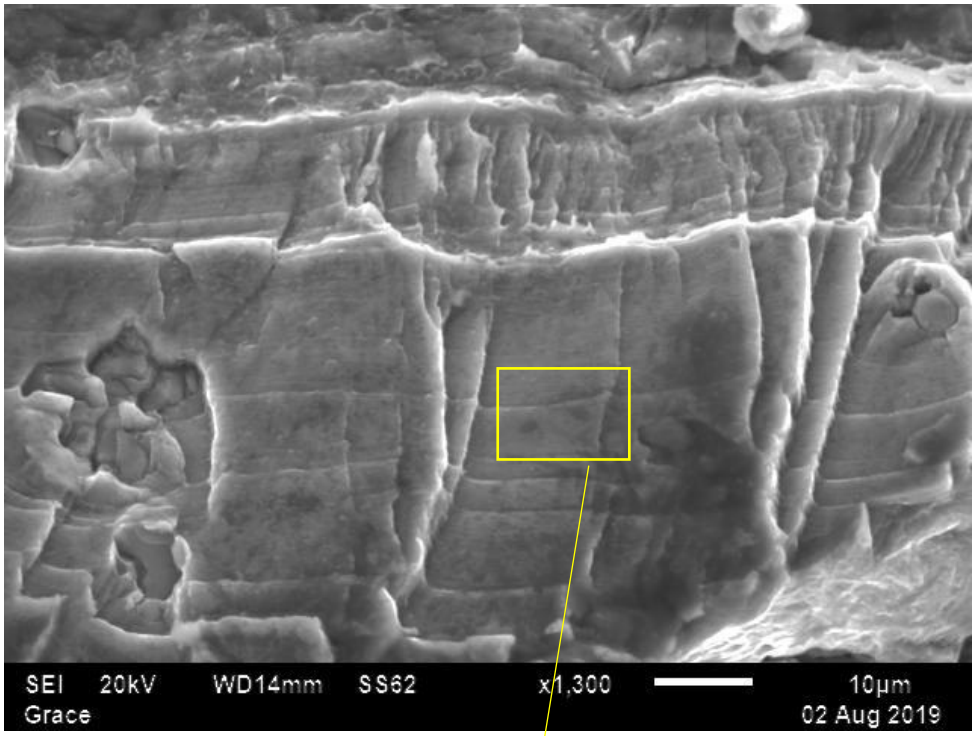


Figure 9: Fracture Piece #1 origin region

a)



b)

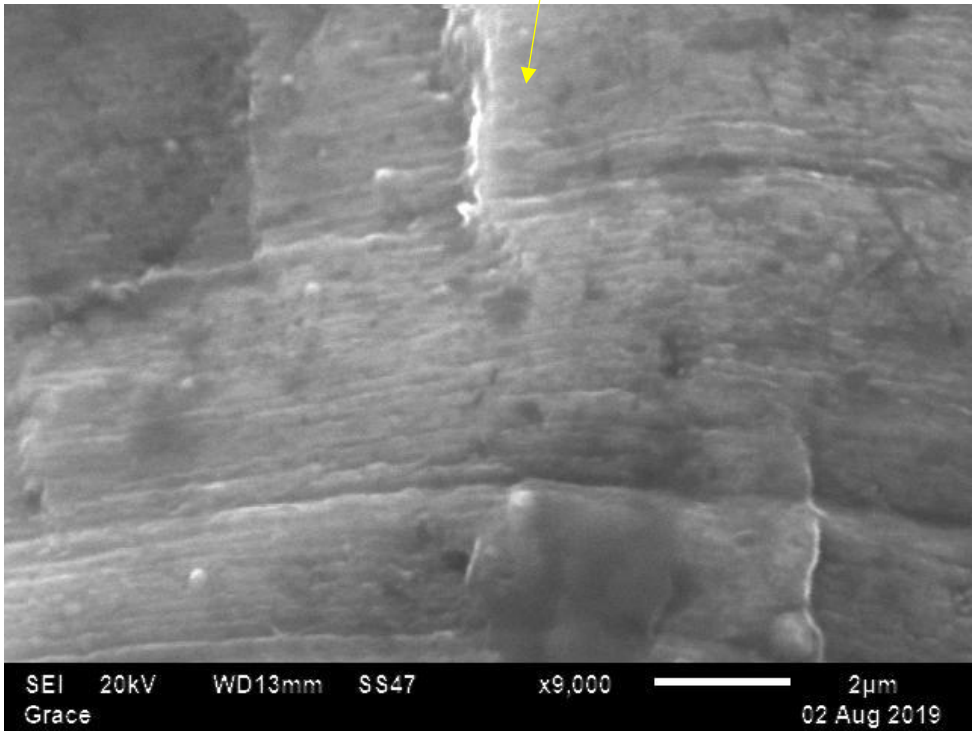
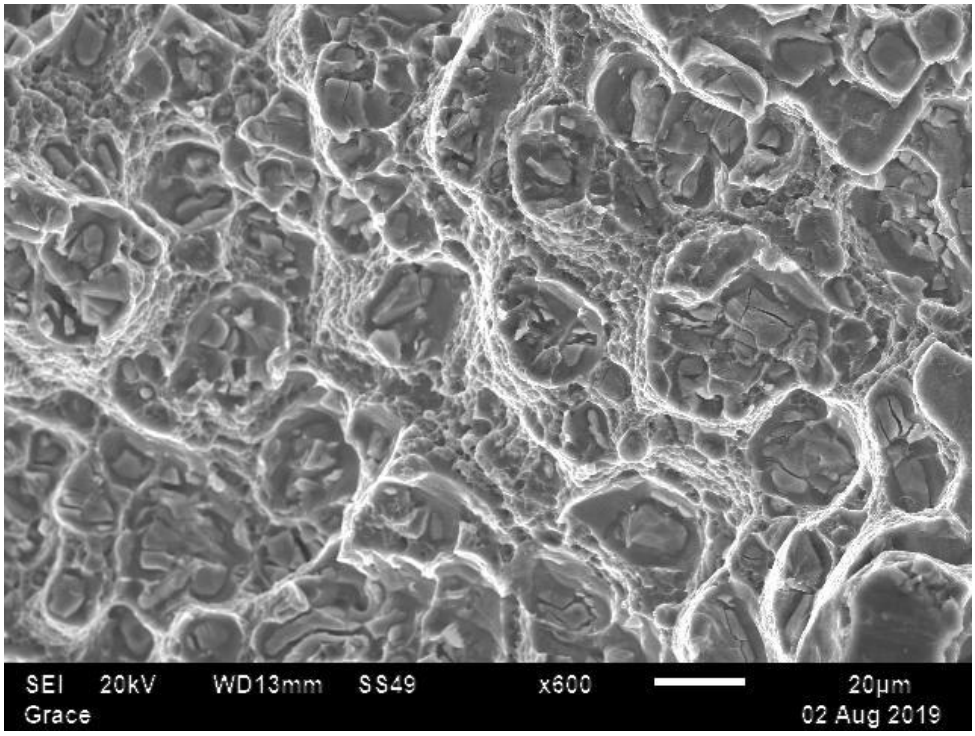


Figure 10: Fracture Piece #1, Visible fatigue striations

a)



b)

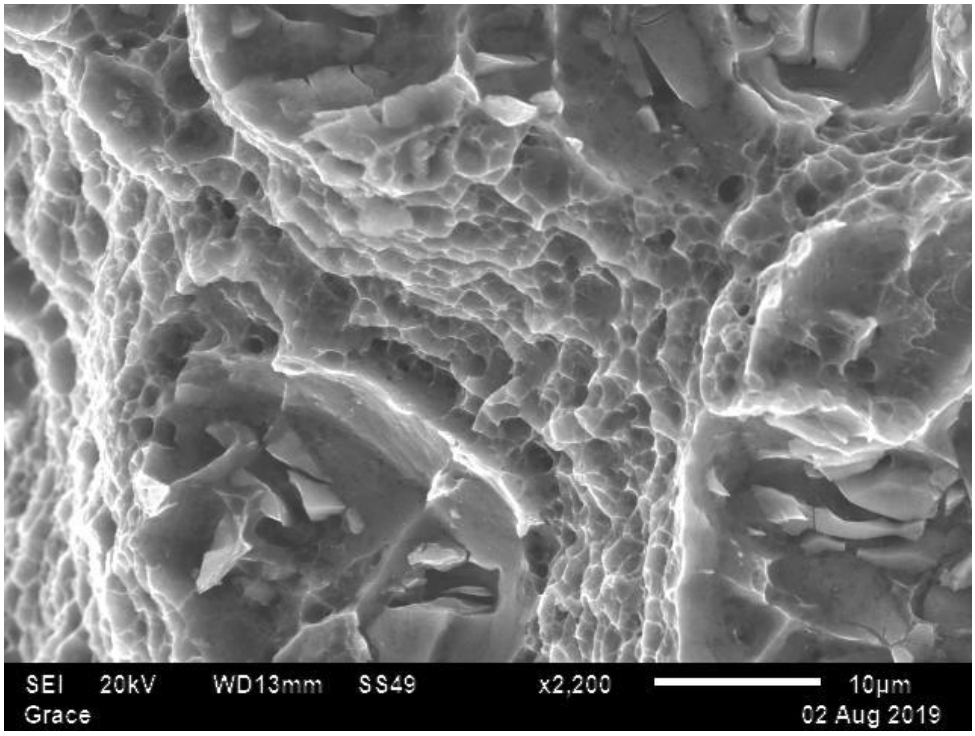


Figure 11: Fracture Piece #1, Overload

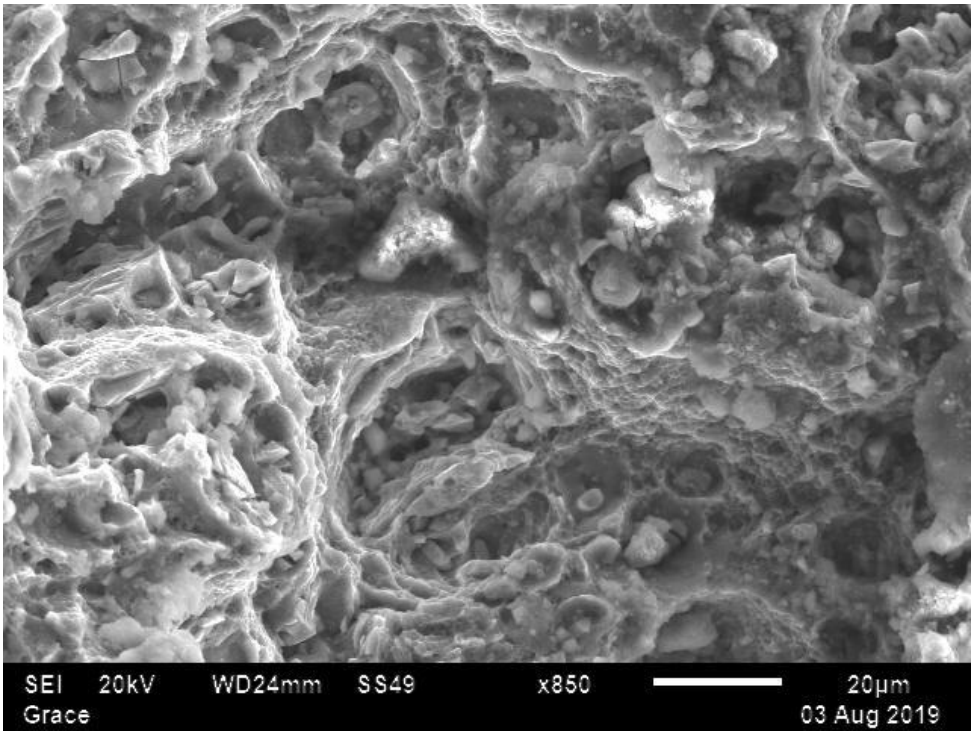


Figure 12: Fracture Piece #2, overload

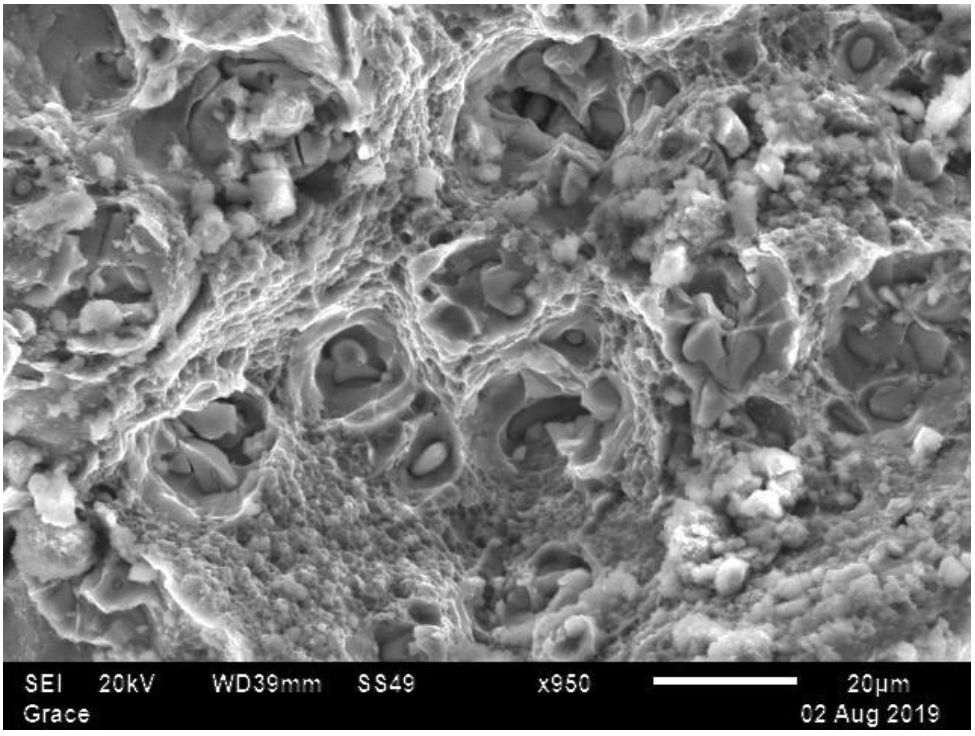


Figure 13: Fracture Piece #3, overload

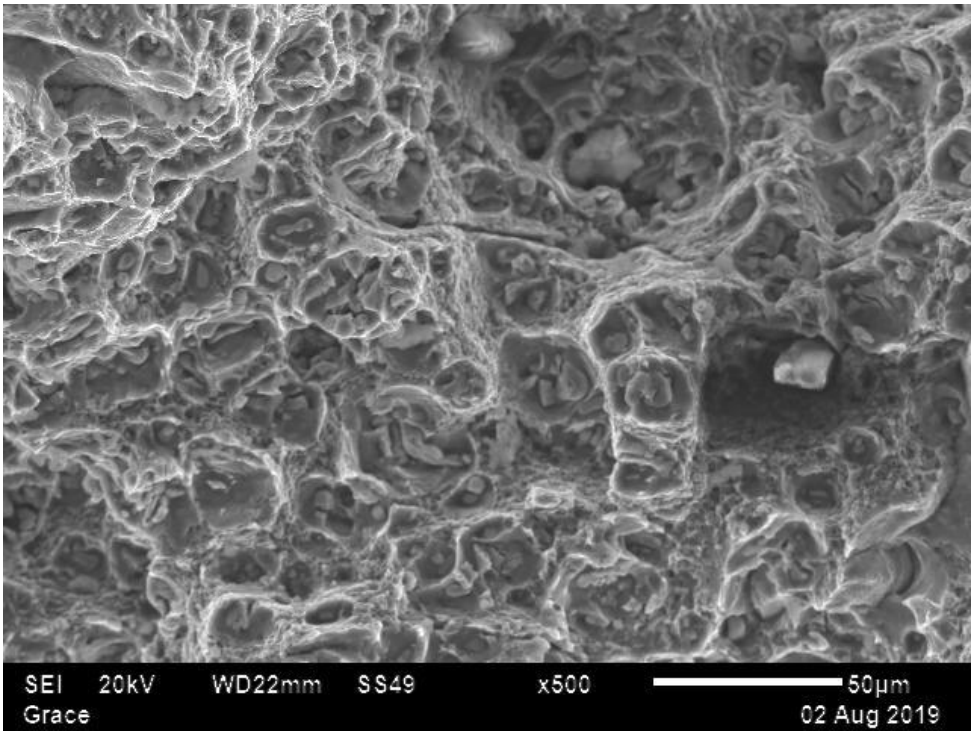


Figure 14: Fracture Piece #4, overload

a)

b)

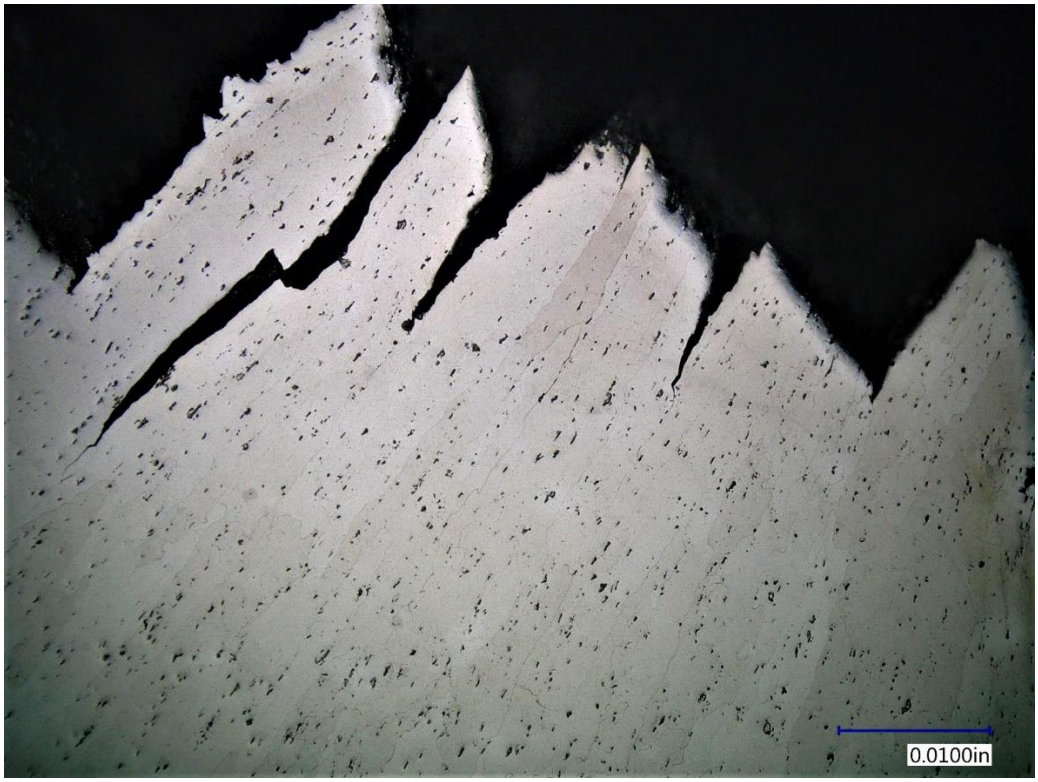


Figure 15: Cross section of upper torque knee a) microstructure is consistent with heat treated 2000 series aluminum. (Etchant: Keller's; Magnification:40x; Mount Index No. 4360) b) Cross section through origin region showing layer separation along grain boundaries (Etchant: Keller's; Magnification: 78x magnification; Mount Index No. 4362)