SOUTH AFRICAN CIVIL AVIATION AUTHORITY

Section/division **Accident & Incident Investigation** Form Number: CA 12-12a

AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:	CA18/2/3/8281	
Aircraft Registration	**ZU-DLV**	**Date of Accident**	7 April 2007	**Time of Accident**	0630Z
Type of Aircraft	Bushbaby 450 (aeroplane)		**Type of Operation**	Private	
Pilot-in-command Licence Type	Microlight	**Age**	44	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours		178.4	Hours on Type	178.4
Last point of departure	Bapsfontein aerodrome (Gauteng province)				
Next point of intended landing	Rhino Park aerodrome (Gauteng province)				
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)					
700 m short of threshold of runway 09, Rhino Park aerodrome (GPS position: South 25°50'57 East 028°32'30)					
Meteorological Information	Surface wind: 090°/5 kts; Temperature: 17°C; Visibility: +10 km				
Number of people on board	1 + 1	**No. of people injured**	0	**No. of people killed**	0

Synopsis

The pilot, accompanied by a passenger, departed from Bapsfontein aerodrome on a private flight to Rhino Park aerodrome, with the intention of returning to Bapsfontein. He stated that he approached Rhino Park from the east and joined on a right downwind for landing on runway 09. He was number two in the circuit for landing.

As he turned onto right base at a height of about 400 to 500 feet above ground level (AGL), the engine failed. He executed a forced landing in an open, dried-out wetland covered in dense grass 500 mm to 700 mm high.

Approximately 30 m after touchdown, the aircraft nosed over and came to rest inverted. Both occupants disembarked from the wreckage immediately, fearing a possible post-impact fire.

Nobody was injured in the accident.

Probable Cause

Unsuccessful forced landing following an engine failure in-flight, which was attributed to a mechanical malfunction.

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner	: Mr J.G. Visser
Name of the Operator	: Private
Manufacturer	: Kitplanes for Africa
Model	: Bushbaby 450
Nationality	: South African
Registration Marks	: ZU-DLV
Place	: Rhino Park
Date	: 7 April 2007
Time	: 0630Z

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 produce without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 The pilot, accompanied by a passenger, departed from Bapsfontein aerodrome on a local pleasure flight with the intention of landing at Rhino Park aerodrome and then returning to Bapsfontein.

1.1.2 According to the pilot, he approached Rhino Park aerodrome from the east and joined on a right downwind for runway 09. He was number two in the circuit for landing. As he turned onto right base at a height of about 400 to 500 feet above ground level (AGL), the engine failed. He executed a forced landing in an open, dried-out wetland covered in dense grass 500 mm to 700 mm in high.

1.3.1 Approximately 30 m after touchdown, the aircraft nosed over and came to rest inverted. The occupants, fearing a post-impact fire, disembarked immediately. Once clear of the wreckage, they turned the aircraft back onto its wheels to stop fuel leaking from the tanks through the fuel filler caps. Nobody was injured in the accident and aerodrome personnel were quickly on the scene to render assistance following notification of the forced landing by another aircraft in the circuit.

1.4.1 The accident occurred during daylight at the coordinates South 25°50’57 East 028°32’30 and at an elevation of 4 784 feet above mean sea level (AMSL).

1.2 Injuries to Persons

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

1.3 Damage to Aircraft

1.3.1 The aircraft sustained substantial structural damage as a result of nosing over.

Figure 1. The aircraft after being righted.

1.4 Other Damage

1.4.1 None.

1.5 Personnel Information

Nationality	South African	Gender	Male	Age	44
Licence Number	*****************	Licence Type	Microlight		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	None				
Medical Expiry Date	31 July 2008				
Restrictions	None				
Previous Accidents	None				

Flying Experience

Total Hours	178.4
Total Past 90 Days	9.7
Total on Type Past 90 Days	9.7
Total on Type	178.4

1.6 Aircraft Information

Airframe

Type	Bushbaby 450	
Serial Number	018	
Manufacturer	Kitplanes for Africa	
Year of Manufacture	2004	
Total Airframe Hours (At time of Accident)	203.7	
Last Annual Inspection (Hours & Date)	191.6	21 January 2007
Hours since Last Annual Inspection	12.1	
Authority to Fly (Issue Date)	22 January 2007	
Authority to Fly (Expiry Date)	21 January 2008	
C of R (Issue Date) (Present Owner)	6 July 2004	
Operating Categories	Non-Type Certified Aircraft	

Engine

Type	Rotax 618
Serial Number	425 4091
Hours since New	253.7
Hours since overhaul	TBO not yet reached.

Propeller

Type	GSC 2-bladed propeller
Serial Number	No serial number available
Hours since New	203.7
Hours since overhaul	TBO not yet reached.

Weight & Balance

Aircraft empty weight	247.5 kg
Pilot	100.0 kg
Passenger	90.0 kg
Fuel (½ tanks = 50ℓ)	36.0 kg
Total weight	**473.5 kg**

According to the aircraft operating manual and information on Bushbaby 450 ZU-DLV (ref: CAA aircraft file), the permitted maximum gross weight for the aircraft was 450 kg. The calculation above indicates that the aeroplane exceeded this limitation by approximately 5.2% or 23.5 kg.

1.7 Meteorological Information

1.7.1 The weather information was obtained from the pilot's questionnaire.

Wind direction	090°	Wind speed	5 kts	Visibility	+ 10 km
Temperature	17°C	Cloud cover	1/8	Cloud base	5 000 ft
Dew point	Unknown				

1.8 Aids to Navigation

1.8.1 The aircraft was equipped with a magnetic compass and the pilot also had a Garmin 196 GPS on board. The GPS was switched off at the time of the accident.

1.9 Communications

1.9.1 The aeroplane was equipped with an Icom A22E VHF radio. The pilot broadcast his intentions on the Rhino Park aerodrome frequency of 135.60 MHz. He was number two for landing behind another aircraft. Following the engine failure, he briefly communicated with the pilot of a third aircraft, indicating his problem and his intention, and asked him to look out for ZU-DLV on the ground.

1.10 Aerodrome Information

1.10.1 The pilot executed a forced landing approximately 700 m short of the threshold of runway 09 at Rhino Park aerodrome. The accident occurred outside the aerodrome perimeter fence in a dried-out wetland covered in tall grass.

1.11 Flight Recorders

1.11.1 The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR). Neither was required by regulations to be fitted to this aircraft type.

1.12 Wreckage and Impact Information

1.12.1 The engine failed while the pilot was turning onto right base for landing on runway 09 at Rhino Park aerodrome. Following the engine failure, the pilot landed straight ahead in an open, grass-covered area. Approximately 30 m after touchdown, the aircraft nosed over, coming to rest inverted.

1.13 Medical and Pathological Information

1.13.1 Neither the pilot nor the passenger was injured in the accident.

1.14 Fire

1.14.1 There was no evidence of a pre-or post-impact fire.

1.14.2 According to the pilot, he and his passenger immediately turned the aircraft back onto its wheels after disembarking as fuel was leaking from the fuel tanks and they wanted to eliminate the risk of a post-impact fire. The two fuel tanks were not ruptured during the accident and each was still approximately half-full.

1.15 Survival Aspects

1.15.1 Both occupants were properly restrained by the aircraft-equipped safety harnesses, and the cabin remained intact during the accident. In addition, the forward speed of the aeroplane at the time it nosed over was slow due to the tall grass absorbing most of the kinetic energy.

1.16 Tests and Research

1.16.1 Engine teardown inspection:

The engine, a Rotax 618, Serial No. 4254091, was removed from the aircraft following recovery of the wreckage and was subjected to a teardown inspection.

The following observations were made:

(i) Both carburettors were found to be undamaged.
(ii) The main jets installed in the carburettors were within the specifications stipulated by the engine manufacturer.
(iii) The water pump, oil pump and gearbox assembly were undamaged and in good condition..
(iv) The spark plugs were removed and found to be in good condition. The electrodes were a greyish colour, consistent with normal engine operation.
(v) The ignition system was removed and inspected, and appeared to be in good condition.
(vi) The cylinder head assembly was undamaged and in good condition.
(vii) A substantial amount of engine oil was present in the engine.
(viii) The injection rotary valve displayed evidence of object damage in line with the No. 2 cylinder.
(ix) A substantial amount of debris, in the form of broken oil rings, was retrieved from within the engine casing. These originated from the No. 2 piston, which had failed during engine operation.
(x) The No. 1 cylinder and piston assembly was found to be in good condition, with both oil rings undamaged.
(xi) The No. 2 cylinder displayed evidence of severe scuffing which resulted from the failure of the lower oil ring in the piston. The piston was also severely scuffed, due to a lack of lubrication and resultant engine seizure.
(xii) All the bearings within the engine assembly were in good condition.
(xiii) The injection intake rotary valve (151° rotation) showed evidence of object damage on the flange in line with the No. 2 cylinder port.
(xiv) No evidence was found of ingestion of foreign objects.

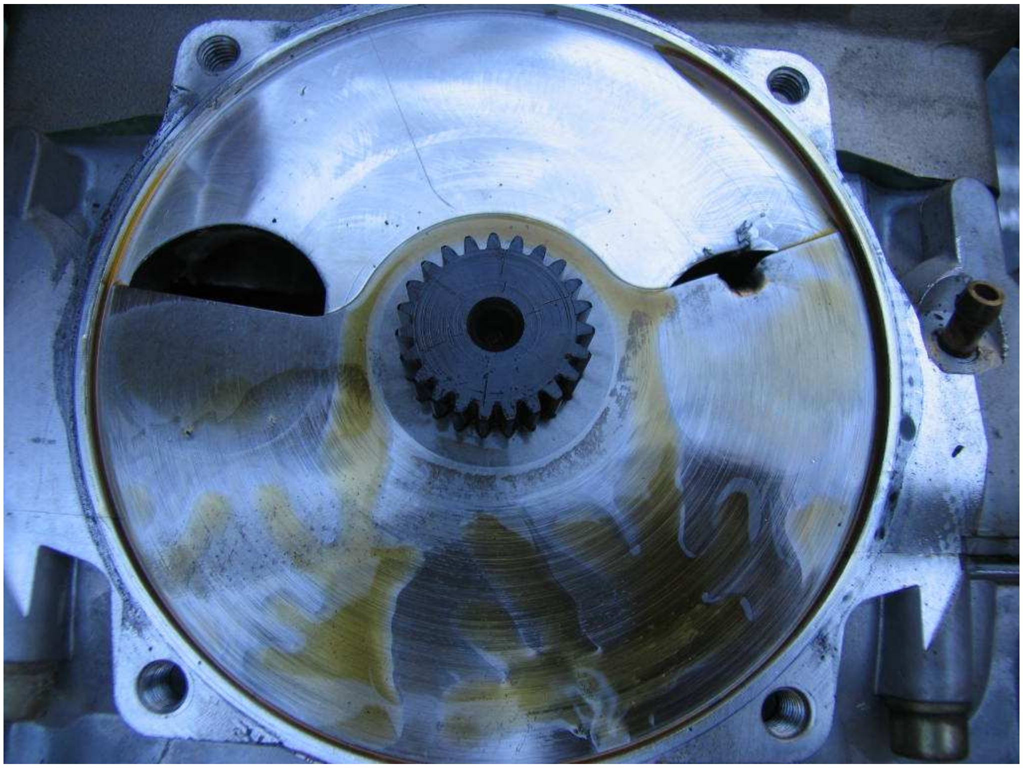

Figure 2. Damage to rotary valve inlet of the No. 2 cylinder.

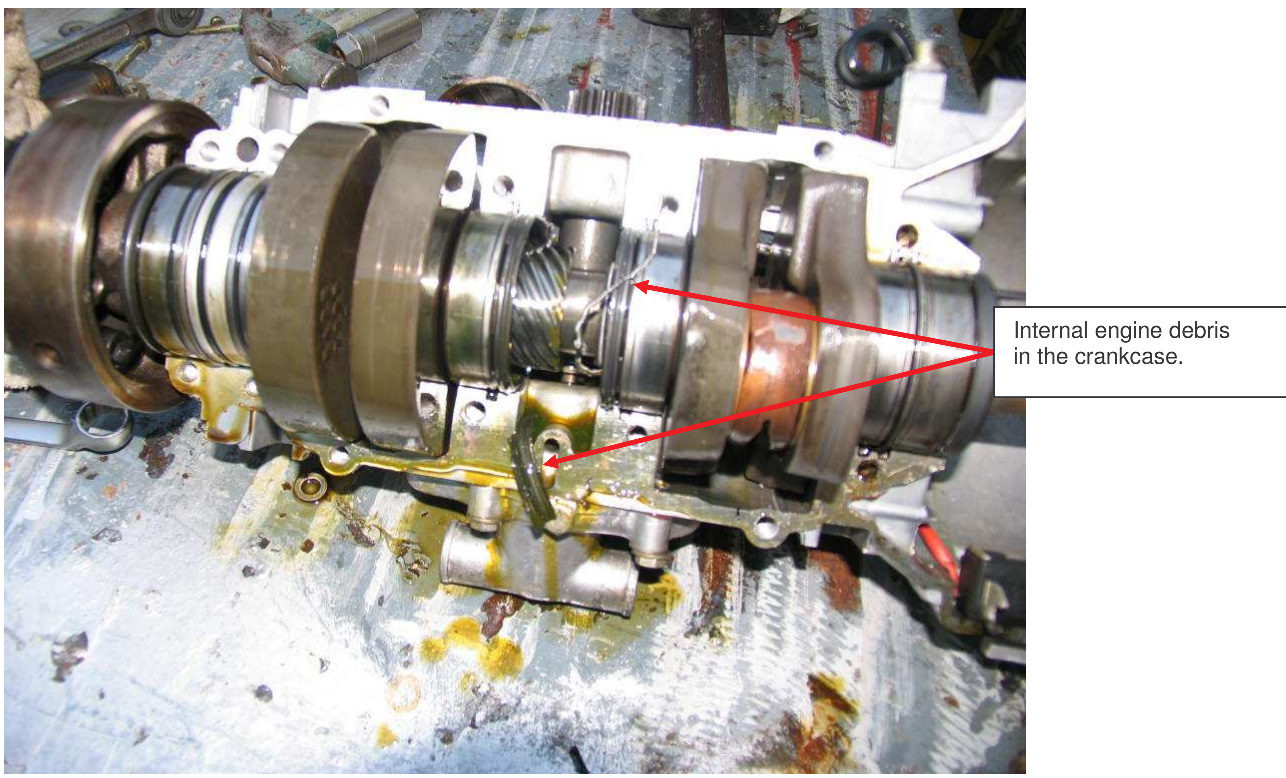

Figure 3. Debris on crankshaft and in casing area.

Figure 4. No. 2 piston displaying evidence of severe scuffing.

1.16.2 Metallurgical Examination

Following the engine teardown inspection, the damaged piston and associated accessories as well as the undamaged piston were subjected to metallurgical examination to determine the reasons for failure. The report is attached as Annexure A.

1.17 Organisational and Management Information

1.17.1 This was a private flight. The pilot was also the owner of the aircraft.

1.17.2 The last annual inspection carried out on the aeroplane prior to the accident was certified by an Approved Person (AP) accredited by the Aero Club of South Africa and Microlight Association of South Africa (MISASA) under the Approved Person Scheme.

1.18 Additional Information

1.18.1 During the on-site investigation the following observations were made:

(i) There was ample fuel on board the aircraft, with both tanks indicating ½ after the aircraft was righted.
(ii) The engine oil quantity in the reservoir was within the prescribed limits.
(iii) It was not possible to rotate the propeller.
(iv) The left wing strut was deformed, and the wing bent downwards.
(v) The vertical fin assembly was damaged when the aircraft nosed over.
(vi) The aft fuselage just forward of the empennage was severely damaged.
(vii) The propeller, spinner and lower engine cowling was substantially damaged.
(viii) The cockpit remained intact.

1.18.2 Two-stroke engine:

The two-stroke, internal combustion engine completes the same strokes as a four-stroke engine (intake, compression, combustion and exhaust) in only two strokes of the piston. It does this by using the beginning of the compression stroke and the end of the combustion stroke to perform the intake and exhaust functions. This allows a power stroke for every revolution of the crank, instead of every second revolution as in a four-stroke engine. For this reason, two-stroke engines provide high specific power, so they are valued for use in portable, lightweight applications.

1. <u>Power and Exhaust</u>
   This stroke occurs immediately after ignition of the charge. The piston is forced down, and as the top of the piston passes the exhaust port, most of the pressurised exhaust gases escape. As the piston continues down, it compresses the air/fuel/oil mixture in the crankcase. Once the top of the piston passes the transfer port, the compressed charge enters the cylinder from the crankcase and any remaining exhaust gases are forced out.

2. <u>Intake and Compression</u>
   The air/fuel/oil mixture has entered the cylinder, and the piston begins to move up. This action compresses the charge in the cylinder and produces a vacuum in the crankcase, pulling in more air, fuel and oil from the carburettor. The compressed charge is ignited by the spark plug and the cycle begins again.

The design types of the two-stroke cycle engine vary according to the method of intake of fresh air/fuel mixture, the method of scavenging the cylinder (exchanging burnt exhaust for fresh mixture) and the method of exhausting the cylinder.

The engine in question used the rotary inlet valve. The intake tract is opened and closed by a thin, rotating disc attached to the crankshaft and spinning at crankshaft speed. The fuel/air path through the intake tract is arranged so that it passes through the disc. This has a section cut out of it: when this section passes in front of the intake pipe, the pipe is opened; otherwise the disc shuts off the pipe.

The advantage of a rotary valve is that it enables the two-stroke engine intake timing to be asymmetrical, which is not possible with two-stroke piston port engines. In the latter, the intake timing opens and closes before and after top dead centre at the same crank angle, making it symmetrical, whereas the rotary valve allows the opening to begin and close earlier.

Rotary valve engines can be tailored to deliver power over a wider RPM range or higher horsepower over a narrower RPM range than either piston port or reed valve engines, although they are more mechanically complicated than either of these.

The two-stroke engines often have a simple lubrication system in which a special two-stroke oil is mixed with the fuel (known as "petroil" from petrol + oil). This reaches all moving parts of the engine. In the design of the engine system in question, the oil pump automatically mixes fuel and oil from separate tanks.

(Adapted from http//science.howstuffworks.com/two-stroke.htm)

1.18.3 Piston ring guide pin

This allows the oil ring limited rotational movement in its slot. The design is such that the open ends of the ring do not make contact with the cylinder inlet or outlet guide port. Should the piston ring guide pin shear, collapse or be deformed, the ring would be able to rotate through 360°. This could result in internal engine damage, in turn causing degraded compression and reduced engine power, or a possible ring failure if the ends of the ring make contact with either the inlet or outlet ports in the cylinder.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 During the recovery of the aircraft it was noted that the engine could not be turned by hand. The teardown inspection and follow-up metallurgical examination revealed that the lower oil ring guide pin on the No. 2 piston (it was a two-cylinder engine) had been forced in too far and had not held the ring itself in place. The ring had then rotated within the ring slot during operation, resulting in damage to the cylinder sleeve and subsequent engine failure. On the inner side of the guide pin position, the piston showed evidence of surface cracking. The guide pin hole had originally been drilled to the correct depth, but it is believed that an external force, most probably produced during fitment of the pin or subsequent engine operation, had forced the pin in too deep. Following the failure of the ring, the associated debris caused extensive internal engine damage, resulting in engine stoppage.

3. CONCLUSION

3.1 Findings

3.1.1 The pilot was the holder of a valid microlight pilot's licence and had the aircraft type endorsed in his logbook.

3.1.2 The pilot was the holder of a valid aviation medical certificate issued by a CAA-approved medical officer.

3.1.3 The aircraft was maintained in accordance with the requirements of Non-Type Certified Aircraft (NTCA).

3.1.4 The aircraft was in possession of a valid Authority to Fly at the time of the accident.

3.1.5 There was ample fuel on board the aircraft at the time of the accident.

3.1.6 The engine failed in flight, resulting a forced landing.

3.1.7 The engine could not be rotated by hand following the accident.

3.1.8 The engine teardown investigation displayed evidence of engine seizure and crankcase damage.

3.1.9 The aircraft's gross weight limitation was exceeded by 5.2% or 23.5kg at the time of the accident.

3.1.10 Nobody was injured in the accident.

3.2 Probable Cause/s

3.2.1 Unsuccessful forced landing following an engine failure in flight, which was attributed to a mechanical malfunction.

4. SAFETY RECOMMENDATIONS

4.1 It is recommended that the manufacturer of Rotax engines should include a note in the maintenance manual emphasising the proper inspection of the ring guide pin for extension and security.

5. APPENDICES

5.1 Annexure A (Metallurgical Examination Report).

Report reviewed and amended by the Advisory Safety Panel on 16 February 2010

-END-

ANNEXURE A

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COMPILED FOR: Civil Aviation Authority	INVESTIGATION REPORT: ROTAX ENGINE FAILURE, BUSHBABY, ZU-DLV	DOCUMENT NUMBER MET-005-07-07	
		DATE 2007-07-30	ISSUE 1

ITEM: **PISTON RING GUIDE PIN FAILURE, ROTAX ENGINE, BUSHBABY, ZU-DLV**

1. INTRODUCTION

1.1. The Rotax failed piston and ring assembly from a Bushbaby, aircraft number ZU-DLV, was submitted to determine the possible reason/s for failure during operation.

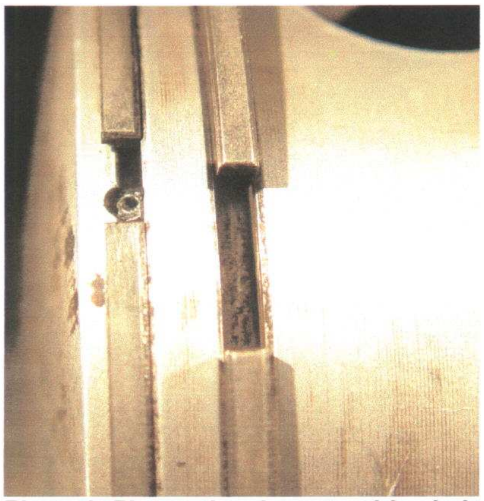

Photo 1: Piston showing no guide pin in position (digital)

1.2. This report is divided into the following sections:

(a)	INTRODUCTION	Par. 1
(b)	APPLICABLE DOCUMENTS	Par. 2
(c)	DEFINITIONS	Par. 3
(d)	INVESTIGATOR	Par. 4
(e)	APPARATUS AND METHODOLOGY	Par. 5
(f)	INVESTIGATION	Par. 6
(g)	DISCUSSION AND CONCLUSIONS	Par. 7
(h)	RECOMMENDATIONS	Par. 8
(i)	DECLARATION	Par. 9

2. APPLICABLE DOCUMENTS

(a) None.

3. DEFINITIONS

(a) SEM		Scanning Electron Microscope
(b) EDS		Energy Disperse X-ray Analysis
(c) OEM		Original Equipment Manufacturer
(d) CAA		Civil Aviation Authority

4. PERSONNEL

(a) The investigative member and compiler of this report is Mr C.J.C. Snyman, ID number 6406105057080. Mr Snyman is a qualified Physical Metallurgist (H.N.Dip Metallurgical Engineering, Tech. PTA), Radiation Protection Officer (RPO) registered with the National Nuclear Regulator (NNR) and Aircraft Accident Investigator (SCSI).

5. APPARATUS AND METHODOLOGY

(a) The apparatus employed for this investigation are Light-, Stereo Microscopes and Digital Camera.

(b) The methodology included a visual investigation of supplied parts followed by a Light- and a Stereoscopic investigation.

6. INVESTIGATION

6.1. **Visual and Stereo-microscope Investigation.** The visual investigation on the as found piston revealed that the bottom ring guide pin to be flush with the ring slot root (Photo 2) when compared to the remaining piston ring guide pin position (Photo 4). This caused the ring to rotate within the ring slot during operation resulting in the damaging of the sleeve and subsequent engine failure. On the inner side of the guide pin position the piston showed surface cracking (Photo 3). This is an indication that the guide pin has been forced from position during fitment and/or operation. After dissecting of the piston it became clear that although both pins are of the same length, the failed piston guide pin was forced to a position deeper than the remaining piston pin (Photo's 5 and 6). On comparing the bottom ends of both guide pins the failed pin showed clear indentations relative to the remaining pin (Photo 7). This can be attributed to some force applied on the pin during fitment and/or operation. The outer end from the failed pin showed slight scuffing marks (Photo 8) relative to the remaining pin and can be attributed to contact with the rotating ring during operation. The guide pin hole from the failed piston (Photo 9) showed some polishing marks generated by the movement on the pin during operation. A clear line to the bottom of the hole is an indication that the hole was most probably drilled to the correct depth but the exposed to some force leading to deformation in the bottom area as well as resulting in the crack formation on the inner side (Photo 3). The effect of this deformation is that the relevant guide pin had only limited protrusion into the ring slot.

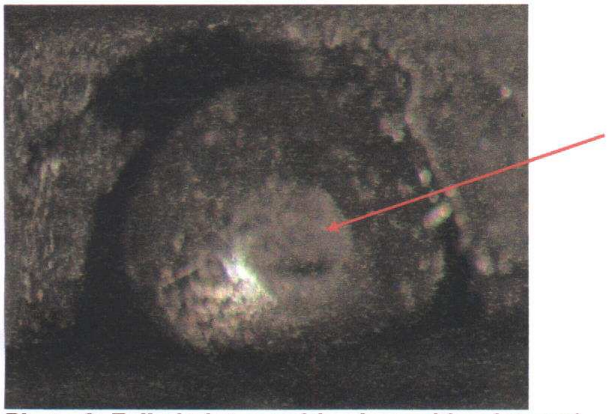

Photo 2: Failed piston guide pin position (stereo)

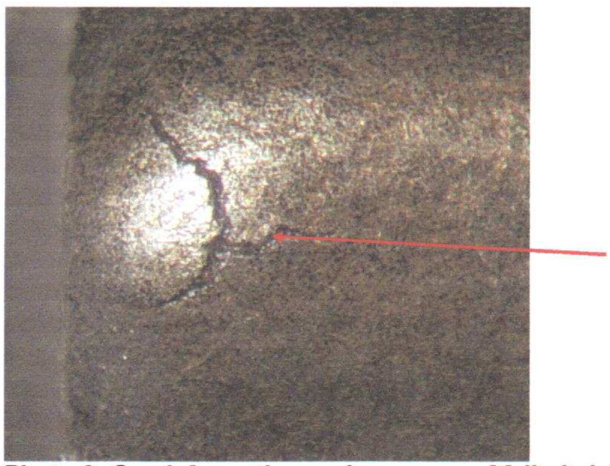

Photo 3: Crack formation on inner area of failed piston (stereo)

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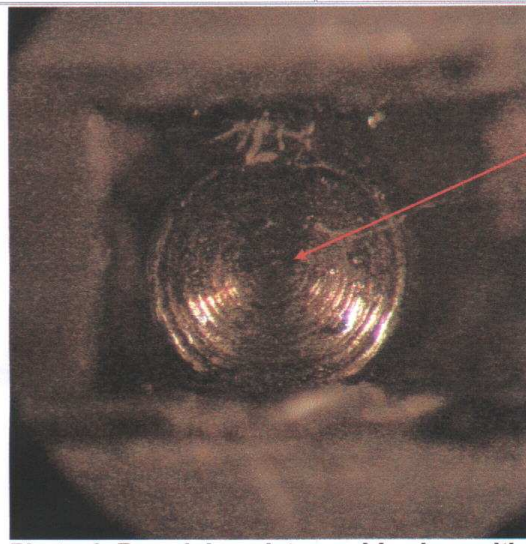

Photo 4: Remaining piston guide pin position (stereo)

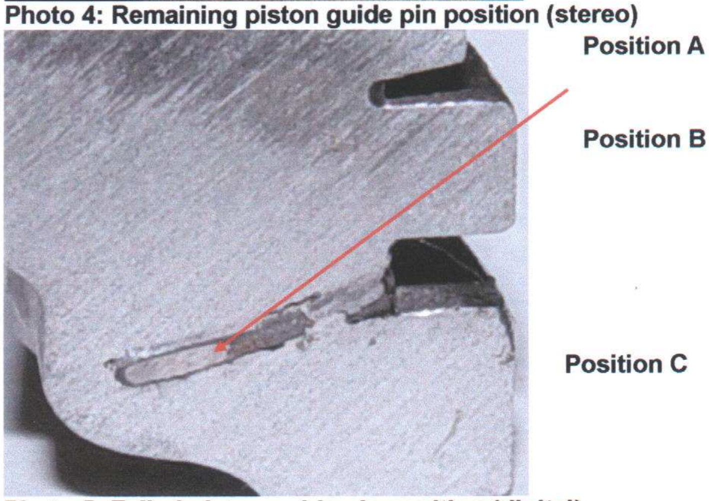

Photo 5: Failed piston guide pin position (digital)

Photo 6: Remaining piston guide pin position (digital)

Photo 7: Guide pins, inner ends (stereo)

Photo 8: Guide pins, outer ends (stereo)

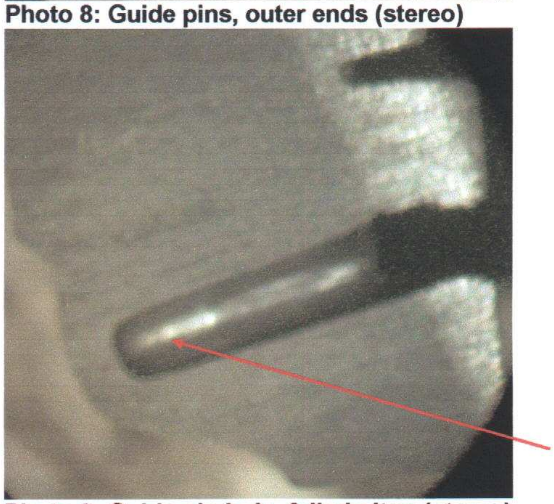

Photo 9: Guide pin hole, failed piton (stereo)

Photo 10: Guide pin hole, remaining piston (stereo)

7. DISCUSSION AND CONCLUSIONS

7.1. The investigation results revealed that the ring guide pin was ineffective by being flush with the ring slot root area. This resulted in the rotational movement of the ring during operation. The guide pin hole was drilled to the appropriate depth but an external force, most probably during fitment thereof, led to the deformation of the hole. The guide pin was probably still protruding to some extent during the fitment of the ring but forced to a greater depth during operation rendering it ineffective.

8. RECOMMENDATIONS

8.1. None.

9. DECLARATION

9.1. All digital images has been acquired by the author and displayed in an un-tampered manner.