AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:		CA/18/2/3/8675	
Aircraft Registration	**ZS-MPB**	**Date of Accident**	18/07/2009			**Time of Accident**	1330Z
Type of Aircraft	Beech 36		**Type of Operation**			Private	
Pilot-in-command Licence Type		Private	**Age**	42		**Licence Valid**	Yes
Pilot-in-command Flying Experience		Total Flying Hours	1898,22			Hours on Type	177,2
Last point of departure		Stellenbosch aerodrome (FASH) in the Western Cape Province					
Next point of intended landing		Upington International Airport (FAUP) in the Northern Cape Province					
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
Gravel road approximately 25 km west of Kenhardt in the Northern Cape							
Meteorological Information	Temperature 22˚C. CAVOK.						
Number of people on board	1+0	**No. of people injured**	0	**No. of people killed**	0		

Synopsis

The pilot was on a private VFR flight from Stellenbosch aerodrome (FASH) to Upington International Airport (FAUP) when he detected the smell of oil and smoke in the cockpit of the aircraft. The aircraft then suffered an uncontained engine failure.

The pilot executed a forced landing on a gravel road. He was not injured in the accident. The aircraft suffered damage to the engine, undercarriage and propeller.

The aircraft had undergone maintenance prior to the flight, to replace a worn starter clutch. A clip seal retainer was omitted during the installation of the starter clutch to the engine. The omission of the clip seal retainer caused the oil seal to become partially detached from its housing. This resulted in loss of engine oil during the flight, causing the engine to seize, resulting in an uncontained failure.

The pilot decided to execute a forced landing on a gravel road. The undercarriage did not extend because the master switch had been switched off prior to the landing gear being extended. The aircraft landed on the gravel road with the landing gear retracted.

The pilot was not injured in the accident sequence. The aircraft suffered damage to the undercarriage and the propeller in addition to the engine damage prior to landing.

Probable Cause

Probable cause

The electrical master switch was disarmed during the uncontained engine failure in flight, and thereafter the emergency system was not utilised to lower the landing gear, resulting in a wheels-up landing.

Contributory factor

(1)The pilot's actions during the uncontained engine failure indicated that his knowledge and understanding of the aircraft's emergency systems and procedures were inadequate.

(2) A clip seal retainer had been omitted during installation of the starter clutch to the engine, resulting in the seal becoming dislodged during flight.

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner/Operator : JF Holdings (PTY) LTD
Manufacturer : Beech Aircraft Corporation
Model : B 36 TC
Nationality : South African
Registration Marks : ZS-MPB
Place : Approximately 20 km west of Kenhardt in the Northern Cape
Date : 18 July 2009
Time : 1330Z

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 The pilot was on a private VFR flight from Stellenbosch aerodrome (FASH) to Upington International Airport (FAUP). The purpose of the flight to Stellenbosch had been to repair his aircraft at an aircraft maintenance organisation (AMO) at Stellenbosch. The aircraft had undergone repairs prior to the return flight, to replace a worn starter clutch as well as to repair cylinder number four, which had a burnt exhaust valve.

1.1.2 Approximately two hours into the flight, during the cruise phase, the pilot detected the smell of oil and smoke in the cockpit of the aircraft. The aircraft then suffered a loss in oil pressure and an uncontained engine failure subsequently occurred.

1.1.3 The pilot decided to execute a forced landing on a gravel road. The pilot then switched off the master switch, as it appeared to the pilot that the aircraft was “about to catch fire”. The pilot selected ‘gear down’. He did not attempt to lower the landing gear manually, as he believed that he had already done so. The aircraft landed on a gravel road with the landing gear still retracted.

1.1.4. The pilot was not injured in the accident. The aircraft sustained damage to the engine, undercarriage and propeller.

1.2 Injuries to Persons

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

1.3 Damage to Aircraft

Picture 1. Showing the landing gear doors closed

Picture 2. Showing the lower part of the aircraft.

1.3.1 The aircraft suffered damage to the engine, underside and propeller.

1.4 Other Damage

1.4.1 None

1.5 Personnel Information

1.5.1 Pilot in command:

Nationality	South African	Gender	Male	Age	42
Licence Number	XXXXXXXXX	Licence Type	Private		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	Night Rating. Flight tests – single engine piston				
Medical Expiry Date	30/04/2010				
Restrictions	Corrective lenses				
Previous Accidents	None				

Flying Experience:

Total Hours	1898,22
Total Past 90 Days	23,9
Total on Type Past 90 Days	23,9
Total on Type	177,2

1.6 Aircraft Information

Airframe:

Type	B 36 TC	
Serial Number	EA-439	
Manufacturer	Beech Aircraft Corporation	
Date of Manufacture	1985	
Total Airframe Hours (At time of Accident)	2187,3	
Last MPI (Date & Hours)	24/11/2009	2116
Hours since Last MPI	71	
C of A (Issue Date)	10/12/2009	
C of R (Issue Date) (Present owner)	30/10/2007	
Operating Categories	Standard	

Engine:

Type	Continental
Serial Number	809402
Hours since New	894,9
Hours since Overhaul	N/A

Propeller:

Type	McCauley
Serial Number	840474
Hours since New	2187,3
Hours since Overhaul	N/A

1.7 Meteorological Information

1.7.1 The information below was taken from the pilot's questionnaire.

Wind direction	Westerly	Wind speed	10 knots	Visibility	Fine
Temperature	22 ºC	Cloud cover	None	Cloud base	None
Dew point	Unknown				

1.8 Aids to Navigation

1.8.1 The aircraft was equipped with standard navigation equipment, which was serviceable at the time of the accident.

1.9 Communications

1.9.1 The aircraft was fitted with the standard communications equipment, which was serviceable at the time of the accident.

1.9.2 The pilot communicated his intentions on frequency 124,8 MHz.

1.10 Aerodrome Information

1.10.1 The accident did not occur at or in the vicinity of an aerodrome.

1.11 Flight Recorders

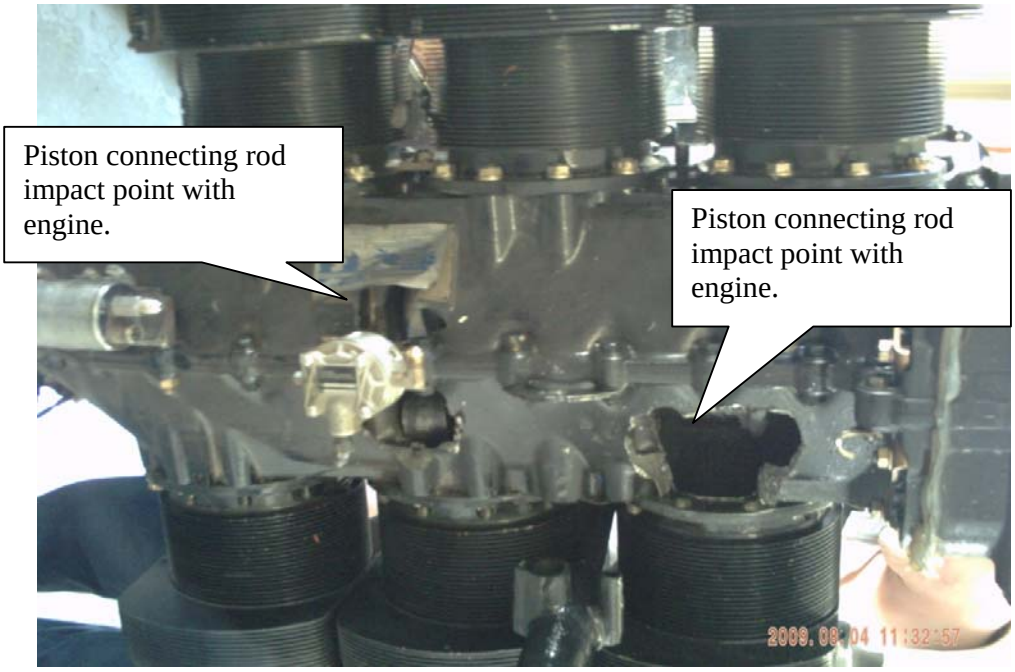
1.11.1 The aircraft was not fitted with a flight data recorder (FDR) or cockpit voice recorder (CVR), and neither was required by the applicable regulations.

1.12 Wreckage and Impact Information

1.12.1 The investigation was an offsite investigation.

1.12.2 The accident occurred on a gravel road approximately 25 km west of Kenhardt in the Northern Cape.

1.12.3 The pilot performed a landing with the wheels up on a gravel road, resulting in the aircraft suffering damage to the undercarriage and propeller.



Picture 3 showing uncontained engine failure.

1.13 Medical and Pathological Information

1.13.1 None, as the pilot did not sustain any injuries.

1.14 Fire

1.14.1 The pilot reported that it appeared as if the engine “looked like it was catching fire” so he elected to turn off the master switch to “prevent any electrical spark”.

1 14 2 There was no evidence of a fire, either in flight or on the ground.

1.15 Survival Aspects

1.15.1 The accident was deemed survivable, due to the low deceleration forces and the fact that the pilot was properly restrained.

1.16 Tests and Research

1.16.1 Following recovery of the aircraft, the following was noted.

The starter clutch assembly is located on the engine between the firewall of the aircraft and the engine of the aircraft.

The starter clutch assembly supplied to the AMO had been removed from another aircraft. The part was supplied “as is”.

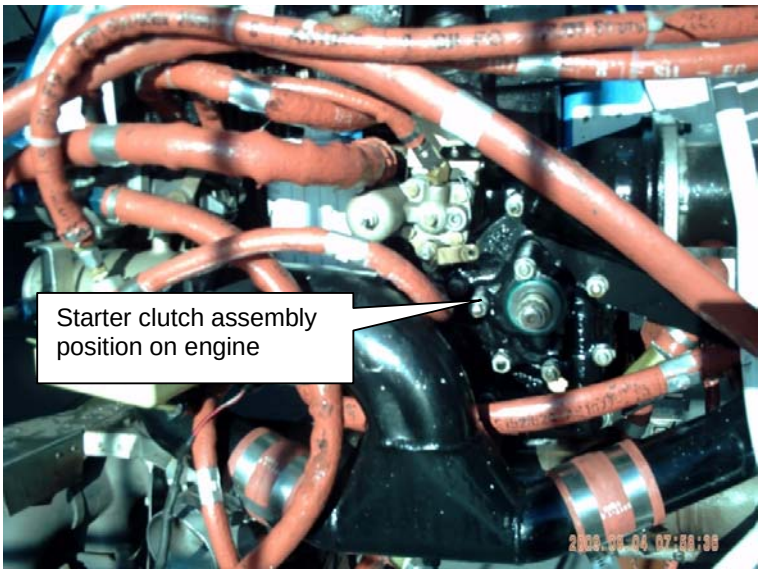
On receiving the starter clutch assembly, the technician noted that it was different from the one removed from the aircraft. After consulting the supplier, the technician was informed that the two units were the same, except for the length of the shaft which was able to accommodate a pulley. The pulley was not fitted to the starter clutch assembly.

Replacing the starter clutch assembly required the technician installing the starter clutch assembly to obtain the assistance of a more experienced technician to assist in the installation of the unit, as he was of the opinion that it would not fit. The more experienced technician, after moving electrical wiring out of the way, managed to slip the starter clutch assembly over the studs without moving the engine.

The technician completed the installation, where after it was inspected by the accountable manager.

A test flight of one hour’s duration was then performed by the pilot. After the test flight, the oil was drained and the engine was checked for any oil leaks. The engine was then refilled with new oil.

Picture 4 showing some of the challenges of installation.



Picture 5 showing the position of the starter clutch assembly on the engine.

1.17 Organisational and Management Information

1.17.1 The aircraft was privately operated by the owner.

1.17.2 The aircraft was maintained by an approved AMO.

1.17.3 The information on the AMO and aircraft maintenance engineer (AME) is tabulated below.

AMO	The AMO was last audited on 20 October 2009. The AMO approved the scope of work included in the aircraft type.
AME	The AME had a valid AME licence.

1.18 Additional Information

1.18.1 **Starter clutch assembly**

The parts removed were the starter and starter adaptor assembly, which included the optional air-conditioning drive.

The part supplied was the starter and starter adaptor assembly, which did not include the optional drive system as illustrated in Figure 1 Part 52, and associated components.

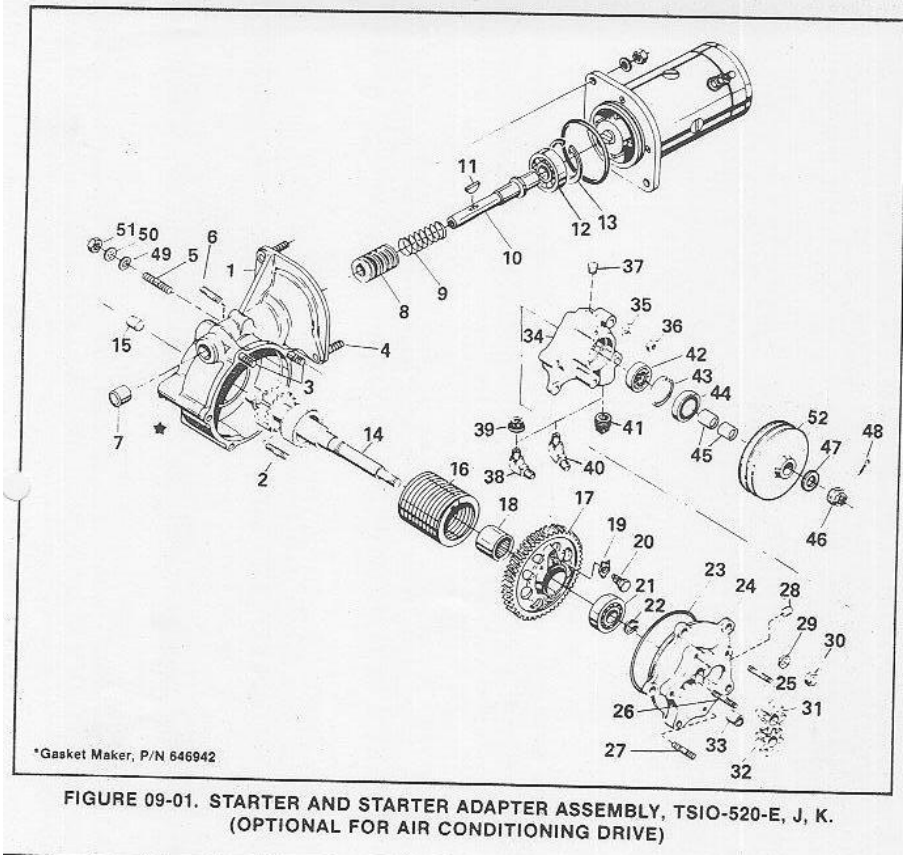


Figure 1 Showing Starter clutch assembly with optional air-conditioning drive.

The absence of the optional air-conditioning drive requires that the starter clutch assembly be assembled as per Figure 3. A clip seal retainer (Figure 3 Part 51) needs to be installed.

The purpose of the clip seal retainer is to secure the oil seal (Figure 3 Part 43) to the body assembly scavenge pump (Figure 3 Part 35).

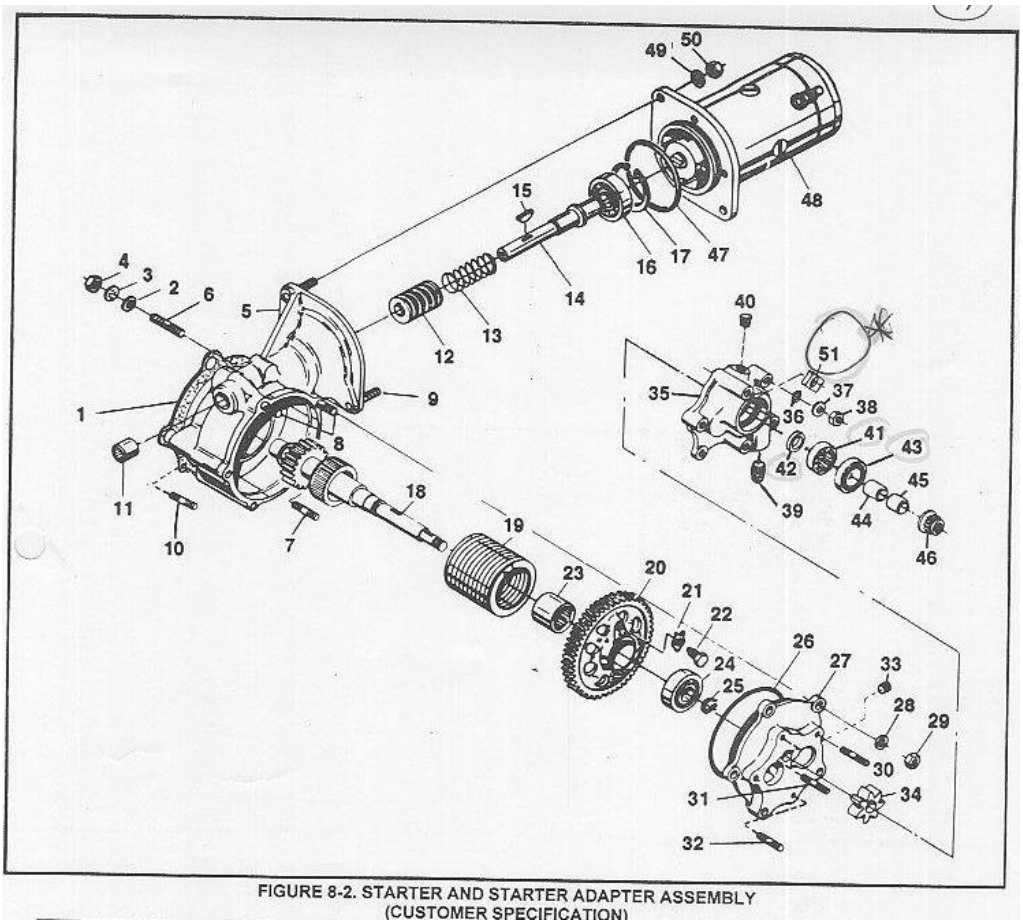
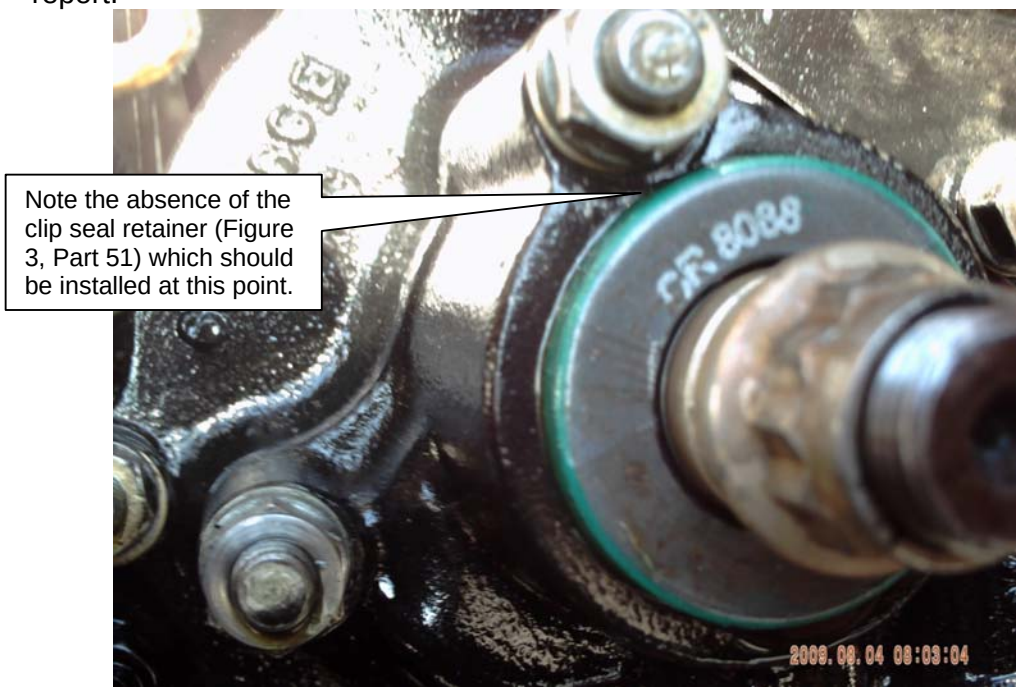


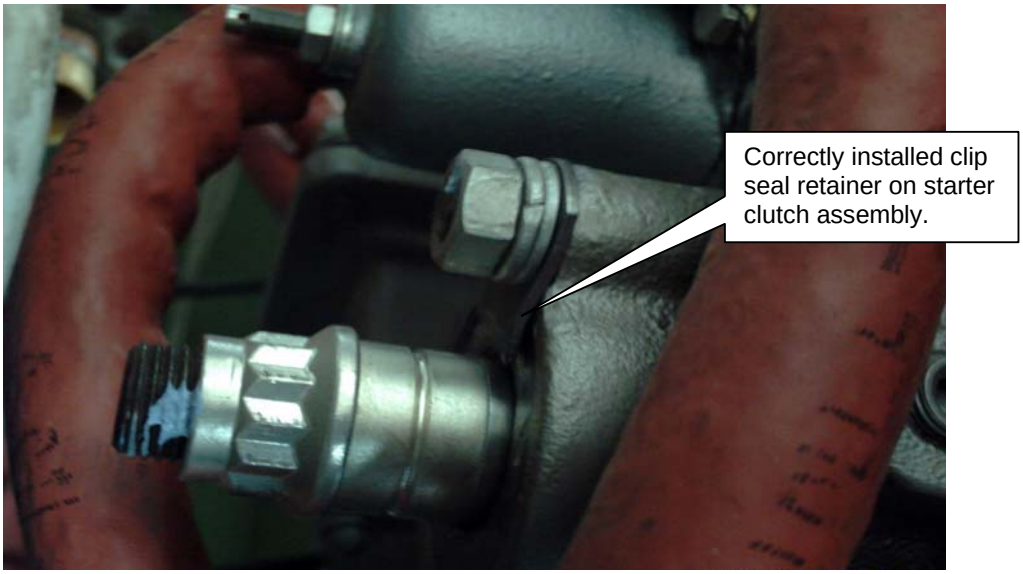
FIGURE 8-2. STARTER AND STARTER ADAPTER ASSEMBLY (CUSTOMER SPECIFICATION)

Figure 3 showing starter clutch assembly without optional air-conditioning drive.

1.18.3 The complete excerpts from the Australian Transport Safety Bureau aviation research safety and analysis report- AR-2008-055 are available as Appendix B of this report.



Picture 6 showing the dislodged oil seal on the starter clutch assembly.



Picture 7 shows an example of the clip seal retainer on the starter clutch.

1.18.4 Section 3 of the pilot's operating handbook details the procedures to follow in an emergency.

Section 3-5 of the pilot's operating handbook states the procedure to follow for an engine fire in flight.

Engine Fire

In Flight

1. Firewall air-control knob – PULL TO CLOSE
2. Fuel selector Valve – OFF
3. Mixture – IDLE CUT-OFF
4. Battery,alternator,and magneto start switches - OFF
   (Extending the landing gear can be accomplished manually if desired.)
5. Do no attempt to restart engine. (See Emergency Descent, Maximum glide configuration and landing without power procedures later in this section.)

Section 3-7 of the pilot's operating handbook states the procedure for landing without power.

Landing emergencies

When assured of reaching the landing site selected, and on final approach:

1. Fuel selector valve – OFF
2. Mixture – IDLE CUT-OFF
3. Magneto/Start Switch – OFF
4. Flaps – Down (30˚)
5. Landing Gear – Down or up (depending on terrain)
6. Airspeed – Establish 85 KTS
7. Battery and Alternator switches – OFF.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 The aircraft had undergone repairs prior to the flight to replace a worn starter clutch as well as repairs to cylinder number four, which had a burnt exhaust valve.

2.2 The starter clutch assembly supplied to the AMO had been removed from another aircraft by another AMO.

2.3 The parts supplied were the starter and starter adaptor assembly, which did not include the optional drive system. The absence of the optional air-conditioning drive requires that the starter clutch assembly be assembled as per Figure 3. A clip seal retainer (Figure 3 Part 51) needs to be installed.

2.4 The starter clutch assembly supplied to the AMO had been removed from another aircraft. The part was supplied “as is”.

2.5 The clip seal retainer was not supplied as part of the starter clutch assembly, as there was no need for it in the original installation which used the optional air-conditioning pulley to hold the seal in position.

2.6 On receiving the starter clutch assembly, the technician noted that it was different from the one removed from the aircraft. After consulting the supplier, the technician was informed that the two units were the same, except for the length of the shaft which was able to accommodate a pulley. The pulley was not fitted to the starter clutch assembly.

2.7 The starter clutch assembly was supplied to the AMO without the clip seal retainer.

2.8 The clip seal retainer was omitted during installation of the starter clutch assembly. This resulted in the seal becoming dislodged during flight. The dislodged seal caused the engine oil to leak out of the engine. The absence of adequate lubrication resulted in the engine suffering an uncontained engine failure in flight.

2.9 The pilot elected to execute a forced landing on a gravel road. The pilot then switched off the master switch to prevent any electrical sparks, as it appeared to the pilot that the aircraft was about to catch fire. The pilot selected ‘gear down’, but nothing happened.

2.10 The undercarriage did not extend because the master switch had been switched off, resulting in no electrical power being supplied to the landing gear system to extend the landing gear. The pilot did not attempt to lower the landing gear manually, as he believed that he had already lowered the landing gear.

2.11 The emergency procedures in the pilot’s operating handbook for an engine fire in flight and for landing without power both call for the landing gear to be extended as part of the emergency procedures.

2.12 The aircraft landed on a gravel road with the landing gear retracted.

2.13 The pilot was not injured in the accident. The aircraft suffered damage to the undercarriage and the propeller in addition to the engine damage prior to landing.

3. CONCLUSION

3.1 Findings

3.1.1 The pilot was the holder of a valid license, with the aircraft type endorsed in his logbook.

3.1.2 The pilot was in possession of a valid aviation medical certificate that had been issued by an approved SACAA medical examiner, with restrictions pertaining to corrective lenses.

3.1.3 The engine was dismantled and analyzed by an AMO to determine the cause of the uncontained engine failure.

3.1.4 The clip seal retainer had been omitted, resulting in the seal becoming dislodged during flight.

3.1.5 The dislodged seal caused the engine oil to leak out of the engine. The absence of adequate lubrication resulted in the engine suffering an uncontained engine failure in flight.

3.1.6 The pilot turned off the master switch, fearing that the engine might catch fire.

3.1.7 The undercarriage did not extend because the master switch had been switched off, resulting in no electrical power being supplied to the landing gear system to extend the landing gear. The pilot did not attempt to lower the landing gear manually as he believed that he had already lowered the landing gear.

3.1.8 The incorrect emergency procedure followed during the forced landing resulted in the landing gear not being extended.

3.1.9 The pilot's actions during the uncontained engine failure indicated that his knowledge and understanding of the aircraft's emergency systems and procedures were inadequate.

3.1.10 The aircraft landed on a gravel road with the landing gear retracted.

3.2 Probable Cause/s

Probable cause

The electrical master switch was disarmed during uncontained engine failure in flight, where after the emergency system was not used for lowering the landing gear, resulting in a wheels-up landing.

Contributory factor

(1)The pilot's actions during the uncontained engine failure indicated that his knowledge and understanding of the aircraft's emergency systems and procedures were inadequate.

(2)A clip seal retainer had been omitted during installation of the starter clutch to the engine, resulting in the seal becoming dislodged during flight.

4. SAFETY RECOMMENDATIONS

4.1 Publish the full Australian Transport Safety Bureau aviation research safety and analysis report- AR-2008-055 in the Safety Link magazine.

5. APPENDICES

5.1 Appendix A – Illustrated parts list showing starter clutch assembly.
5.2 Appendix B – Extract from the Australian Transport Safety Bureau.

Report reviewed and amended by the Advisory Safety Panel 18 January 2011.

-END-

Appendix A

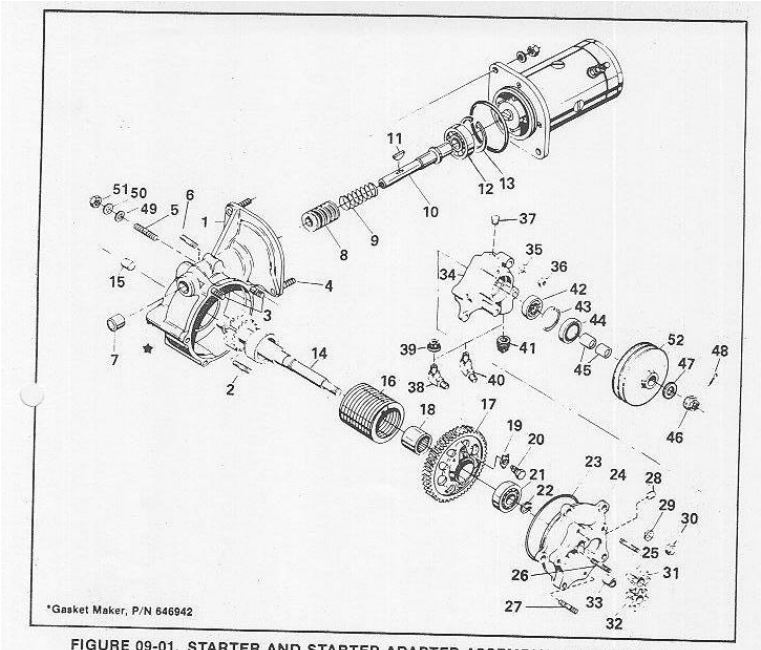


FIGURE 09-01. STARTER AND STARTER ADAPTER ASSEMBLY, TSIO-520-E, J, K. (OPTIONAL FOR AIR CONDITIONING DRIVE)

INDEX	PART NUMBER	1 2 3 4 5 DESCRIPTION	QUANTITY B	D	E	J	K	L	N	UB	VB	WB
09-01-	642087A8	⊙Adapter Assy., Starter Drive, Complete			1	1	1					
- 1	642087	. Housing Assy., Starter Adapter			1	1	1					
- 2	352655	† . . Stud, 5/16 x 2-11/16 Inch Long			1	1	1					
- 3	401881	† . . Stud, 5/16 x 1-1/8 Inch Long			2	2	2					
- 4	402127	† . . Stud, 3/8 x 1-17/32 Inch Long			2	2	2					
- 5	401814	† . . Stud, 5/16 x 1-7/8 Inch Long			1	1	1					
- 6	401971	† . . Stud, 5/16 x 1-5/8 Inch Long			1	1	1					
- 7	641368	. Bearing, Needle			1	1	1					
- 8	539805	. Gear, Starter Worm			1	1	1					
- 9	536552	. Spring, Starter Worm Gear			1	1	1					

09-02

FIG INDEX	PART NUMBER	1 2 3 4 5 DESCRIPTION	QUANTITY								
			B	D	E	J	K	L	N	UB	VB	WB
08-01-14	637837	. Spring, Valve, Outer	2	2	2	2	2	2	2	2	2	2
-15	625393	. Retainer, Valve Spring, Inner	2	2	2	2	2	2	2	2	2	2
-16	629117	. Roto-Coil Assembly, Exhaust Valve	2	2	2	2	2	2	2	2	2	2
-17	24802	. Key, Valve Spring Retainer	4	4	4	4	4	4	4	4	4	4
-18	539742	Rocker Assembly, Intake Valve	6	6	6	6	6	6	6	6	6	6
-19	639629	. Bushing, Valve Rocker	2	2	2	2	2	2	2	2	2	2
-20	21007	. Screw, Drive	1	1	1	1	1	1	1	1	1	1
-21	641682	Rocker Assembly, Exhaust Valve	6	6	6	6	6	6	6	6	6	6
-22	639629	. Bushing, Valve Rocker	2	2	2	2	2	2	2	2	2	2
-23	21007	. Screw, Drive	1	1	1	1	1	1	1	1	1	1
24	639573	† Washer, Thrust	24	24	24	24	24	24	24	24	24	24
25	539740	Shaft, Valve Rocker	12	12	12	12	12	12	12	12	12	12
-25	646775	Shaft, Valve Rocker - Chrome	Opt.	Opt.	Opt.	Opt.	Opt.	Opt.	Opt.	Opt.	Opt.	Opt.
		ATTACHING PARTS										
26	2473	Washer, Plain	12	12	12	12	12	12	12	12	12	12
27	537019	Screw, Hex Head	12	12	12	12	12	12	12	12	12	12
		• • • •										
28	534857	S Gasket, Valve Rocker Cover	6	6	6	6	6	6	6	6	6	6
29	625615	Cover, Valve Rocker	6	6	6	6	6	6	6	6	6	6
		ATTACHING PARTS										
30	20522	Washer, Plain	48	48	48	48	48	48	48	48	48	48
31	MS35337-44	Washer, Lock	48	48	48	48	48	48	48	48	48	48
32	535118	Screw, Fillister Head, 1/4 x 3/4 Inch Long	48	48	48	48	48	48	48	48	48	48
		• • • •										
33	628260	S Gasket, Exhaust Flange	6	6	6	6	6	6	6	6	6	6
		ATTACHING PARTS										
34	643967	Nut, Hex Head 1/4 - 28	24	24	24	24	24	24	24	24	24	24
		• • • •										
35	537296	Housing, Push Rod	12	12	12	12	12	12	12	12	12	12
36	534609	Washer, Push Rod Housing	48	48	48	48	48	48	48	48	48	48
37	534610	S Packing, Push Rod Housing	24	24	24	24	24	24	24	24	24	24
38	626147	Spring, Push Rod Housing	12	12	12	12	12	12	12	12	12	12
39	538304	† Push Rod Assembly	12	12	12	12	12	12	12	12	12	12
40	531001	Nut, Flanged, 7/16 - 20	36	36	36	36	36	36	36	36	36	36
41	644505	Nut, Flanged, 1/2 - 20	12	12	12	12	12	12	12	12	12	12

NOTES.

① 646277 or 641709 lifter must be used in exhaust position if cylinder incorporates 641951 exhaust guides.
② Older cylinders may have the 643767 ni-resist guide.
③ See Service Bulletin M78-6.
④ This assembly contains six (6) seals and one installation tool.

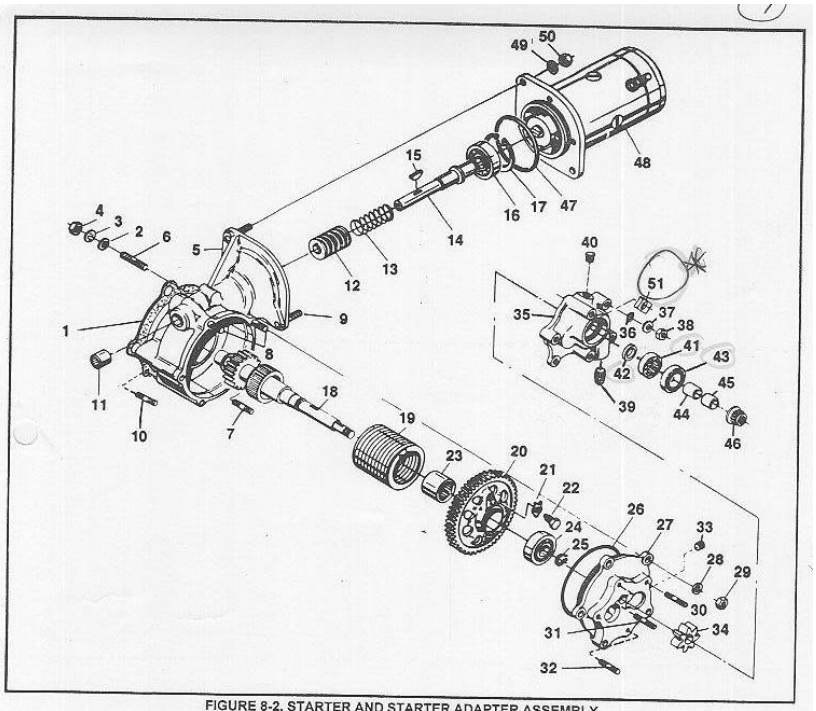


FIGURE 8-2. STARTER AND STARTER ADAPTER ASSEMBLY
(CUSTOMER SPECIFICATION)

FIG. & INDEX		PART NUMBER	1 2 3	DESCRIPTION	QUANTITY
8-2	-1	653470	$	Gasket	1
		642087A35		Adapter Assy., Starter Drive, Complete	1
				ATTACHING PARTS	
	-2	2473		Washer, Plain	4
	-3	MS35337-45		Washer, Lock	4
	-4	2439		Nut, Plain, Hex	4
				****	
	-5	642087		Adapter Assembly, Starter	1
	-6	352655	†	Stud, 5/16 X 2-11/16 Inch Long	1
	-7	401814	†	Stud, 5/16 X 1-7/8 Inch Long	1
	-8	401881	†	Stud, 5/16 X 1-1/8 Inch Long	2
	-9	402127	†	Stud, 3/8 X 1-17/32 Inch Long	2
	-10	401971	†	Stud, 5/16 X 1-5/8 Inch Long	1

8-4

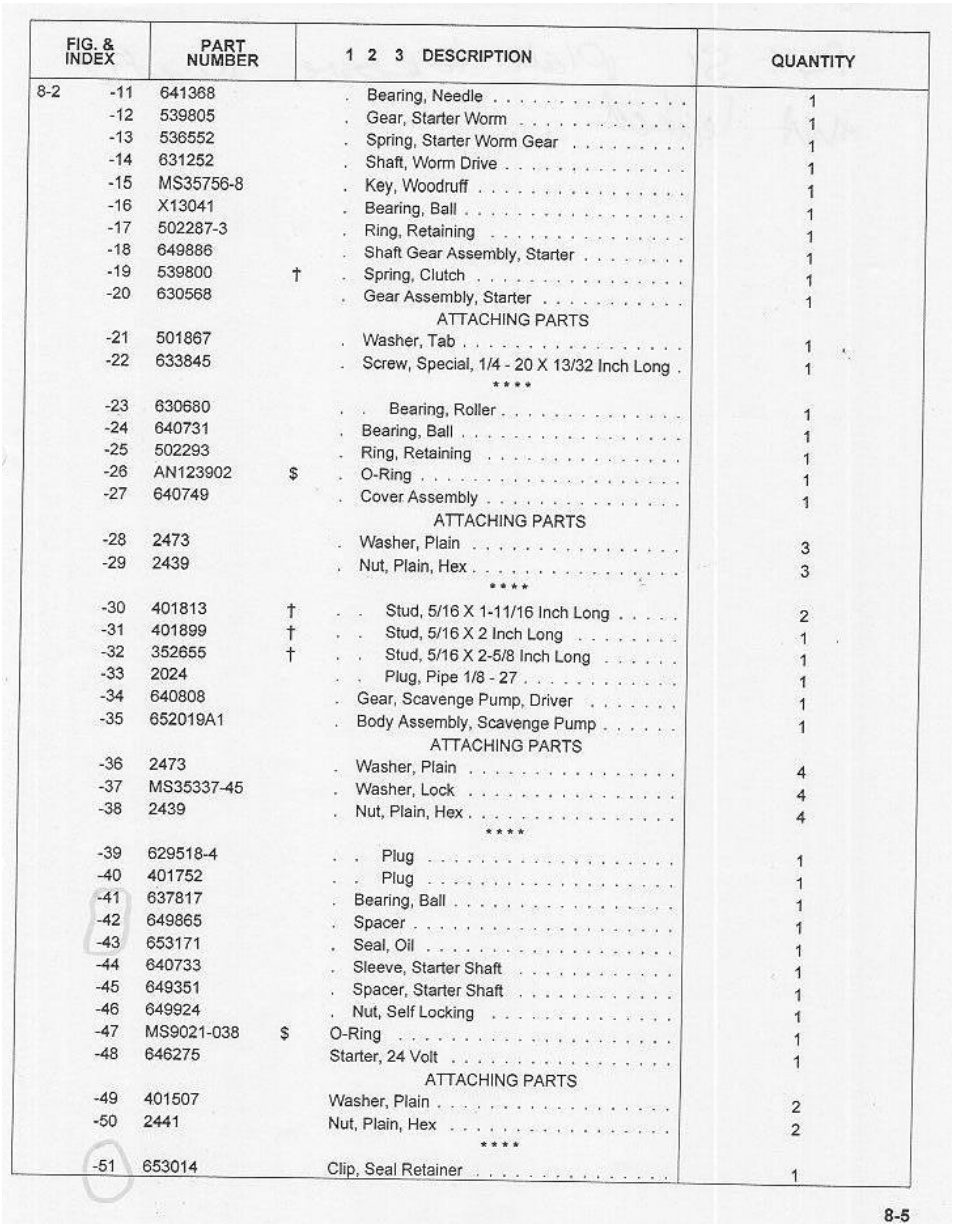


FIG. & INDEX	PART NUMBER		1 2 3 DESCRIPTION	QUANTITY
8-2 -11	641368		. Bearing, Needle	1
-12	539805		. Gear, Starter Worm	1
-13	536552		. Spring, Starter Worm Gear	1
-14	631252		. Shaft, Worm Drive	1
-15	MS35756-8		. Key, Woodruff	1
-16	X13041		. Bearing, Ball	1
-17	502287-3		. Ring, Retaining	1
-18	649886		. Shaft Gear Assembly, Starter	1
-19	539800	†	. Spring, Clutch	1
-20	630568		. Gear Assembly, Starter	1
			ATTACHING PARTS	
-21	501867		. Washer, Tab	1
-22	633845		. Screw, Special, 1/4 - 20 X 13/32 Inch Long	1
			****	
-23	630680		. . Bearing, Roller	1
-24	640731		. Bearing, Ball	1
-25	502293		. Ring, Retaining	1
-26	AN123902	$	. O-Ring	1
-27	640749		. Cover Assembly	1
			ATTACHING PARTS	
-28	2473		. Washer, Plain	3
-29	2439		. Nut, Plain, Hex	3
			****	
-30	401813	†	. . Stud, 5/16 X 1-11/16 Inch Long	2
-31	401899	†	. . Stud, 5/16 X 2 Inch Long	1
-32	352655	†	. . Stud, 5/16 X 2-5/8 Inch Long	1
-33	2024		. . Plug, Pipe 1/8 - 27	1
-34	640808		. Gear, Scavenge Pump, Driver	1
-35	652019A1		. Body Assembly, Scavenge Pump	1
			ATTACHING PARTS	
-36	2473		. Washer, Plain	4
-37	MS35337-45		. Washer, Lock	4
-38	2439		. Nut, Plain, Hex	4
			****	
-39	629518-4		. . Plug	1
-40	401752		. . Plug	1
-41	637817		. Bearing, Ball	1
-42	649865		. Spacer	1
-43	653171		. Seal, Oil	1
-44	640733		. Sleeve, Starter Shaft	1
-45	649351		. Spacer, Starter Shaft	1
-46	649924		. Nut, Self Locking	1
-47	MS9021-038	$	O-Ring	1
-48	646275		Starter, 24 Volt	1
			ATTACHING PARTS	
-49	401507		Washer, Plain	2
-50	2441		Nut, Plain, Hex	2
			****	
-51	653014		Clip, Seal Retainer	1

8-5

Appendix B

5.2 The following excerpts were taken from the Australian Transport Safety Bureau aviation research safety and analysis report- AR-2008-055.

The issue of maintenance violations is one of the most difficult human factors issues currently facing the aviation industry. Yet many aviation professionals outside the maintenance field are either unaware of the issue, or else take a simple moralistic approach when they hear of the extent to which maintenance workers routinely deviate from procedures to accomplish tasks. Maintenance personnel are often confronted with a double standard of task performance. On the one hand, they are expected to comply with a vast array of requirements and procedures, while also being expected to complete tasks quickly and efficiently.

The most common maintenance errors in a Boeing database are omissions: equipment or parts not installed and incomplete installation of components. In an Australian study, the most commonly reported maintenance errors with airworthiness implications were commissions involving the unsafe operation of systems such as flaps or thrust reversers during maintenance, and the incomplete installation of components, an omission. An analysis of over 1,000 maintenance incidents reported to the US National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System, revealed that the most common problem was the omission of a required service procedure, followed by various documentation irregularities (often the commission of a sign-off by an unauthorized person), and the fitment of wrong parts, a commission.

Psychological descriptions of errors

Psychological error models require us to categorize errors according to the person's intentions at the time of their action. For example, rather than just concluding that an engineer did not secure a plumbing connection, we would try to understand their mindset at the time of the error. For example, we would want to know: Did they forget? Did they intend to leave it loose? Did they assume that a colleague was going to complete the task? Obviously, we can never know for certain what a person was thinking, but we can usually make reasonable judgments.

A simple way to assign a psychological description to an error is to imagine what the person who made the error might have said the moment they realized that they had not acted correctly. If they did not realize they had made an error, it helps to imagine what they would have said had they become aware of their error. An advantage of psychological descriptions is that they enable us to place the error in its organisational context, and then develop countermeasures tailored to the root causes of the problem. For example, if we conclude that someone did not perform a necessary action because they forgot, we might consider the prompts to memory available to them, such as documentation. We might also consider what could be done in future to catch similar memory lapses. If, on the other hand, we conclude that a person did not perform a necessary action because they thought the procedure did not require it, our investigation might lead us to organisational issues such as training or procedure design.

Maintenance procedures and documentation

Aircraft maintenance is heavily reliant on documented procedures. According to the FAA, aviation maintenance personnel spend between 25 and 40 per cent of their time dealing with maintenance documentation. Poor documentation is one of the leading causes of maintenance incidents. Poor maintenance procedures can lead to a range of errors including memory lapses, technical misunderstandings, and rule violations.

When it comes to the content of maintenance manuals, structural repair manuals and other documents such as the minimum equipment list, the primary problem is not generally inaccuracies or technical errors. A survey of US maintenance technicians found that respondents rarely, if ever, found errors in maintenance manuals. However, there were other problems with the content of documented procedures. Only 18 per cent of those who returned the survey agreed with the statement: 'the manual describes the easiest way to do a procedure'. Only 13 per cent agreed with the statement 'the manual writer understands how I do maintenance'. Most respondents reported that they overcame difficult-to-follow procedures by consulting colleagues or finding their own way through a procedure.

Teamwork

Few maintenance workers work completely alone, and to perform their work successfully, they must coordinate with other operational personnel. Coordination problems such as misunderstandings, ineffective communication, and incorrect assumptions feature in many maintenance incidents. In a survey at a US airline, lead maintenance engineers identified communication and 'people' skills as the issues most important to job effectiveness.

Lack of system knowledge

In a study of maintenance incidents in Australia, a lack of training or system knowledge emerged as a contributing factor in just over 12 per cent of occurrences. While training issues were sometimes associated with unlicensed or newly-qualified personnel, experienced certifying engineers also reported incidents related to inadequate knowledge, skills or experience.

Design for maintainability

Although maintenance personnel rarely have the opportunity to influence the design of the systems they maintain, poor design is a major factor leading to maintenance problems. An awareness of design limitations can help prepare maintenance technicians guard against design-induced maintenance errors. Examples of poor designs for maintainability include:

• Components that are difficult to reach, particularly where unrelated components, must be disconnected to enable access.

• Obstructions to vision; etc.