AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/8940
Aircraft Registration	**ZS-HDK**	**Date of Accident**	1 July 2011	**Time of Accident**	1120Z
Type of Aircraft	Eurocopter AS350B3 (Helicopter)		**Type of Operation**	Aerial Survey	
Pilot-in-command Licence Type	Commercial	**Age**	36	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	410.5		Hours on Type	297.1
Last point of departure	Sishen Aerodrome (FASS), (Northern Cape province)				
Next point of intended landing	Sishen Aerodrome (FASS), (Northern Cape province)				
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)					
To the left of Runway 35 at Sishen Aerodrome (GPS co-ordinates: South 27°39'00" East 23°00'00")					
Meteorological Information	Wind direction: 350°Magnetic, Wind speed: 5 knots, Visibility: 10000m, Temperature 23°C, Cloud cover: Clear sky.				
Number of people on board	2 + 1	**No. of people injured**	0	**No. of people killed**	0

Synopsis

On 1 July 2011, a Eurocopter AS350B3 helicopter, registration ZS-HDK, was being utilized in a geographical survey flight in the Sishen area. Onboard the helicopter was two pilots and a survey equipment systems operator. On approach to the Sishen aerodrome at a height of approximately 1200 feet above ground level (AGL), the pilot-not-flying (PNF), without permission from the pilot-in-command (PIC), who was also the pilot flying (PF) at the time, deactivated the "ACCU TST" switch (Accumulator Test Switch) on the instrument panel and the "HYDR" (Hydraulic) warning light illuminated. The PNF then suggested they perform a simulated' hydraulic failure as a training exercise whereby the PF agreed. They followed the pilot's operating handbook (POH) procedure to instigate the simulated failure, which required the master hydraulic switch located on the collective pitch lever to be switched off. The PF then reduced the speed as required and lined the helicopter up for runway 35 whilst descending towards the landing area. At about 3-6 feet above the ground the PNF asked the PF to switch on the hydraulic switch on the collective pitch lever, whereby the PF complied. The helicopter suddenly started to yaw to left. The PF was unable to counter act the yaw with the rudder pedals, which was described by him as being very hard at that stage. The PNF then took control of the helicopter but was also unable to address the yaw rate, which by now had intensified. During the yaw, the right-hand skid gear struck the ground and a dynamic rollover ensued with the helicopter coming to rest on its right-hand side.

Neither of the occupants onboard was injured during the sequence of the accident.

The helicopter sustained substantial damage during the sequence of the accident.

Probable Cause

Unsuccessful landing, following interference by the pilot-not-flying during a critical phase of flight, resulting in a loss of control in close proximity to the ground, which was aggravated by the incorrect reactivation of the hydraulic system.

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner	: Delmon Mining and Civils (Pty) Ltd
Operator	: Delmon Mining and Civils (Pty) Ltd
Manufacturer	: Eurocopter
Model	: AS350B3
Nationality	: South African
Registration Marks	: ZS-HDK
Place	: Sishen Aerodrome
Date	: 1 July 2011
Time	: 1120Z

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

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 On 01 July 2011, at approximately 0800Z, a Eurocopter AS350B3 helicopter, registration ZS-HDK, took-off from Sishen Aerodrome on a geographical survey flight. Onboard the helicopter was two pilots and a survey equipment systems operator. After being airborne for approximately 2½ hours they returned to Sishen aerodrome to refuel the helicopter prior to the second part of the survey. The flight was being conducted under visual meteorological conditions (VMC).

1.1.2 On approach to the Sishen aerodrome at a height of approximately 1 200 feet above ground level (AGL), the pilot-not-flying (PNF), without permission from the pilot-in-command (PIC), who was also the pilot flying (PF) at the time, deactivated the "ACCU TST" switch (Accumulator Test Switch) on the instrument panel and the "HYDR" (Hydraulic) warning light illuminated as well as the associated audio warning. (See additional information Appendix A for description of system). The PNF then suggested they perform a simulated' hydraulic failure as a training exercise, whereto the PF agreed.

1.1.3 Both crew then followed the emergency procedure as stipulated in the Pilot Operating Handbook (POH) to instigate the simulated failure, which required the master hydraulic switch located on the collective pitch lever to be switched off. The pilot flying then lined the helicopter up for runway 35 and reduced the speed to approximately 60 knots whilst descending towards the landing area. As the helicopter descended the speed also decayed. At a height of approximately 3-6 feet above the runway level the PNF asked for the hydraulics to be switched on again, to which the PF complied. As the PF was about to perform a skid-on landing on the runway the helicopter suddenly yawed to the left. He attempted to correct the yaw by applying opposite rudder pedal but stated the he was unable to as the pedals was very hard, to such an extent that he could not move/depress them although he tried. Within a brief period they had to make several decisions and it would appear that during this period the PNF took over control of the helicopter in an attempt to stop the yaw rate, whereby he closed the throttle and pulled the collective pitch lever to try and cushion the landing. However, the left yaw continued and the right-hand skid gear struck the ground to the left of the runway and a dynamic rollover ensued with the helicopter coming to rest on its right hand-side. The engine was still running at idle speed at that stage and the PNF closed the fuel shut off lever, which shutdown the engine. All the occupants disembarked from the wreckage via the left forward cabin door as they feared a post accident fire. After they were sure there was no fire, the PIC climbed back into the cockpit and isolated the systems and switched off all the electrical switches.

1.1.4 None of the occupants onboard the helicopter were injured. Emergency services responded quickly and the accident site was secured.

1.1.5 The accident occurred during daylight conditions at a geographical position determined to be South 27°39'00" East 23°00'00" at an elevation of 3848 feet above mean sea level (AMSL).

1.2 Injuries to Persons

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

1.3 Damage to Aircraft

1.3.1 The helicopter sustained substantial damage by the impact forces.

Figure 1. A view of the helicopter as it came to rest next to the runway.

1.4 Other Damage

1.4.1 No other damage was caused during the sequence of the accident.

1.5 Personnel Information

1.5.1 PF (Pilot Flying)

Nationality	South African	Gender	Male	Age	36
Licence Number	0272298274	Licence Type	Commercial Pilot		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	Night Flight				
Medical Expiry Date	29 May 2012				
Restrictions	None				
Previous Accidents	None				

Flying Experience:

Total Hours	410,5
Total Past 90 Days	69,3
Total on Type Past 90 Days	69,3
Total on Type	297,1

1.5.2 PNF (Pilot-not-flying)

Nationality	South African	Gender	Male	Age	28
Licence Number	0270508476	Licence Type	Private Pilot		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	Night Flight				
Medical Expiry Date	31 October 2012				
Restrictions	None				
Previous Accidents	Yes on 22 October 2001 (See note below)				

*NOTE: On 22 October 2001 the pilot was involved in an accident while flying a Robinson R22 when he failed to counteract the main rotor thrust during landing at Rand Aerodrome. The pilot was not injured during the accident but the aircraft sustain substantial damage when it rolled-over on landing.

Flying Experience:

Total Hours	1638,1
Total Past 90 Days	36,7
Total on Type Past 90 Days	36,7
Total on Type	108,5

1.6 Aircraft Information

Airframe:

Type	Eurocopter AS350-B3	
Serial Number	7027	
Manufacturer	Eurocopter	
Year of Manufacture	2010	
Total Airframe Hours (At time of Accident)	280,6	
Last MPI (Hours & Date)	205,5	24 May 2011
Hours since Last MPI	75,1	
C of A (Issue Date)	13 September 2010	
C of R (Issue Date) (Present owner)	4 August 2010	
Operating Categories	Standard Part 127	

Engine:

Type	Turbomeca Ariel 2B1
Serial Number	51064
Hours since New	277,4
Hours since Overhaul	TBO not yet reached

1.7 Meteorological Information

1.7.1 Meteorological information was obtained from the pilot flying questionnaire.

Wind direction	350°M	Wind speed	5 knots	Visibility	10000m
Temperature	23°C	Cloud cover	Clear Sky	Cloud base	Nil
Dew point	Unknown				

1.8 Aids to Navigation

1.8.1 The helicopter was equipped with standard navigational equipment as per Minimum Equipment List approved by the Regulator. There were no recorded defects to navigational equipment prior to the flight.

1.9 Communications.

1.9.1 The helicopter was equipped with standard communication equipment as per Minimum Equipment List approved by the Regulator. There were no recorded defects to communication equipment prior to the flight.

1.9.2 The pilot did communicate his intentions to land on the Sishen Aerodrome frequency 123.5 MHz.

1.10 Aerodrome Information

Aerodrome Location	4 Nautical miles north-west of the town Sishen (Northern Cape province)	
Aerodrome Co-ordinates	S 27°39'00" E23°00'00"	
Aerodrome Elevation	3 848 feet	
Runway Designations	17/35	
Runway Dimensions	1 740m x 23m	
Runway Used	Runway 35	
Runway Surface	Asphalt	
Approach Facilities	NDB, VOR and runway lights.	

1.11 Flight Recorders

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

1.12 **Wreckage and Impact Information**

1.12.1 Final impact point

The final impact point was to the left of Runway 35 at Sishen Aerodrome The helicopter came to rest facing in south-westerly direction, determined to be 240° Magnetic. **(See Fig 2)**

Figure 2. Helicopter as it came to rest to the left side of Runway 35.

1.12.2 Aircraft attitude during impact

During impact the helicopter had a nose down and bank angle to the right. The degree of bank angle and nose down attitude is unknown.

1.12.3 Aircraft configuration during impact

At the time of impact, the engine was at flight idle. The PNF closed the throttle prior to him disembarking from the wreckage.

1.13 Medical and Pathological Information

1.13.1 Neither the pilots, nor the passenger sustained any injuries during the sequence of the accident.

1.14 Fire

1.14.1 There was no pre- or post-impact fire.

1.15 Survival Aspects

1.15.1 This accident was considered survivable due to both pilots and the third crew member wearing safety harnesses and due to the low impact forces on the cockpit area of the helicopter.

1.16 Tests and Research

1.16.1 A hydraulic test rig was connected to the helicopter and the hydraulic system was operated without any abnormalities or warning indicators.

1.16.2 All relevant hydraulic components (pump drive belts, hydraulic pump and pressure transmitter was tested and found to be working satisfactory.

1.17 Organizational and Management Information

1.17.1 Operator

The operator at the time of the accident was in possession of a valid operator's certificate approved by the Regulator.

1.17.2 Maintenance Organization

The last Mandatory Periodic Inspection (MPI) on this helicopter was done on 24 May 2011 at 205.5 airframe hours by a SACAA approved Aircraft Maintenance Organization (AMO) which was in possession of a valid AMO certificate.

1.17.3 Regulator (SACAA)

During the investigation, several discrepancies were noted in the audit reports that were carried out by the Regulator on the two Aviation Training Organizations (ATO) responsible for the training of the two pilots involved in this accident.

One of the pilots (PF) was trained without any syllabus as guidance to the training and at a facility that did not have a classroom for lectures. The ATO was not able to provide the Investigator with proof of any ground training (technical training) that was conducted during the conversion course onto the AS350-B2. Evidence available (SACAA records) indicate the ATO was audited and found to be compliant with all requirements whereas evidence at the ATO proved to be different.

The PNF was trained by a different ATO who was in possession of all relative documentation and a proper classroom for training purposes.

1.18 Additional Information

1.18.1 Initial accident statements received.

The initial statements by both pilots on the sequence of the accident state, the cause of the accident to be as a result of a hydraulic failure they experienced during flight, which render the helicopter uncontrollable in close proximity to the ground and it rolled over.

The helicopter was taken to the manufacturer's maintenance facility in South Africa. Under the supervision of the Investigator-in-charge (IIC); the helicopter was inspected and all relevant hydraulic components were removed and tested to ensure system integrity was not compromised. Inspection of all the relevant components did not reveal any evidence of any hydraulic component failure prior to the accident.

After further investigation and during a second interview with the pilots (individually) they then changed their statements to a 'pilot induced simulated' hydraulic failure and was not as a result of a mechanical failure of the hydraulic system as previously stated as the probable cause resulting in this accident.

1.18.3 Follow-up statement received by both pilots:

At a height of approximately 1 200 feet above ground level (AGL), while returning to Sishen Aerodrome to refuel the aircraft, the PNF decided to push the "ACCU TST" button on the systems control panel without permission from the pilot-in-command. Immediately the aural warning sounded and the "HYDR" warning light on the

Warning-Caution-Advisory panel illuminated. **(See *Note on page 12)**

Figure 3. Position of the “HYDR” warning light on instrument panel.

Figure 4. Position of the master “HYD” switch on the collective pitch lever.

- Both pilots agreed that they perform the simulated hydraulic failure as a training exercise.
- The pilot-in-command then followed the hydraulic system failure procedure as prescribed within the Pilot Operating Handbook (POH). **(See Appendix B)**

- The decision was made to land the helicopter onto Runway 35 at Sishen Aerodrome. When approaching the runway for landing, at a height of approximately

3-6 feet above the runway, the helicopter yawed to the left. The pilot-not-flying then asked the pilot-in-command to switch the main hydraulic switch back on (switch located on the collective pitch lever). After switching the hydraulic system back on, the pilot-in-command increased collective pitch control to cushion the landing. The helicopter then violently started to yaw to the left.

- PF handed over controls to the PNF. The pilot-not-flying then took over control of the helicopter. He stated he had no tail rotor control at that stage. He then closed the throttle to the flight idle position as the helicopter yawed through 360° before the right-hand skid made contact with the ground and the helicopter rolled over onto its right-hand side.

***NOTE:** *(AS350B3 Flight Manual)*
"The ACCU TST switch has a TEST and an OFF position. Selected to the TEST position during pre-flight checks, emergency procedures, and also when performing hydraulics off training, it will result in the solenoid valve opening on the regulator unit, which depressurize the hydraulic system. It will also open the tail rotor servo solenoid, depressurizing the tail rotor load compensating servo but allows the main rotor servos to be powered by the accumulators in their respective safety units."
(See Fig 5)

Figure 5. Position of the "ACCU TST" switch on the systems control panel.

1.18.3 During an interview with the PIC it was noted he did not fully understand the operation of the hydraulic system of the AS350B3 including the operation of the

"ACCU TST" switch.

1.18.4 The Civil Aviation Regulations stated the following regarding the responsibilities of the pilot-in-command:

Part 91.02.8 Duties of pilot-in-command regarding flight operations

(1) The pilot-in-command of an aircraft shall be responsible for-

(a) the operation and safety of the aircraft while he or she is in command;

(b) the conduct and safety of flight crew members and passengers carried; and

(c) the maintenance of discipline by all persons on board;

1.18.5 Hydraulic system

The hydraulic system is used on helicopters to act as a power assistance to the pilot in the control of the main and tail rotor blades. They reduce the forces that the pilot has to apply to the cyclic, collective pitch lever and the anti torque pedals. In an event of a failure an accumulator gives the pilot a limited amount of assistance before the system pressure is entirely dissipated, after which control forces experienced increase significantly. When this occurs the pilot must land as soon as possible and avoid any manoeuvre which increases or decreases torque significantly, the idea being to maintain forward flight and perform a gradual descent to instigate a run on landing – i.e., touchdown with forward motion.

A detailed description of the system could be found attached to this report as Appendix A.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 Crew

2.1.1 According to available information, the pilot-in-command was in possession of a valid commercial pilot license (helicopter). The second pilot (PNF) that was onboard the helicopter was in possession of a valid private pilot license (helicopter). The PNF had a total of 1638.1 flying hours of which 108.5 was on type whereas the PF had a total of 410.5 hours of which 297.1 was on type.

2.1.2 There was no planning, nor any briefing on the simulated hydraulic failure exercise prior to the execution thereof. The pilot-not-flying deactivated the "ACCU TST" switch (Accumulator Test Switch) on the instrument panel and the "HYDR" (Hydraulic) warning light illuminated. It was only when the HYDR warning light illuminated that the PF became aware of the situation. Then dialog followed and it was decided by both crew members to continue with a simulated hydraulic failure, however no clear task allocation followed resulting in confusion within the cockpit during the latter stage of the exercise. The fact that it was not a private pilot requirement to attend a CRM course (which was not a regulatory requirement for a private pilot licence holder) should be considered in the error chain as a significant/critical communication breakdown in the cockpit, which ultimately had a direct effect on the outcome of this accident.

2.1.3 The pilot-in-command allowed the second crew member to intervene with the operation of the helicopter while in flight without taking any actions to prevent this situation from developing into an unsafe situation.

2.1.4 During the initial stages of the investigating the investigation team was misled by the two pilots, which provided a fabricated version of the actual accident sequence during the first interview with both of them on 4 July 2011. Following their fabricated version the assistance of the helicopter manufacturer was requested for assistance. The subsequent testing of the hydraulic system and various components, which was found to be undamaged in the accident, resulted in a substantial amount of time and resources being utilized in order to establish the primary cause of the hydraulic failure.

2.1.5 It was further noted that the training standard of the two pilots flying the helicopter, at the time of the accident, was compared to the standard of training of the chief pilot of the company operating the helicopter. It was found that between the two pilots there were two different standards of conversion training on the AS350B3 helicopter as both had conducted their type conversion at different ATO's.

2.1.6 Audit reports obtained from the SACAA on the two ATO's responsible for the type conversion training of the two pilots contained inconsistencies and discrepancies as to what was actually found when inspecting these facilities and documents at the relevant ATO's. One of the pilots (PF) was trained without any syllabus as guidance to the training and at a facility that did not had a classroom for lectures. The ATO was not able to provide the Investigator with proof of any ground training (technical training) that was conducted during the conversion course onto the AS350-B2. Evidence available (SACAA records) indicate the ATO was audited and found to be compliant with all requirements whereas evidence at the ATO proved to be different.

2.1.7 The PNF was trained by a different ATO which was in possession of all relative documentation and a proper classroom for training purposes which had, according to SACAA audit report, several findings against the ATO. The audit reports shown major inconsistencies between the two ATO's in question.

2.2 Helicopter

Maintenance records revealed the helicopter was properly maintained by a SACAA approved aircraft maintenance organization (AMO), which was in possession of a valid AMO certificate at the time of the maintenance. No unresolved maintenance discrepancies were outstanding prior the departure of the helicopter on the accident flight. It did came to the attention of the IIC that several technical related abnormalities was never recorded in the helicopters flight folio by the pilots flying the helicopter on pre accident flights, which resulted in improper record keeping of such defects.

Initial notification indicated the accident was the result of a hydraulic failure in flight. Although the helicopter was substantially damaged during the accident the hydraulic system remained basically intact, which allowed integrity test(s) to be performed on the system and associated components. No anomalies were found that could have contributed or have caused a hydraulic failure in-flight. Both pilots later revealed they did not experience a hydraulic failure but opted to perform a simulated hydraulic failure exercise. During such exercise the “ACCU TST” switch was deactivated by the pilot-not-flying in flight to simulate a hydraulic failure. The "ACCU TST" switch, unlike the HYD mater switch located on the collective pitch lever was never switched back on before an attempt was made to land the helicopter in close proximity to the ground. This resulted in an incomplete re-activation of the hydraulic system before performing a normal landing. As the PF increased collective pitch, close to the ground the helicopter started to yaw to the left a yaw rate that neither pilots was able to address/stop. The deactivation of the "ACCU TST" switch had caused the tail rotor load compensating servo to stay depressurised during this phase of flight resulting in no hydraulic power assistance to the tail rotor to counteract the torque / helicopters gyroscopic effect.

2.3 Environment

Weather information obtained from the pilot's questionnaire indicated that fine weather conditions prevailed at the time of the accident and was not considered too have had any bearing on the accident.

3. CONCLUSION

3.1 Findings

3.1.1 The pilot-in-command held a valid commercial pilot licence and was properly certified according to current regulations. He was doing all the flying as this was a commercial operation.

3.1.2 The PNF held a valid private pilot licence and was properly certified and qualified according to current regulations.

3.1.3 Both pilots misled the investigation team during the initial phases of the investigation by not providing a true reflection of the circumstances leading up and evitable resulting in this accident.

3.1.4 The helicopter was properly maintained and had a valid Certificate of Airworthiness.

3.1.5 The helicopter was properly certified, equipped and maintained in accordance with current regulations. An inspection of the helicopter after the accident revealed no evidence of structural, engine or system failure other than those as a result of the accident sequence.

3.1.6 The hydraulic system was only partially switched on after it was completely switched off during the simulated hydraulic failure exercise.

3.1.7 An un-planned simulated hydraulic failure emergency situation was caused by the pilots following the incorrect actions in reactivating the system.

3.1.8 The flight was operated as a Commercial flight under VFR rules.

3.1.9 The investigation revealed several discrepancies pertaining to the two pilots conversions training onto the AS350B2/3 type helicopter.

3.1.10 Form CA 141-03 in use by SACAA, Flight Operations, Part 141 was found to be a generic form and not task specific.

3.1.11 The helicopter crashed to the left of Runway 35 at FASS, which was a licensed aerodrome.

3.1.12 Emergency services quickly attended to the accident site. None of the three occupants onboard the helicopter was injured.

3.1.13 Fine weather conditions prevailed on the day of the accident and had no bearing on the accident.

3.2 Probable Cause/s

3.2.1 Unsuccessful landing, following interference by the pilot-not-flying during a critical phase of flight, resulting in a loss of control in close proximity to the ground, which was aggravated by the incorrect reactivation of the hydraulic system.

3.3 Contributing Factors

3.3.1 Disregard for safe operating procedures.

3.3.2 Improper use of Emergency System.

3.3.3 Lack of knowledge of the hydraulic system by the crew.

3.3.4 Lack of flight crew supervision.

3.3.5 Failure in Crew Resource Management (CRM).

3.3.6 Poor Airmanship.

3.3.7 Lack of communication between crew members.

4. SAFETY RECOMMENDATIONS

The following safety recommendations were issued within the procedural frame work of the Accident and Incident Investigation Division (AIID) and was approved and accepted by the Acting Director for Civil Aviation on 21 July 2011.

4.1 It is recommended to the Director for Civil Aviation that the staff shortage that exists within the Flight Operations Division, Part 141 be addressed as a matter of extreme urgency.

Having to audit all flying schools currently registered throughout South Africa with four (4) auditors becomes an impossible task, not alone to ensure all the ATO's are being audited but that the quality of aviation training in South Africa are not compromised.

4.2 It is recommended to the Director for Civil Aviation that Part 141 auditors be accompanied by at least one "other" Flight Operations Inspector (i.e., Part 121, 127 or 135) as an interim measure until such time that additional personnel had been appointed and had received the required training to become operational auditors.

4.3 It is recommended to the Director for Civil Aviation that the current checklist(s), reference number CA 141-03 and supporting sub parts currently in use by Part 141 should be reviewed. Not all ATO's engage in basic/entry level pilot training, certain ATO's does provide training on more advanced/high performance aircraft, however, they are being subjected to the same audit checklist, which contains certain subheadings, which is not applicable to these ATO's and the type of training conducted.

5. APPENDICES

5.1 Appendix A (Hydraulic system description)

5.2 Appendix B (Hydraulic emergency procedure as stipulated in the POH).

7.7 HYDRAULIC SYSTEM

7.7.1 GENERAL

To reduce pilot's workload, the flight controls are hydraulically boosted in order to give very light control loads on the cyclic stick, collective lever, and tail rotor pedals. There are three main rotor servos, one longitudinal and two lateral; and also a tail rotor servo for yaw control.

The hydraulic fluid used must comply with the approved specifications in SECTION 2 of the present flight manual.

Total system fluid volume is 3 liters (0.79 US gal or 0.66 UK gal) up to the maximum level mark on the reservoir.

7.7.2 SYSTEM DESCRIPTION

7.7.2.1 Hydraulic system components

- a separate reservoir secured on the top of the MGB,
- a single constant flowrate gear-pump generates the hydraulic power. The hydraulic pump is driven by a drive belt mounted between the pump pulley attached to a pulley on the engine power drive shaft close to the MGB power input.
- a regulator unit fitted with :
  - a pressure regulating valve set to 40 bar (580 psi),
  - a pressure switch;
  - a 3 microns filter with a clogging indicator, and,
  - a solenoid electrovalve.
- a distribution system which comprises flexible pressure and return hoses, supplies the four single-body servo-controls and the tail rotor load compensator.

- three single-cylinder servos to control the main rotor, which move the stationary swash plate. Each servo is fitted with a safety unit which consists of :
  - a hydraulic accumulator,
  - a non-return valve; and,
  - a solenoid electrovalve.

The safety units allow for continued hydraulic assistance for a limited time in the event of a hydraulic pressure loss in the system.

The limited time is sufficient to allow the pilot to achieve a flight regime under which the control feedback forces are acceptable without hydraulic assistance.

- a single-cylinder yaw servo.
- a load compensating system to reduce, in the event of a hydraulic pressure loss, the yaw pedal feedback forces for an indefinite period. The load compensator pressure can only be dumped by selecting the accumulator test switch to TEST. This system consists of :
  - a hydraulic accumulator,
  - a non-return valve,
  - a pressure relief valve,
  - a pressure-drop solenoid electrovalve on the accumulator, and,
  - a load compensator actuator.
- Hydraulic system warnings :
  If the pressure regulating unit pressure switch senses the hydraulic pressure dropping below 30 bar (435 psi) the following cockpit indications are provided :
  - a red HYDR light on the Warning-Caution-Advisory panel; and
  - a Gong sounds one time (the Gong is used to indicate any red warning lighting).

7.7.2.2 System controls and monitoring

The hydraulic system is controlled using two switches :

- the Hydraulic cut-off switch : guarded switch mounted on the collective with two positions, ON and OFF.
  Normally left in the ON position, allows the main-rotor servos to be powered when the hydraulic system is operating normally. Selected to OFF, during pre-flight checks, emergency procedures, and also when performing hydraulics off training, the hydraulic system is then depressurized, and the accumulators on the main rotor servo safety units are depressurized simultaneously, the tail rotor load compensating system retains its assist function.

- the accumulator test pushbutton : **[HYD TEST]** or **[ACCU TST]** pushbutton switch mounted on the center console with two positions : TEST (down) and OFF (up). It is normally left in the OFF position.
  Selected to the TEST position during pre-flight checks, emergency procedures, and also when performing hydraulics off training, it will result in the solenoid valve opening on the regulator unit, which depressurizes the hydraulic system. It will also open the tail rotor servo solenoid, depressurizing the tail rotor load compensating servo but allows the main rotor servos to be powered by the accumulators in their respective safety units.

7.7.2.3 Main rotor servos

The AS 350 can be fitted with servos produced by two suppliers, SAMM and Dunlop. The servos are interchangeable, but have some differences.

SAMM Servos – SAMM servos are fitted with an input clearance locking system. The input clearance locking system was designed to reduce control system freeplay, and therefore enhance aircraft handling qualities when operating in the unpowered (bypass) mode. During system pressurization and with collective in locked position, as hydraulic pressure rises, if the input locking devices on the lateral servos unlock at different pressures, a large cyclic stick movement to the right or to the left may occur in normal operation. The pilot can prevent the cyclic from moving by firmly holding the cyclic with his hand and knees. The force required to prevent control movement is approximately 5 daN (11 lbf). The movement occurs because one lateral servo can become hydraulically assisted before the other due to:

- the main rotor control loads not being equally applied to both lateral servos; and/or,
- the hydraulic pressure threshold necessary to activate unlocking of the servos (change from non-boosted mode to hydraulically boosted mode) can be slightly different for the RH and the LH lateral servos due to manufacturing tolerances.

In flight, a small cyclic movement may occur when switching from powered to unpowered (bypass) and vice versa.

Dunlop Servos – Dunlop main rotor lateral servos do not include an input locking device, and are not subject to asymmetric switching from unpowered (bypass) mode to powered mode. Small cyclic movement may occur when switching from powered to unpowered (bypass) and vice versa.

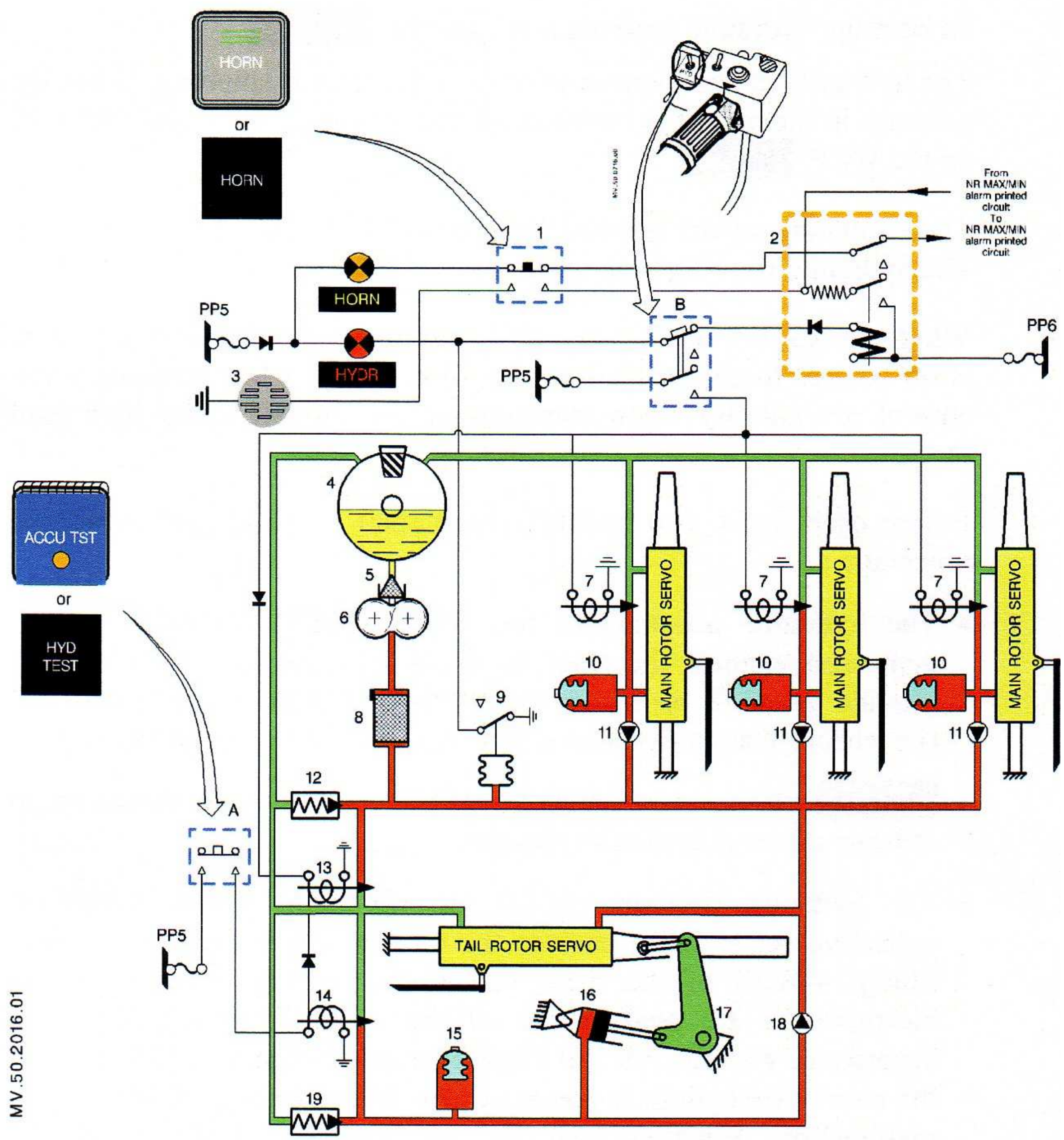

Figure 7 - 27 : Hydraulic system block-diagram

7.7.3 NORMAL OPERATIONS

At start-up, hydraulic pressure is nil and the HYDR .

The hydraulic pump operates as soon as the rotor is spinning. When the pressure in the circuit is between 20 and 30 bar (290 psi and 435 psi), on the WCP: HYDR.

The regulating valves regulate the pressure at 40 bar ±2 (580 psi ±29). The hydraulic warning light is out.

When the AS 350 B3 flight control system is operating normally there is no control force feedback to the pilot, except when reaching servo control reversibility when maneuvering the aircraft under high load factor.

Before each flight, two hydraulic tests shall be performed as normal procedure :

- The hydraulic accumulator test **[HYD TEST]** or **[ACCU TST]** depressed enables the pilot to check that the accumulators still provide hydraulic assistance should the hydraulic power system fail (i.e. checks that there are no significant leaks in the accumulators).

  HYDR (flashes post MOD 07 3317) and the Gong comes on to indicate a loss of hydraulic pressure.

- The hydraulic pressure cut-off test (hydraulic cutoff switch on collective set to OFF) enables the pilot to check the electrovalves (dump valves) of the main servos for correct operation. These electrovalves are used to cut off the hydraulic power system in accordance with the AS 350 Flight Manual emergency procedures, in the event of a hydraulic power system failure or other flight control malfunctions. When the hydraulic cut-off switch is placed in the cut-off position, the accumulators are depressurized simultaneously by opening of the three electrovalves.

Non-related to hydraulic malfunction, the [**HYD TEST**] or [**ACCU TST**] switch is only used in flight to deplete the tail rotor accumulator and load compensator in case of tail rotor control failure in order to bring tail rotor to low pitch. On ground the [**HYD TEST**] or [**ACCU TST**] pushbutton is used to deplete the tail rotor accumulator and load compensator after engine shutdown.

- The accumulators will be repressurized when the hydraulic cut-off switch is returned to the ON position.

  The accumulators are checked for correct nitrogen pressurization by measuring the time required for the hydraulic system pressure to return to its nominal level. It will take normally 3 seconds until pressure rises to the nominal operating level. The pilot must note the time from placing the hydraulic cut-off switch to the normal position HYDR.

  Expected cyclic movement is explained in previous paragraph.

7.7.4 ABNORMAL OPERATIONS

7.7.4.1 Accumulator malfunction

After hydraulic pressure cut off test completion, the normal period for accumulators repressurization is 2 to 3 seconds, but is reduced to 1 second if at least one of the accumulators is defective. If a defective accumulator is detected then maintenance action must be performed prior to flight.

7.7.4.2 Hydraulic pressure loss

The conventional hydraulic system failure is caused by hydraulic system pressure dropping below 30 bar (435 psi), with the normal functioning of the servos, accumulators, safety units, electrovalves, and hydraulic cut-off switch.

Indications to pilot:

- HYDR,
- Gong sounds,
- Controls remain powered by the accumulators.

The pilot should perform the AS 350 flight manual hydraulic pressure loss (illumination of HYDR warning light) emergency procedure:

- The average time required to attain the required recommended safety speed range 40 to 60 kt (74 to 111 km/h) from VNE or the hover is less than 30 seconds. If the accumulators are properly serviced they will power the flight controls throughout the maneuvers required to reach the recommended safety speed range. If control force feedback is felt prior to attaining the safety speed range then the pilot should immediately select the hydraulic cutoff switch to OFF.

- It is then required to cut off the hydraulic power system as soon as the recommended safety speed is reached. It is necessary even if the accumulators still provide some hydraulic assistance because this enables simultaneous depressurization of the three main rotor accumulators.
  This will avoid reaching a stage at which one of the two lateral accumulators depletes while the other is still operative. This condition would result in asymmetric control forces.

- The pilot will be required to continuously exert the following forces in order to maintain aircraft attitude when at the recommended safety speed 40 to 60 kt (74 to 111 km/h) and with the collective in its neutral position (approximately 40 percent Torque) :
  - Lateral Cyclic : force to push left, approximately 4 daN (9 lbf),
  - Longitudinal Cyclic : force to push forward, approximately 5 daN (11 lbf),

Non-related to hydraulic malfunction, the [**HYD TEST**] or [**ACCU TST**] switch is only used in flight to deplete the tail rotor accumulator and load compensator in case of tail rotor control failure in order to bring tail rotor to low pitch. On ground the [**HYD TEST**] or [**ACCU TST**] pushbutton is used to deplete the tail rotor accumulator and load compensator after engine shutdown.

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- Collective : will have a tendency to reach by itself the neutral position where zero force is required from the pilot while providing the appropriate power setting for the recommended safety speed in level flight, unless the pilot decides to change power from the neutral position.

- As the aircraft flies at recommended safety speed without significant control loads, this generally allows the pilot sufficient time to choose a landing area suitable for a running landing.
  If necessary, increase IAS, but the control load feedback will also increase in both cyclic axes as the speed is increased, and on the collective as the collective is moved from the neutral (zero force) position. The pilot is required to exert continuous forces in order to maintain aircraft control and must be careful not to become excessively tired and unable to maintain aircraft control.

- The recommended flat approach at low speed and the slight running landing can be performed with very little change to collective pitch, which results in reduced cyclic force variations. During the running landing, around 10 kt (19 km/h), the pilot may have to exert a forward longitudinal force up to 17 daN (38 lbf) for less than 30 seconds with low lateral forces.
  If the aircraft is hovered, the control forces change in both direction and intensity as the pilot attempts to maintain a steady position. The pilot will have to exert longitudinal and lateral forces of up to 5 daN (11 lbf) which can change quickly in direction. This results in excessive pilot workload and controllability problems.
  Due to pilot fatigue, it is thus not recommended to perform extensive flight time after an hydraulic failure and the pilot should divert to the nearest suitable landing site.

The exception to this is if the hydraulic cutoff switch is rendered ineffective due to loss of electrical power, broken wires, or a faulty switch. The function of the switch is verified prior to every flight when performing the pre-flight checks. If the hydraulic cutoff switch is ineffective, the control forces should become normal (for hydraulics off) after all the accumulators have depleted.

There may be some cases where the control forces remain non conventional for the duration of the flight. The pilot should minimize the time of flight and plan a shallow approach to a no-hover/slow run-on landing into wind.

The maximum forces the pilot will have to exert on the controls in order to maintain aircraft attitude are approximately :

- Lateral cyclic 15 daN (34 lbf) left or right;
- Longitudinal cyclic 17 daN (38 lbf) forward.

Although these forces are high, they are generally found at the extremes of the speed envelope. The pilot can reduce the required force inputs by attaining the safety speed range 40 to 60 kt (74 to 111 km/h).

3.7 VARIOUS WARNINGS, FAILURES AND INCIDENTS NOT INDICATED ON THE CWP

3.7.1 ROTOR BRAKE INOPERATIVE

WARNING

WAIT FOR FULL ROTOR SHUTDOWN BEFORE LEAVING THE AIRCRAFT.

Rotor stopping with wind blowing:

1. Aircraft..INTO WIND.
2. Cyclic stick...slightly INTO WIND.

3.7.2 HYDRAULIC SYSTEM FAILURES

Yaw servo-control slide-valve seizure :

- In hover

. If no movement about yaw axis :

LAND normally.

. If yaw axis rotation :

[**HYD**] switch (collective grip) ....OFF.

- In cruise flight

1. Airspeed ....REDUCE between 40 to 60 kt (74 to 111 km/h) in level flight, enter sideslip if necessary.
2. [**HYD**] switch (collective grip) ....OFF, apply HYDR procedure.