Section/division Occurrence Investigation Form Number: CA 12-12a

AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/9106
Aircraft Registration	**ZU-MDI**	**Date of Accident**	21 November 2012	**Time of Accident**	1530Z
Type of Aircraft	Falcon 402		**Type of Operation**	Private	
Pilot-in-command Licence Type	Private Aeroplane	**Age**	44	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	950		Hours on Type	30
Last point of departure	Lanseria Aerodrome (FALA)				
Next point of intended landing	Wonderboom Aerodrome (FAWB)				
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)					
Right hand side of runway 29 at Wonderboom					
Meteorological Information	Surface Wind: Westerly, 8kts. Visibility: CAVOK. Temp: 25˚C.				
Number of people on board	1 + 2	**No. of people injured**	0	**No. of people killed**	0

Synopsis

The pilot accompanied by two passengers took off from Lanseria Aerodrome to Wonderboom Aerodrome (FAWB) for an Approved Person to conduct an annual inspection. The right hand undercarriage failed to extend during landing at FAWB. It was revealed that the rod end failed due to prior undetected damage, when the gear was selected “down” for the landing.

The pilot and the passengers sustained no injuries.

The aircraft sustained damages to the right hand undercarriage, flap and the left wing tip.

Probable Cause

Unsuccessful forced landing due to the right hand undercarriage failing to extend.

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner/Operator : Red October Aviation cc
Manufacturer : DMI Engineering (PTY) LTD
Model : Falcon 402
Nationality : RSA
Registration Marks : ZU-MDI
Place : FAWB
Date : 21 November 2012
Time : 1530Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation :

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (1997) this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and ***not to establish legal liability****.*

Disclaimer:

This report is given without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 According to the pilot on the 21st November 2012 he took off from Lanseria (FALA) to Wonderboom (FAWB) for the aircraft to have annual an inspection. During the flight in the circuit the pilot saw the red indication with the undercarriage down position that indicates unlocked, the right hand undercarriage indication light illumination was not green. The pilot flew slowly past the tower for confirmation of undercarriage. The pilot then elected to fly to the general flying area one in Pretoria and tried to do an emergency extension procedure but was unsuccessful.

1.1.2 He performed gear extension manoeuvres. He called FAWB tower to explain the situation. The pilot came in to land at the slowest speed with full flaps, after touch down the aircraft veered to the right hand side and the right hand undercarriage collapsed. The aircraft was shut down by the pilot and after the aircraft came to a stop all occupants evacuated the aircraft.

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	1	-	2	-

1.3 Damage to Aircraft

1.1.3 The aircraft sustained damages to the right hand undercarriage, flap and the left wing tip.

1.4 Other Damage

1.4.1 None.

1.5 Personnel Information

Nationality	RSA	Gender	Male	Age	44
Licence Number	0270299019	Licence Type	Private		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	Night				
Medical Expiry Date	28 February 2013				
Restrictions	Reading glasses				
Previous Accidents	None				

Flying Experience :

Total Hours	950
Total Past 90 Days	30
Total on Type Past 90 Days	30
Total on Type	30

1.6 Aircraft Information

Airframe :

Type	Falcon 402	
Serial Number	402/06	
Manufacturer	DMI Engineering (PTY) LTD	
Year of Manufacture	1972	
Total Airframe Hours (At time of Accident)	176.1	
Annual Inspection (Date & Hours)	05 December 2011	9126.1
Hours since Authority to Fly	8950	
Authority to Fly (Issue Date)	07 December 2011	
Authority to Fly (Expiry Date)	05 December 2011	
C of R (Issue Date) (Present owner)	06 December 2011	
Operating Categories	Private operation	

Note: The aircraft in question initially was a Cessna before it was rebuilt to a Falcon402. The total airframe hours at the time of the accident on the Falcon was 176.1 hours

Engine :

Type	Walter 601D
Serial Number	872038
Hours since New	176.1
Hours since Overhaul	TBO not yet reached

Propeller :

Type	Avia V508/7
Serial Number	930663084
Hours since New	176.1
Hours since Overhaul	TBO not yet reached

1.7 Meteorological Information

1.7.1 Weather information as obtained from the pilot's questionnaires:

Wind direction	Westerly	Wind speed	8kts	Visibility	CAVOK
Temperature	25°C	Cloud cover	Nil	Cloud base	Nil
Dew point	Unknown				

1.8 Aids to Navigation

1.8.1 The aircraft was equipped with standard navigation instruments as per manufacture design. None were reported unserviceable prior to or during the accident.

1.9 Communications.

1.9.1 The aircraft was equipped with standard communication equipment as required by the Regulator. There were no recorded defects to communication equipment prior to the flight.

1.10 Aerodrome Information

Aerodrome Location	FAWB	
Aerodrome Co-ordinates	S253913.78 E0281351.52	
Aerodrome Elevation	4095	
Runway Designations	29	11
Runway Dimensions	1828 x 30	1828 x 30
Runway Used	29	
Runway Surface	Asphalt	
Approach Facilities	NDB, Runway lights, PAPI	

1.11 Flight Recorders

1.11.1 The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR) nor was it required by regulation to be fitted to this aircraft type.

1.12 Wreckage and Impact Information

1.12.1 During the flight while in the circuit the pilot noticed the red light illumination which indicates undercarriage unlocked, he elected to extend them manually. During touch down the aircraft veered to the right hand side of the runway and the right hand main undercarriage collapsed.

Figure 1: Wreckage of the aircraft

1.13 Medical and Pathological Information

1.13.1 None.

1.14 Fire

1.14.1 There was no pre or post impact fire.

1.15 Survival Aspects

1.15.1 The pilot and the passengers were properly restraint with the safety harnesses and due to the low impact force associated with the accident it was considered a survivable accident.

1.16 Tests and Research

1.16.1 The AMO who recovered the aircraft removed the rod end for push pull and sent it to the metallurgist for analysis. The report is attached on appendix 1.

1.17 Organizational and Management Information

1.17.1 This was a private flight.

1.18 Additional Information

1.8.1 None.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 The pilot (who was the owner of the aircraft) accompanied by two passengers took off from Lanseria Aerodrome to Wonderboom Aerodrome for an Approved Person to conduct an annual inspection. The right hand undercarriage failed to extend. It was revealed that the rod end failed due to prior undetected damage, when the gear was selected "down" for the landing. This failure caused the "down lock" mechanism in the starboard main undercarriage to be unsecure and subsequently folding in late during the take-off.

2.2 According to available maintenance records, the aircraft was properly maintained. The Annual Inspection was conducted as per regulations.

2.3 Fine weather conditions prevailed at the time of accident. Therefore it is concluded that weather was not a contributory factor to the accident.

2.4 The undetected damage can however be associated with two failure locations due to failures in the landing gear mechanism.

2.5 Further analysis can be found in the appendix

3. CONCLUSION

3.1 Findings

3.1.1 The pilot had a valid private license and was properly rated on the aircraft type.

3.1.2 The pilot had a valid medical certificate which expires on the 28 February 2013.

3.1.3 The aircraft had a valid Authority to Fly issued on the 07th December 2011 and expires on the 05th December 2012.

3.1.4 The aircraft initially was a Cessna and it was rebuilt to a Falcon 402.

3.15 Weather was not a contributory factor to the accident.

3.2 Probable Cause/s

3.2.1 The right hand undercarriage failed to extend. It was revealed that the rod end failed due to prior undetected damage, when the gear was selected "down" for the landing.

4. SAFETY RECOMMENDATIONS

4.1 None.

5. APPENDICES

Failure surface characterisation of Cessna Landing component

1 SCOPE

A failure on one of a Cessna 402 landing gear components resulted in an incident whereby the landing gear was not properly locked during the landing of the aircraft. The tie-rod is reportedly manufactured from a type 7075 aluminium and the fracture surface appears different at the two failure locations. The aim of the failure surface and material characterisation is to establish whether there may have been existing damage that could have lead to the failure. Furthermore, if such defect does exist the scope should be to characterise the nature of this defect.

2 SAMPLE DESCRIPTION

One failed tie-end remnant of the Cessna 402 landing gear, containing two fracture surfaces (only the one side of each fracture) was received (see Figure 1). The opposing fracture surfaces (the other part of the tie-end) were not provided. The two fracture surfaces are referred to as bright and dull as indicated in Figure 1.

3 TESTS

Visual evaluation of the failed component was undertaken to identify any macro failure features. A stereo microscope was used to facilitate higher magnification of the fracture surfaces and all characteristics were recorded via digital photography.

A cross-sectional sample through the fracture region of the failed component was prepared for metallographic examination. After polishing the sample to a 1 µm finish the sample was etched with Keller's reagent for 38 seconds. The microstructure was subsequently assessed by means of light microscopy and any anomalies and characteristics recorded by means of photography.

Triplicate hardness measurements were performed in accordance with ASTM E18- 11 on a section of the component with a load of 100 kgf and a 1/16 ball indenter.

The failure region(s) were also examined using a scanning electron microscope at various magnifications in order to characterise the fracture surface. The surface spot measurements to determine the composition of deposits or contamination was performed by means of semi-quantitative analysis using Energy Dispersive Spectrometry (EDS). An example of such an analyses and spectrum (for region 2 of the dull fracture surface) is provided in Appendix A.

4 RESULTS

4.1 Visual examination

From the visual examination of the failed component it was apparent that the appearance of the two fracture surfaces was significantly different (Figure 1). The one fracture surface appeared dull and red-brownish whilst the other was bright and grey-ish in colour. Close-ups of the respective fracture surfaces as viewed during stereo microscopy are provided in Figure 3 and Figure 4 for respectively the dull and bright surfaces. The dull fracture surface was soiled with some contaminant in the form of a yellowish residue (bottom-middle section) as shown in Figure 3. The edged was significantly tapered and showed clear evidence of mechanical rubbing damage (see Figure 5 for a side view of the same section). The fracture surface of the bright surface (Figure 4) was more rectangular and grey-ish, reminiscent of an unsullied fracture surface. At the top end of the fracture surface (Figure 4) the coating layer is clearly evident.

A slight deviation from the edge profile was observed for the bright surface section as illustrated by the yellow reference lines in Figure 2. It appears that the end section was slightly twisted in relation to the remainder of the component. Viewing the component from the side, a fine hairline crack was observed at the location of deviation and/or twisting (Figure 2). Since the original design drawing is not available it can not be confirmed whether there was originally an intentional geometrical change in this region, however, the twisting related deformation is definitely incurred by the failure event.

4.2 Hardness testing

The hardness measurements as determined with an Indentec hardness tester is respectively 71.8, 72.3 and 73 HRB for the three indentations made. The average hardness is thus 72.4 HRB. The typical hardness for wrought type 7075 aluminium in the tempered condition is 80 HRB (or 150 HB)[1].

4.3 Metallographic evaluation

The microstructure of the failed component showed that a significant volume of precipitates were present (as expected for the type of alloy). The microstructure at various magnifications is provided in Figure 6. Significant plastic deformation was also identified at the fracture end. No Anomalies were observed.

[1] Aluminium federation of Southern Africa, datasheet wrought 7075 in either temper condition T6 or T8. www.afsa.org.za.

4.4 Scanning Electron Microscopy

Evaluation of the dull fracture surface, initially in the as-received condition (to aid surface analyses) did not yield any failure features. The Fracture surface was significantly covered with debris or contamination (as shown in the top section of Figure 7) which made it impossible to distil any details of the fracture mode. Subsequent to performing various surface analyses in order to characterise the fracture surface and identify the debris, the sample was chemically cleaned in a citric acid solution in an ultrasonic bath. Following the cleaning the sample was again assessed by means of Scanning Electron Microscopy, and a section (predominately coinciding with the area where the yellow debris covered the surface –see Figure 3), void coalescence and ductile tearing was observed (bottom image of Figure 7). Other sections of the cleaned surface was smooth and also showed some rubbing and smearing damage similar to that observed in Figure 8. The remainder of the fracture surface (apart from the ductile overload section) was thus too damaged to allow proper characterisation of the original failure surface.

The bright fracture surface was also examined and most of the fracture surface was characterised by micro void coalescence and ductile overload failure (Figure 9). In some instances the precipitates could be discerned within the ductile failed cups. It was not necessary to clean this surface since, in the as-received condition, the characterisation could easily be performed.

4.5 Energy Dispersive Spectrometry (EDS)

Multiple surface analyses of as-received condition of the two fracture surfaces were performed. The results of the surface semi-quantitave analyses is summarised in Table 1.

Table 1: Summary of surface analyses performed on the dull and bright fracture surfaces.

Location		O	Mg	Al	Si	Fe	Ti	Mn	Other
Dull	Region 1	20.0	0.4	39.3	31.2	4.74	1.88	0.3	Cl = 0.6, K = 0.5, Ca= 0.3, Cu = 0.83
	Region 2	31.1	1.6	24.2	21.3	9.6	6.1	1.1	S= 1.0, K=1.0, Ca = 0.8, Cr = 0.7, Cu = 0.8, Zn = 0.8
	Region 3	39.6	-	2.6	45.7	1.9	7.4	-	P = 1.1, Ti = 7.4, Zn = 1.7
	Region 4 (highlights)	24.9	-	39.3	16.1	3.9	3.2	1.0	P = 0.9, S = 1.0, Cl = 0.9, K = 1.2, Ca = 0.5, Cu = 1.1, Zn = 0.6
	Region 4	25.5	-	27.1	25.8	7.5	5.7	1.0	P = 1.1, S = 1.1, Cl = 1.0, k = 1.2, Ca = 0.9, Cu = 1.1, Zn = 1.0
	Region 5	34.0	-	14.9	19.3	5.0	4.1	0.8	P = 6.1, S = 1.8, Cl = 1.0, K = 1.1, Ca = 1.0, Cu = 0.8, Zn = 9.5
	Region 7	33.8	1.1	7.7	46.6	5.6	1.7	-	K = 2.0, Ca = 1.6
	Region 8	28.0	1.0	31.9	28.8	3.8	1.3	-	S= 1.1, Cl = 1.9, K = 1.0, Ca = 0.7, Cu = 0.7
Bright	Region A	2.6	1.4	81.1	1.6	1.8		1.9	Cu = 4.3
	Region B	2.4	1.6	82.1	1.8	1.3	-	1.3	Cu = 4.3
	Region C	2.2	1.7	73.4	1.85	1.8	-	2.2	Cu = 16.8
	Region D	2.0	1.3	86.44	2.98	1.2	-	1.3	Cu = 4.8

* Carbon has been identified (but not quantified) in all of the analyses.

5 DISCUSSION

The manufacturer prescribed minimum hardness has, however not been provided, thus it cannot be concluded whether the hardness of the material was insufficient, yet it is noted that the hardness is lower than conventional 7075 Aluminium as indicated in § 4.2 and would indicate a lower tensile strength than typically anticipated.

The presence of some copper, magnesium, silicon, iron, manganese, titanium and chromium for the various surface analyses performed can be anticipated as these are the alloying used for a type 7075 aluminium. However, with a thick layer of debris or contamination, the portion of the substrate (alloy) within the interaction volume of the electron beam for the analyses diminishes and thus the quantity of the alloying elements for the particular analyses. From Table 1 it is evident that dull fracture surface contained surface regions with a significant oxygen content (20 to 39.6 wt.%) and the bright fracture surface a negligible between 2 to 2,6 wt.% content. The latter implies that the dull fracture surface is in a more severe oxidised state and/or contains debris rich in oxygen. This is (in part) possible when a severely aggressive corrosive reagent attacked the aluminium or when the component is exposed to normal atmospheric conditions for a prolonged period. Given that the chance of aggressive localised contamination (only on the dull fracture surface) is slim, it is most likely that the dull fracture surface has been exposed for a much longer time to atmospheric conditions. This suggests that the dull fracture surface should have failed on a previous occasion, a significant time before bright fracture surface. This postulation of a previous (initial) failure would also explain the accumulation of more debris, the extensive rubbing damage and mechanical smearing noted (Figure 3) for the dull fracture ligament.

The slight twisting (Figure 2) of the bright fracture surface section would also suggest that during an abnormal loading event that the other ligament must have already been severed in order to facilitate the torsion on the bright fracture surface ligament.

A portion of the dull fracture surface did contain evidence of ductile overload (i.e. excessive loading or force) (Figure 7) however, this could in theory be the portion that was failed in overload after some initial fatigue crack propagation that severed the remainder of the fracture surface. However, no failure characteristics typical of fatigue degradation were observed. The rubbing, smearing and fracture surface degradation makes it impossible to establish what the original fracture surface characteristics are. It is also plausible that the gear mechanism was impinged during previous operation or damaged or crushed during repair or inspection work, which could have caused the mechanical degradation as noted in Figure 8 too. Another alternative is that this mechanical damage was incurred as subsequent damage during the landing incident. However the last statement is in contradiction with the well preserved bright fracture surface of the same component. Perhaps photograph(s) and/or reconstruction of the scene of the landing incident can clarify whether the alternative scenario is possible or not. Moreover, comparing the mating fracture surfaces of the other portion of the tie-end (not received) would facilitate a check for consistency of the findings.

The dull fracture surface failed in overload as attested by the micro void coalescence and cup and dimple fracture surface (Figure 9).

6 CONCLUSIONS

The following conclusion can be mad e based on the investigation results:

- The hardness of the failed component remnant was 72 HRB and is lower than the typical hardness for conventional wrought 7075 aluminium in the T6 condition.
- The dull appearing fracture surface contained significant debris and a significant higher quantity of oxygen, suggesting that the aluminium could be more severely oxidised at this location. The latter may be possible if the dull fracture failed during a separate incident some time before the tie-end was completely severed.
- The dull fracture surface did contain an area that failed in ductile overload. The remainder of the fracture surface was smooth and degraded by mechanical rubbing and corrosion, whereby it can no longer be distilled what the original fracture surface characteristics were.
- The bright fracture surface failed in overload as attested by the micro-void coalescence and cup and dimple fracture surface.

7 FIGURES

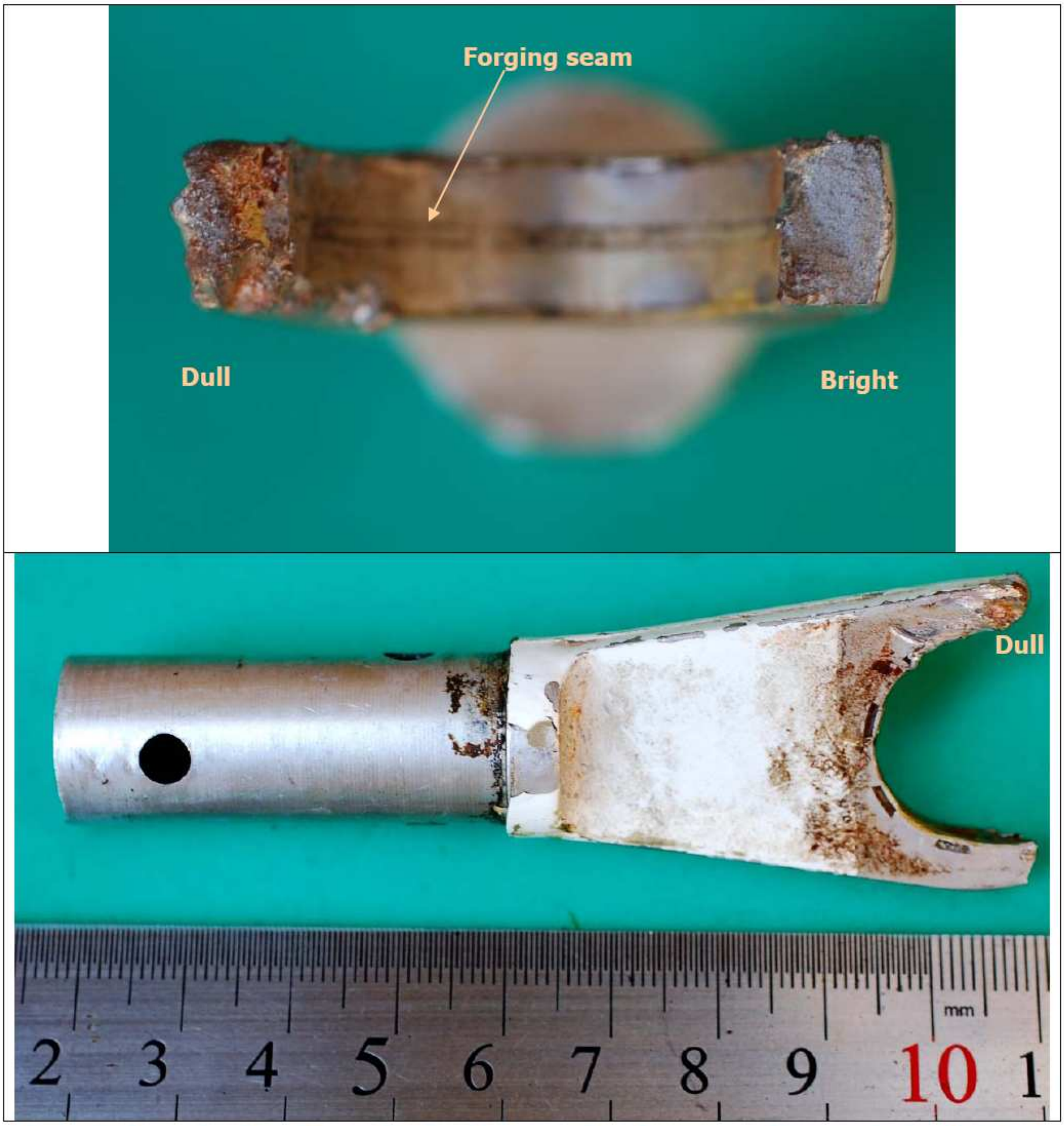


Figure 1: As-received condition of the landing gear tie end remnant with two single sided fracture surfaces respectively referred to as dull and bright.

Figure 5: Side view of dull fracture end, showing additional mechanical damage to the side walls.

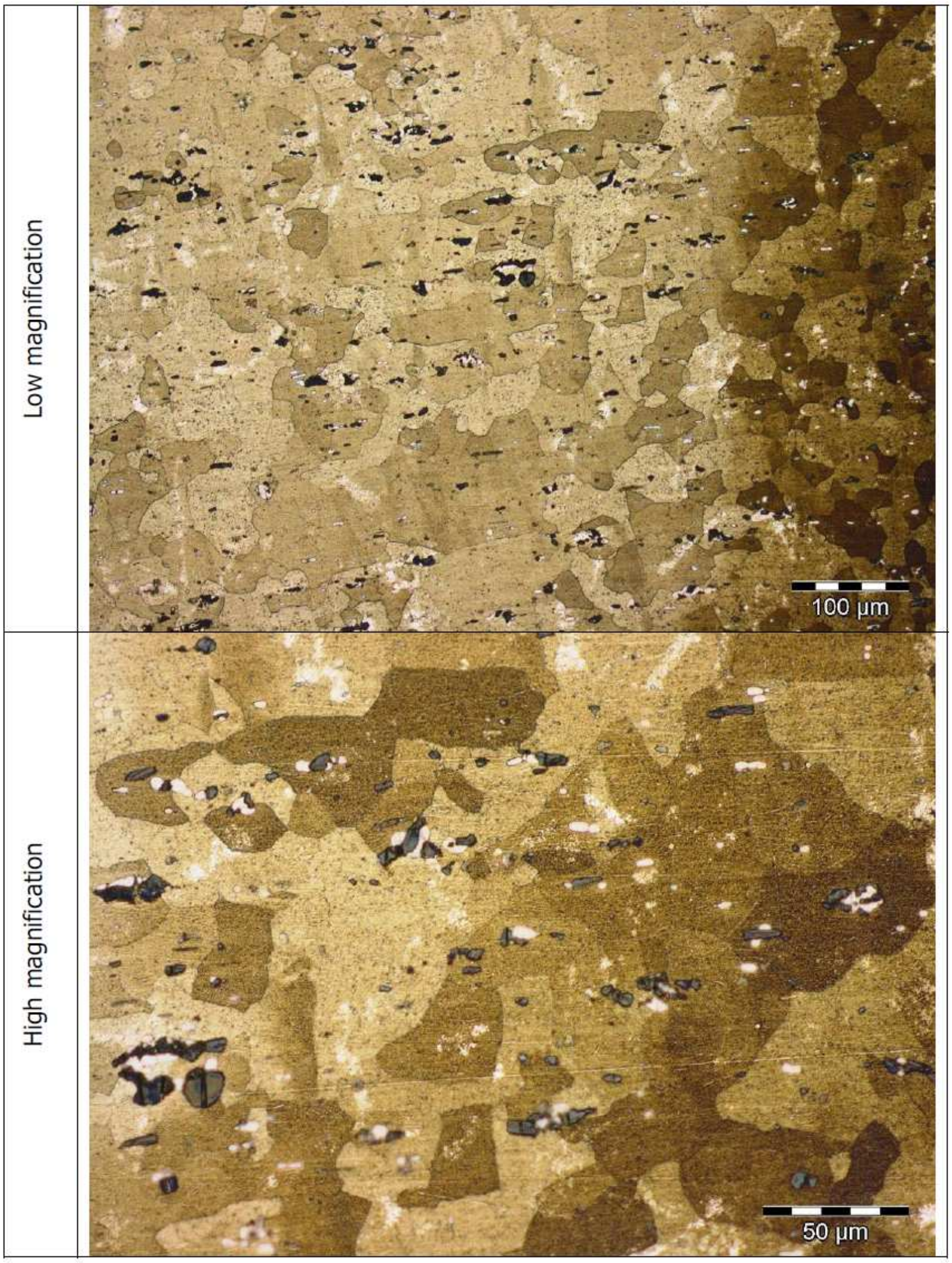


Figure 6: Microstructure of the dull fracture cross-section at various magnifications after etching with Keller's reagent.

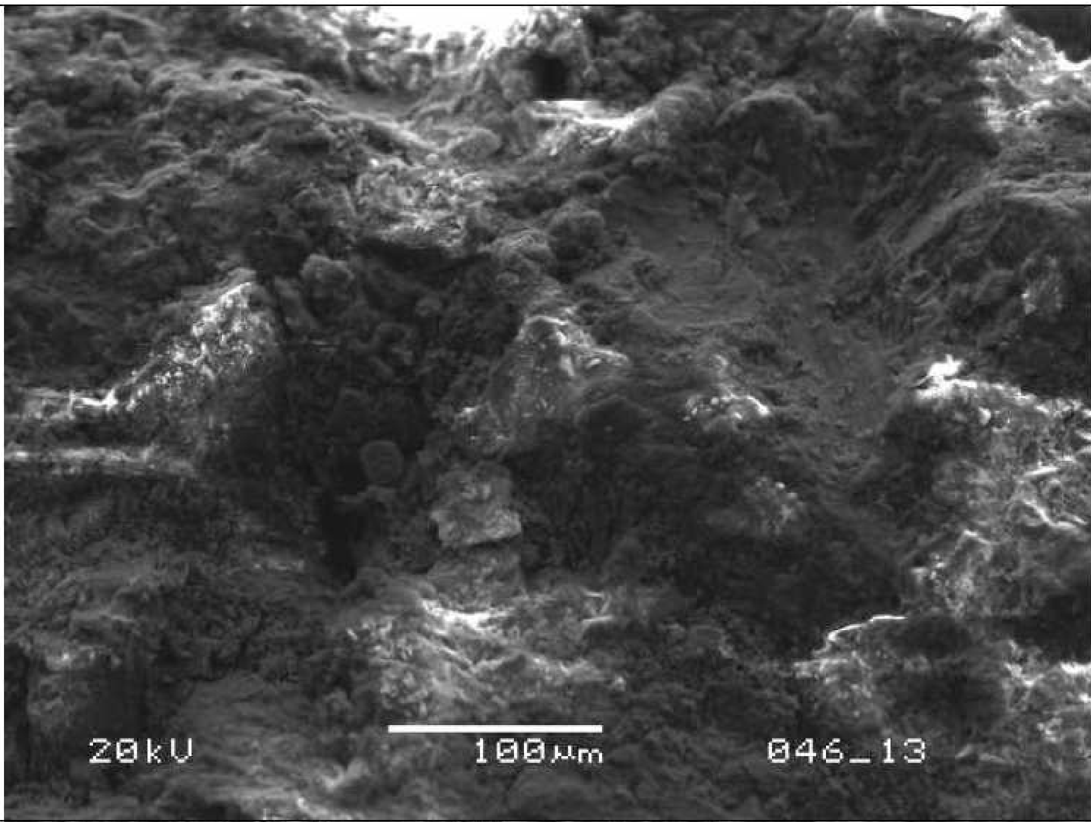
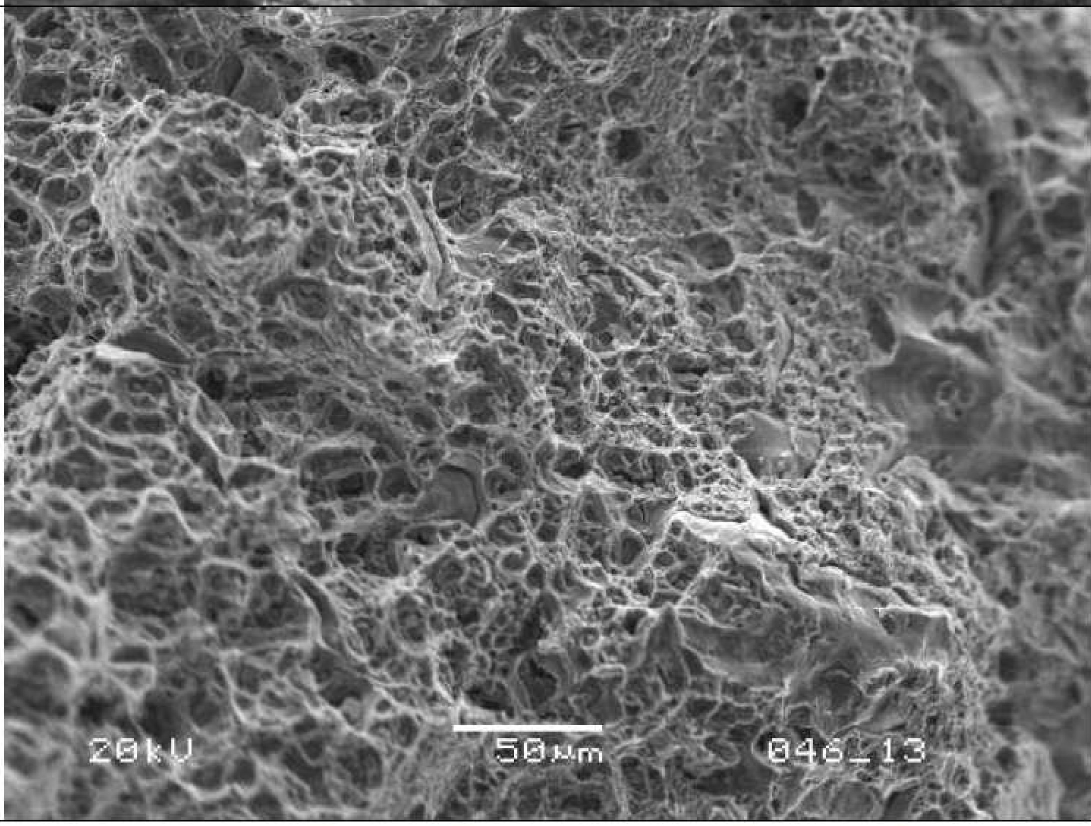
As-received (prior to cleaning)	
Surface debris removed with chemical cleaning	

Figure 7: Various regions of the dull fracture surface before and after cleaning.

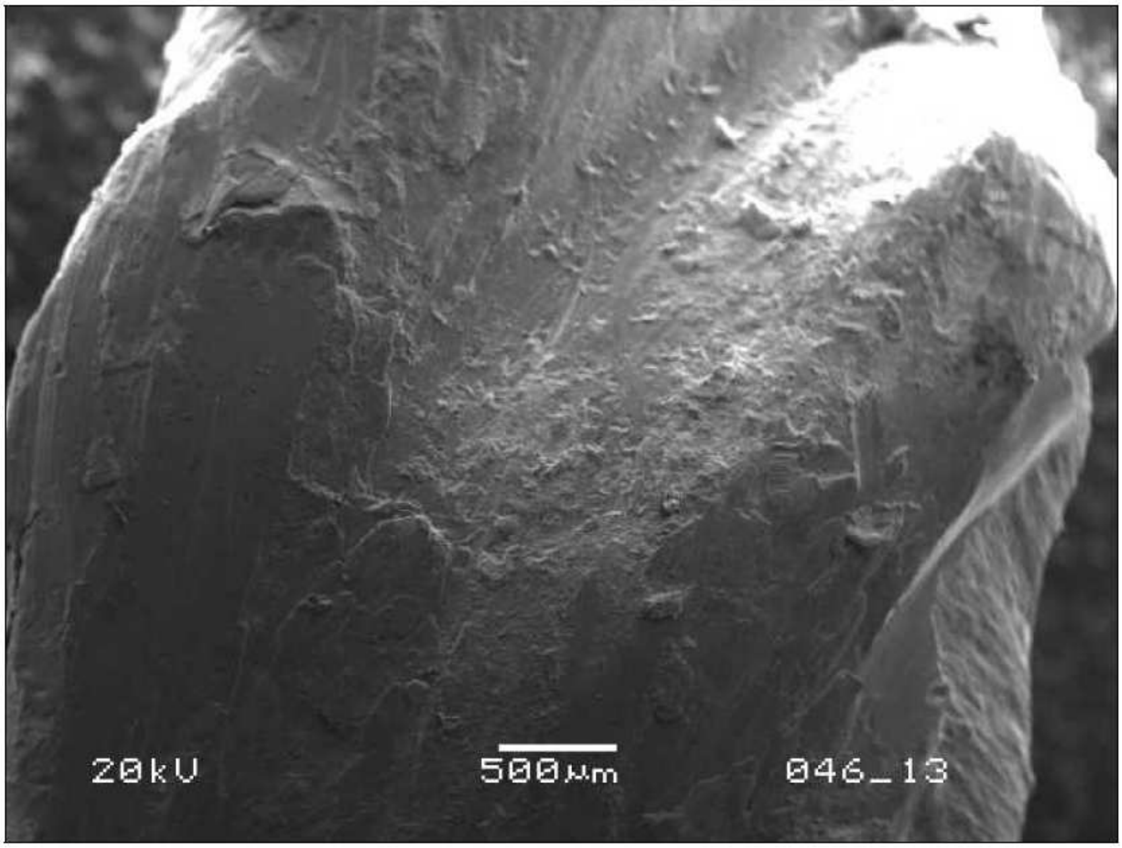


Figure 8: Side view of dull fracture end showing significant rubbing and forging damage.

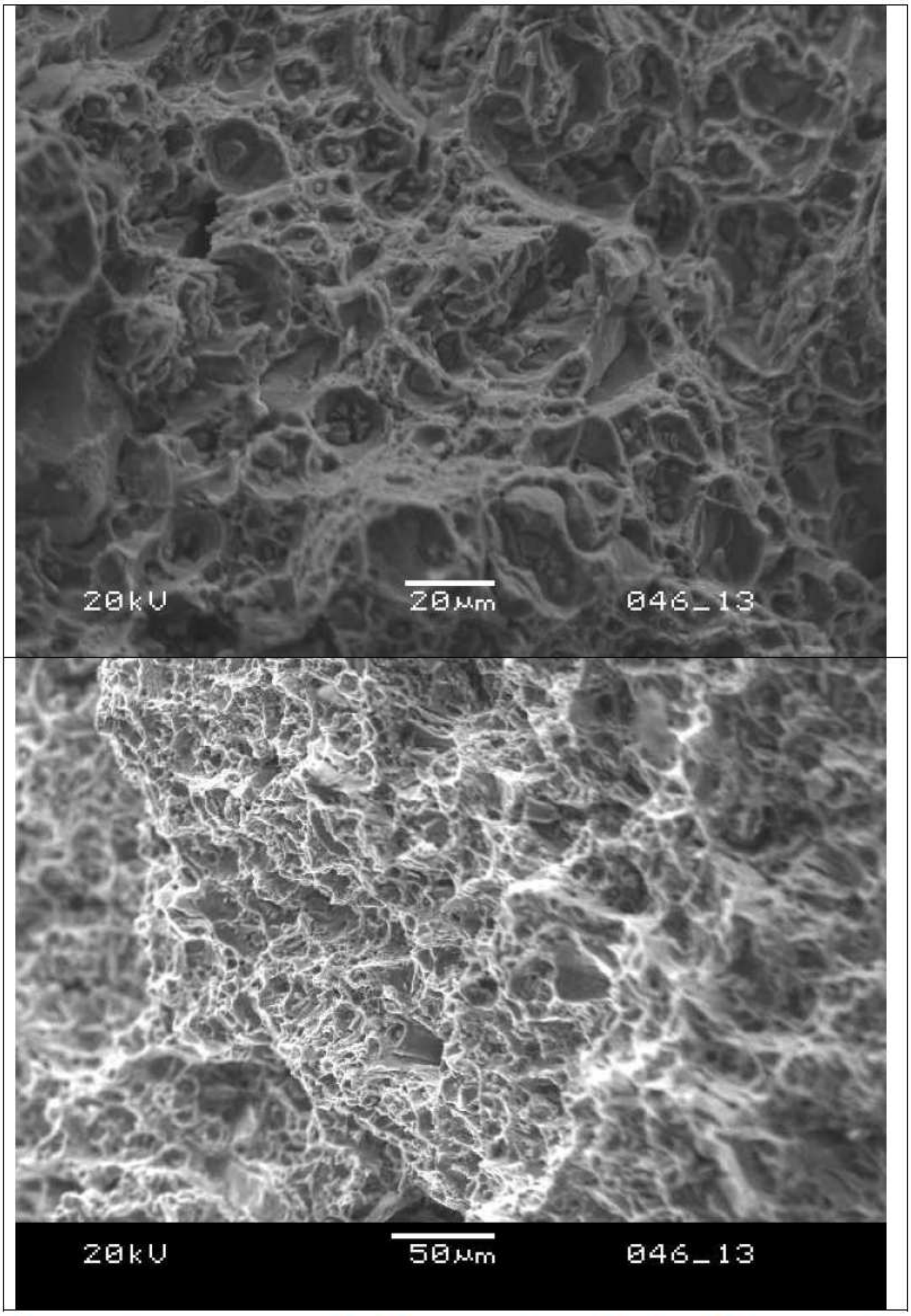
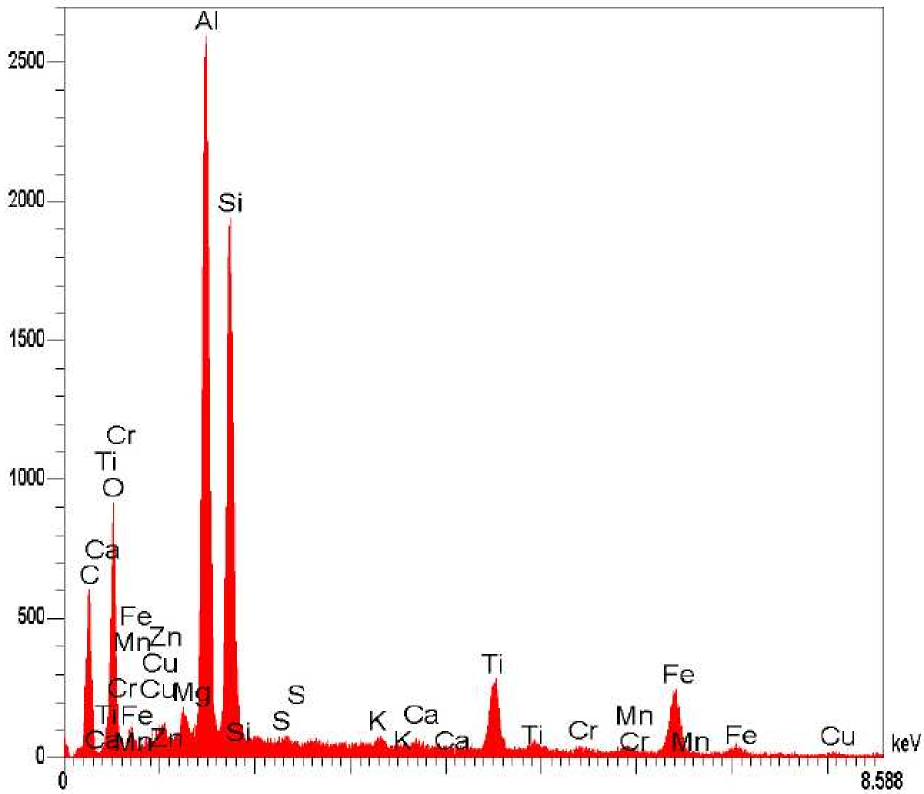


Figure 9: Various regions of the fracture surface of the bright fracture surface, as-received.



Analysis Conditions

Accelerating Voltage (kV):	20.0
Beam Current (nA):	670.000
Tilt Angle (deg):	0.0
Take Off Angle (deg):	45.0
Magnification:	100
Live Time (s):	60
Azimuth Angle (deg):	0.0
Preset Time (s)	60

Nb Channels	2048
Ev / Channel	10
Offset (keV)	0
Width (keV)	20

Analysis

Correction Method:	XPP
Analysis Type:	StdLess
Number of oxygens:	8
X 2	4.81

Quantitative Results

Elt	XRay	Int	Error	K	Kratio	W%	A%	ZAF	Formula	Ox%	Cat#
C	Ka	66.9	1.0560	0.0000	0.0000	0.00	0.00	9.4544		0.00	0.00
O	Ka	108.2	1.3428	0.1588	0.0916	31.01	47.35	3.3833		0.00	0.00
Mg	Ka	21.7	0.6020	0.0159	0.0092	1.61	1.62	1.7555		0.00	0.00
Al	Ka	377.4	2.5078	0.2792	0.1611	24.15	21.87	1.4989		0.00	0.00
Si	Ka	291.6	2.2046	0.2251	0.1299	21.31	18.53	1.6403		0.00	0.00
S	Ka	12.8	0.4613	0.0118	0.0068	0.99	0.76	1.4582		0.00	0.00
K	Ka	12.5	0.4559	0.0149	0.0086	1.02	0.64	1.1900		0.00	0.00
Ca	Ka	9.2	0.3908	0.0120	0.0069	0.78	0.47	1.1201		0.00	0.00
Ti	Ka	56.2	0.9676	0.0905	0.0522	6.13	3.13	1.1735		0.00	0.00
Cr	Ka	5.4	0.3010	0.0111	0.0064	0.74	0.35	1.1532		0.00	0.00
Mn	Ka	6.7	0.3339	0.0156	0.0090	1.07	0.48	1.1903		0.00	0.00
Fe	Ka	52.5	0.9355	0.1418	0.0818	9.55	4.18	1.1673		0.00	0.00
Cu	Ka	2.7	0.2115	0.0119	0.0069	0.84	0.32	1.2195		0.00	0.00
Zn	Ka	2.1	0.1872	0.0113	0.0065	0.80	0.30	1.2185		0.00	0.00
				1.0000	0.5771	100.00	100.00			0.00	0.00

Compiled by:

....
For: Director of Civil Aviation

Date: ……………………………..

Investigator-in-charge: ………………………………

Date: …………………………..

Co-Investigator: ………..………………………….

Date: …………………………