

ORIGINAL

NO.HQCAA/1901/202/SIB



CIVIL AVIATION AUTHORITY

**AIRCRAFT INCIDENT INVESTIGATION M/S PLAC
TWIN OTTER REG.NO.AP-BCH WHICH OCCURRED
ON 20TH FEBRUARY, 1996**

AT

MUZAFFARABAD AIRPORT



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CIVIL AVIATION AUTHORITY
KARACHI

INVESTIGATION REPORT

INCIDENT TO M/S PIAC TWIN OTTER AIRCRAFT REG NO AP-BCH
AT MUZAFFARABAD AIRPORT ON 20TH FEBRUARY, 1996

Authority:- Director General Civil Aviation Authority Memorandum
No. HQ CAA/1901/202/SIB dated 27th February, 1996
(Appendix 'A')

COMPOSITION OF INVESTIGATION TEAM

- (a) Air Cdre (Retd) Rashid A. Bhatti : Investigator Incharge
Pilot Investigator, SIB CAA
- (b) Mr. Shaukat Iqbal Rana : Investigator
Manager Engineer QC
(PIAC) Islamabad

Summary of Incident

1. Captain Athar H. Butt ALTP No.489 and First Officer Shaukat Mahmood CPL No.1156 of PIA were scheduled to operate PK-425 on 20th February, 1996 from Muzaffarabad - Rawalakot - Islamabad sector on Twin Otter Aircraft Registration No.AP-BCH. After normal start up, taxi clearance was given for RW 13. The aircraft taxied out for take off from RW 13. After entering RW 13 while turning left to line up on centre line of RW, the Captain observed complete hydraulic failure as such the operation of nose wheel steering and wheel brakes were lost. Therefore, the aircraft instead of turning left for line up on centre line it kept on going towards right side. The Captain selected both engines into reverse but as the terrain was slopping down ward the reverse did not help in stopping the aircraft. The brakes were applied with full pressure but there was no response and aircraft kept going down hill. Lastly both engines were switched off and aircraft went into small ditch and subsequently it went into a bigger ditch. At this stage the First Officer realized that the aircraft may not stop and is heading towards the river, he therefore, decided to jump off the aircraft. The aircraft finally came to a stop in a ditch against a big stone in front of left wheel of aircraft. Three passengers on board the aircraft were evacuated safely. No passenger was hurt and aircraft sustained no damage. However, the First Officer got minor injuries.

Injury to Persons

2. As a result of the incident First Officer Shaukat Mahmood received minor injuries when he jumped out of the moving aircraft.

Damage to Aircraft and Property

3. As a result of this incident no damage was caused to the aircraft or any other property.

Meteorological Condition

4. The weather was fair and visibility was good. Weather was not a factor in this incident.

Aids to Navigation / Communications

5. Aids to Navigation and Communications were not a factor in this incident.

Aerodrome and Ground Facilities

6. Runway 13/31 which is 3000 feet in length and 75 feet wide with 200 feet over-run. The area S.W of RW 13 and F.W.S have slopping down terrain.

INVESTIGATION

Scene of Incident

7. PIAC Twin Otter aircraft PK-425 taxied out at 1047 hours (local) from Apron (100 X 40 feet) located on the left side adjacent to beginning of RW 13. While entering the RW 13 the aircraft could not turn left to line up for take off and went straight off the Runway crossing the F.W.S. on a heading of 270 degree and kept going on a slopping down terrain and came to a stop in a ditch 178 feet from the edge of the RW 13 (Appendix 'B' and 'C'). The APM Muzaffarabad despatched the RIV to the scene of incident alongwith the Airport Staff. The APM took other actions as per existing procedures. The President Safety Investigation Board, CAA alongwith engineering staff of PIAC reached at the scene of incident at about 1000 hours on 21st February, 1996.

8. The examination of the aircraft at the scene of incident revealed the following evidences :- (Appendix 'D').

- a. Main Hydraulic System Pressure Indicator = Zero PSI
- b. Hydraulic Brake Pressure Indicator = 600 PSI
- c. Main/Damping Accumulator Air Pressure = 600 PSI Indicator.
- d. Brake Accumulator Air Pressure Indicator = Zero PSI
- e. Parking Brake Handle in Pulled Position
- f. Hydraulic Oil Pump Circuit Breaker at IN Position
- g. Hydraulic Oil Reservoir Full
- h. Flaps at Take-Off Position (10 degree)
- j. Nose Wheel Steering mechanism and Pip Pin found in serviceable condition.
- k. With Parking Brake Handle in Pulled Position the aircraft could not be moved at the time of recovery of the aircraft from the scene of incident. The aircraft could be moved with the parking brake in released position.

AIRCRAFT SERVICEABILITY CHECK AT MUZAFFARABAD

9. After the recovery of aircraft from the scene of incident the aircraft was inspected thoroughly by the PIAC engineering staff in presence of President SIB and Captain of the aircraft. After the inspection, the aircraft BATTERY was switched ON to check the Hydraulic System of aircraft which operates the wing flaps, nose wheel steering and wheel brakes. It was observed that the main components of hydraulic system i.e. electric motor - driven pump, damping and brake accumulators, flap and nose wheel steering actuators were all serviceable and normal hydraulic pressure was available for operation of flaps, nose wheel steering and wheel brakes.

10. After establishing the serviceability of hydraulic system, Captain Athar H. Butt started the aircraft in order to establish the effectiveness of nose wheel steering and wheel brakes during taxi. The investigation team on board the aircraft observed that the nose wheel steering and wheel brakes were functioning properly and electric motor-driven hydraulic pump was maintaining the damping and brake accumulators pressure within normal limits. During taxiing both the throttles were selected in Reverse range and desired effect was observed. However, it was noticed that when engines were selected in Reverse range at normal taxi speed on the runway, the aircraft came to a halt after travelling about 100 feet without any brake application.

11. The aircraft was declared serviceable and was cleared for ferry flight from Muzaffarabad to Islamabad. Captain Athar H. Butt ferried the aircraft to Islamabad with the Investigation Team on board the aircraft. Since the Captain had experienced a hydraulic failure before take off from Muzaffarabad on 20th February, 1996 therefore, the investigators recommended that a detailed technical examination of all hydraulic system components and its power supply system be carried out with a view to establish the cause of One time failure of hydraulic system.

Detailed Technical Examination

12. The following components of hydraulic system were removed from the aircraft for detailed Examination at PIAC Inspection Department, Karachi :-

- a. Hydraulic Pressure Accumulator
- b. Circuit Breaker (Hydraulic Pump)
- c. Pressure Switch
- d. Hydraulic Pump Relay

13. The examination revealed that the Accumulator, Circuit Breaker and Pressure Switch were serviceable and test reports were as per Component Maintenance Manual. However, the Hydraulic Pump Relay Part No. MS 24166-D1 revealed the following defects :- (Appendix 'E').

- a. On applying the voltage the relay was found energizing between 17 V to 21 V whereas the limit is 15..5V maximum.
- b. The Drop-out Voltage was 5 V whereas the limit is 7 V to 6.5 V.
- c. Millivolt-drop between the contacts was 250 millivolts against the limit of 150 millivolts maximum.
- d. Contact guide plunger found sticky and stepped thus causing obstruction in free movement.
- e. Main contacts of the relay found badly pitted and over heated.
- f. Shift of material was also noticed from one contact to the other, confirming excessive heat generation during use.

- g. The relay also got hot during testing.
- h. Failure of relay occurred at 1675 hours since installed.

14. Keeping in view the above results, the same type of relay installed on another aircraft No.AP-BCG was removed for condition check. The test report is as follows :- (Appendix 'F').

- a. The relay passed all the electrical checks as prescribed in the Maintenance Manual.
- b. The relay was disassembled to examine the condition of the power points and was found heavily pitted. The material had melted and got transferred from one contact to the other.
- c. This relay also turned hot during testing.
- d. This condition of the relay was at 1324 hours since new.

15. As mentioned in para 8(d) that during the inspection of aircraft at the scene of incident the Brake Accumulator Air Pressure was zero PSI which should have been around 600 PSI. The loss of brake system accumulator pre-charge pressure was due to worn out gaskets in the plumbing area. The brake accumulator however was serviceable.

16. All electric wiring of hydraulic system were checked thoroughly to detect any abnormality in the power supply system. The test report was satisfactory.

17. The Electric Motor Driven Hydraulic Pump was checked thoroughly to determine its operation as per manual. The performance of hydraulic pump was satisfactory.

Witnesses

18. The following relevant information was obtained from the statements of Captain, First Officer and eye witnesses :- (Appendices 'G', 'H', 'J', 'K' and 'L').

- a. Captain while entering on RW 13 was taxiing the aircraft at normal taxi speed. This was also confirmed by eye witnesses.
- b. Complete hydraulic failure had occurred when the aircraft was about to turn left to line up on centre line of RW 13.

- c. Hydraulic Pump failure light did not come ON.
- d. Captain stated that Hydraulic Pump Circuit Breaker was not pulled out before engine start. However, he stated that when pilot feels that the battery is weak than it is recommended to pull the CB out before start to reduce load on battery for internal start.
- e. Captain Hamidulla P No.52377 stated that on 5th January, 1996 while operating PK-439 from Parachanar, he experienced hydraulic failure during taxi for take-off. The nose wheel steering and wheel brakes were not effective. Therefore, as per check list actions he cycled the Hydraulic Pump CB 3 to 4 times and hydraulic pump started working and hydraulic pressure became normal. When Hydraulic failure occurred the light had not come ON.
- f. Captain Ather while replying to a question regarding First Officer's action of jumping out of moving aircraft, he said that ethically speaking he should not have jumped out of the aircraft.
- g. First Officer stated that, since the aircraft was not stopping with the application of brakes and he could see in front that the aircraft is heading towards river and we had no control over the aircraft, therefore, as a natural response under the prevailing situation he decided to jump out of the aircraft.
- h. Flying Experience.
 - i. Captain Ather H. Butt

Grand Total	=	7500 Hrs
Total in Command	=	7000 Hrs
Total in Command on Twin Otter	=	900 Hrs
 - ii. First Officer Shaukat Mahmood

Grand Total	=	700 Hrs
Total in Command	=	450 Hrs
Total Co-Pilot on Twin Otter	=	160 Hrs

Documents

19. Following relevant information was obtained from PIA aircraft AP-BCH Technical Log regarding Hydraulic System defects as reported by the air crew :- (Appendix 'M').

- a. On 3rd January, 1996 Captain made an entry that hydraulic electric motor pump failed at Muzaffarabad Airport and heavy background sound in Intercom of co-pilot side was observed.

Rectification : The hydraulic pump circuit breaker was found in pulled-out position. It was reset and pump started functioning. Therefore, as a preventive maintenance electric checks of hydraulic motor, pressure switch and circuit breaker were carried out.

- b. On 5th January, 1996 Captain made an entry that Electric Hydraulic Pump failed and flight completed with Emergency Hand Pump.

Rectification : Electrical connections retorqued. Operation on ground sat. Pump suspected functioning intermittently. Hydraulic Pump changed and safetied

DISCUSSION AND ANALYSIS

20. The sequence of events leading to incident as described by the Captain of Twin Otter aircraft and evidences obtained from examination of aircraft at the scene of incident, aircraft hydraulic system serviceability check at Muzaffarabad after the incident and detailed technical examination of all hydraulic system components and its power supply system revealed that hydraulic pressure was not available for the operation of nose wheel steering and wheel brakes due to one time failure of hydraulic pump to maintain the damping and brake accumulator pressures within normal limits when the aircraft was taxiing for take-off from RW 13 at Muzaffarabad Airport on 20th February, 1996.

21. The statement of Captain and evidences obtained from other sources are pointing towards one time failure of Electric Motor-Driven Hydraulic Pump to energize and pressurize the accumulators. It is therefore, considered pertinent to include a brief description of Hydraulic System of Twin Otter aircraft before any discussion is carried out on the possible causes of one time failure of Hydraulic Pump to energize and pressurize the accumulators.

Hydraulic System

22. The hydraulic system operates the wing flaps, nose wheel steering and wheel brakes. The main components of the system are: an electric motor-driven pump, emergency hand pump, damping and brake accumulators, flap and nose wheel steering actuators. The system is pressurized by the motor-driven pump and pressure supply

is retained by the damping and brake accumulators. Pressure is immediately available from the damping (main) accumulator for operation of the flaps, nose wheel steering and wheel brakes. The brake accumulator supplements the damping accumulator in supplying the brakes, and also maintains a reserve pressure for brake operation in the event of pressure loss from the damping accumulator or failure of the motor-driven pump. The pressure switch senses system pressure and regulates the operation of the motor-driven pump so that a predetermined working pressure is always maintained by the two accumulators.

23. The Electric Motor-Driven Hydraulic Pump is powered from the left DC Bus. It maintains the damping and brake accumulators at a working pressure in response to pressure sensed by the pressure switch. When pressure falls 175 PSI below the normal system pressure, the motor-driven pump is energized and pressurizes the accumulator to $1550 + 50$ PSI, at which pressure it is de-energized. The motor driven pump circuit is protected by a HYD OIL PUMP circuit breaker. HYD PUMP C/BKR open caution light provides visual indication that the HYD OIL PUMP circuit breaker is open. If the HYD OIL PUMP circuit breaker is open, operation of nose wheel steering, brakes and flaps will quickly deplete the system accumulators and the hydraulic services will become inoperable. (When Hydraulic Pump has failed or de-energized and the HYD PUMP CB is IN, the caution light will not illuminate).

24. Failure of the electric motor-driven hydraulic pump will be indicated by failure of the hydraulic system pressure indicator and the brake pressure indicator to register maximum pressure again after a hydraulic system operation or brake operation. If all hydraulic fluid is lost it will be impossible to lower flaps. Limited wheel braking will be available from the brake accumulator.

Possible Causes for Hydraulic Pump Failure.
To Energize and Pressurize the Accumulators.

25. From the sequence of events leading to the incident and the evidences obtained from various sources, the Investigation Team is of the opinion that the Electric Motor-Driven Hydraulic Pump powered from the left DC Bus failed to energize and pressurize the accumulators at a working pressure. The Investigators discussed the following possible causes of Hydraulic Pump failure to energize and pressurize the damping and brake accumulators.

- a. Hydraulic Pump Failure.
- b. Pressure Switch Malfunction.

- c. HYD OIL PUMP C/BKR Malfunction.
- d. HYD Oil Pump Circuit Breaker in pulled-out position.
- e. Relay Malfunction.

26. The detailed technical examination of various Hydraulic System components revealed that Electric Driven Hydraulic Pump, Pressure Switch and Hyd Oil Pump Circuit Breaker were serviceable. Therefore, the possibility of hydraulic system failure due to malfunction of these components is ruled out. The most likely cause of hydraulic system failure could be the failure of power supply to electric motor driven hydraulic pump from the left DC bus. This could have been caused due to hyd Pump C B in open (Pulled Out) position or relay malfunction. Both the possibilities are being discussed in the subsequent paragraphs.

27. Hyd Oil Pump C B in Pulled out Position. The Twin Otter Pilot Training manual says, if batteries are not fully charged, pull the HYD OIL PUMP Circuit breaker to prevent pump operation during starting cycle. Reset the circuit breaker after the engines are running and both generators are on. The Captain stated that he did not pull out the HYD PUMP C B before starting engines as the batteries were fully charged. A caution light labeled HYD PUMP C/BKR OPEN provide a visual indication that the HYD OIL PUMP circuit breaker is open. The Captain stated that at the time of hydraulic system failure, this caution light was off. The examination of aircraft at the scene of incident also revealed that Hydraulic Pump circuit breaker was at IN position. Therefore, the possibility of failure of power supply to electric motor driven hydraulic pump due to Hyd Oil Pump C B in pulled out position is ruled out.

28. Hydraulic Pump Relay : The Relay P/N M S 24166 - D1 S/N PIAC 12393 was removed from AP-BCH aircraft for detailed technical examination. The test report revealed that on applying the voltage the relay was found energizing between 17 volts to 21 volts whereas the Component Maintenance Manual (CMM) limit is 15.5 volts maximum. The millivolt drop between the contacts were found as 250 millivolt against the CMM Limit of 150 millivolt maximum. The strip report revealed that the main contacts of the relay were badly pitted and over heated. The contacts guide plunger was found to be sticky and stepped thus causing obstruction in free movement. The test and strip examination of Hydraulic Pump Relay confirmed that the power supply to electric motor driven hydraulic pump was intermittent due to sticky and badly pitted relay contact.

Sequence of Events Leading to Incident

29. In the opinion of the Investigation Board the likely sequence of events leading to incident to Twin Otter aircraft No.AP-BCH is as follows :-

- a. After normal start the cockpit crew carried out the pre-taxiing checks and no abnormality was observed while carrying out hydraulic system checks.
- b. The electric motor-driven hydraulic pump had energized and pressurized the accumulators to 1575 PSI and at this pressure the pump is de energized in response to pressure sensed by the pressure switch.
- c. As the Captain taxied out he used the brakes and nose wheel steering and hydraulic pressure dropped to 1400 PSI and hydraulic pump did not energize to pressurize the accumulators to 1575 PSI as the faulty relay did not operate to energize the pump.
- d. Due to very short taxi distance from apron to RW 13 the Captain did not notice the failure of hydraulic pump to energize and pressurize the accumulators to 1575 PSI.
- e. During Taxi, before entering RW 13 for take-off the pilot operated the flaps to 10 degree position.
- f. As the hydraulic pump was not operating due to faulty relay, the residual pressure provided by the accumulator pre-charge was just enough for short taxi and operation of flaps to 10 degrees.
- g. After entering RW 13 when Captain wanted to turn left to line up on the centre line for take off, the operation of nose wheel was not available due to loss of hydraulic pressure and the aircraft kept going straight across the runway.
- h. The brake accumulator which maintains a reserve pressure for brake operation in the event of pressure loss from main accumulator could not supply the brake pressure due to loss of brake system accumulator pre-charge pressure through the worn out gaskets in the plumbing. Therefore, the aircraft could not be stopped and kept going on a slopping down terrain and came to a stop in a ditch against a big stone infront of left wheel of aircraft.

First Officer's Action of Jumping Out of Moving Aircraft.

30. After hydraulic system failure while the aircraft was going towards a slopping down terrain, the First Officer got into panic and jumped out of the moving aircraft. Ethically speaking he should not have jumped out of the moving aircraft with passengers on board the aircraft. However, when he realized that the aircraft is now getting out of control despite all possible efforts made by the Captain to stop the aircraft and he could see in front that the aircraft is heading towards river down below, as a natural response under the prevailing situation he decided to jump out of the aircraft. This of course was also not a very safe course of action particularly when the engine propellers were still running. Therefore, it appears that the First Officer Shaukat Mahmood while anticipating a very disastrous situation had to quickly decide on the best course of action to be followed. His decision to jump out of the aircraft can be justified.

CONCLUSIONS

Findings

31. From the foregoing investigation and analysis the investigators find that :-

- a. PIA aircraft Twin Otter Registration No.AP-BCH was scheduled to operate PK-425 on 20th February, 1996 from Muzaffarabad - Rawalakot - Islamabad Sector.
- b. The aircraft taxied out for take-off from RW 13 and after entering Runway while turning left to line up on centre line, the Captain experienced complete hydraulic system failure as such the operation of nose wheel steering and wheel brakes were lost.
- c. The aircraft could not be turned left to line up for take-off and went straight off the runway crossing the F.W.S on a heading of 270 degree.
- d. The aircraft kept going on a slopping down terrain and could not be stopped as the brake pressure was not available due to complete hydraulic system failure.
- e. The aircraft finally came to a stop in a ditch against a big stone in front of left wheel of the aircraft.
- f. All three passengers and two crew on board the aircraft were safe.

- g. The Twin Otter aircraft sustained no damage.
- h. The aircraft was fully certificated and had been maintained as per laid down standards.
- j. The Pilots were properly certificated and authorized for the flight. Captain Ather H. Butt ALTP No.489 was Pilot-in-Command and First Officer Shaukat Mahmood CPL No.1156 was the Co-Pilot.
- k. The serviceability check of the aircraft at Muzaffarabad revealed that normal hydraulic pressure was available for the operation of flaps, nose wheel steering and wheel brakes.
- l. The effectiveness of nose wheel steering and wheel brakes was checked during Taxi and found to be serviceable.
- m. The aircraft was declared serviceable and was cleared for ferry flight from Muzaffarabad to Islamabad for further investigation to determine the cause of one time failure of Hydraulic System.
- n. The detailed technical examination of various hydraulic components revealed that Hydraulic Pump, Pressure Switch and Circuit Breaker were serviceable.
- o. The Hydraulic Pump Relay P/N MS 24166 - D1 S/N PIAC 12393 test report revealed that the main contacts of the relay were badly pitted, over heated, guide plunger sticky and stepped thus causing obstruction in free movement of plunger.
- p. Due to faulty Relay the power supply to electric motor driven hydraulic pump was intermittent which resulted in One time failure of hydraulic system as the relay did not operate to energize the hydraulic pump after it had been de-energized at cut-out pressure of 1575 PSI.
- q. The Captain did not notice the failure of hydraulic pump to energize and pressurize the accumulators to 1575 PSI. The residual pressure provided by the accumulator pre-charge was just enough for short taxi and operation of flaps to 10 degrees.

- r. The brake accumulator which maintains a reserve pressure for brake operation could not supply the brake pressure due to loss of brake system accumulator pre-charge pressure through the worn out gaskets in the plumbing.
- s. The Hydraulic Pump Relay badly failed at very low hours, TSI = 1675 hours. This probably occurred due to following reasons :-
 - i. The setting of operating range of Pressure Switch i.e. CUT-IN pressure of 1400 PSI with CUT-OUT pressure to 1575 + 50 PSI increases the duty cycle of the pump and the relay thereby deteriorate faster than normal.
 - ii. The rating of the Hydraulic Pump Circuit breaker being at 35 AMP with the nominal current of 30 AMP indicates that a lower rating of relay has been used for the circuit.
- t. The hydraulic system failure experienced by the pilots on 3rd and 5th January, 1996 and later confirmed by the ground engineers that hydraulic system was satisfactory is also a confirmation of peculiar behavior of the relay as found in the test report. The rapid deterioration of the relay in 1600 hrs operation is due to inappropriate rating and design of relay for the circuit.

Cause of the Incident

32. From the analysis of the available evidence the investigators are of the opinion that the cause of incident to PIA Twin Otter aircraft No.AP-BCH while operating PK-425 on 20th February, 1996 was due to failure of Relay P/N MS 24166 -D1 S/N PIAC 12393 to supply power to energize the electric motor-driven hydraulic pump which pressurizes the accumulators at a working hydraulic pressure. The residual pressure provided by the accumulator pre-charge was just enough for short taxi and operation of flaps to 10 degrees. The loss of brake system accumulator pre-charge pressure could not supply reserve pressure for brake operation as such pilot could not stop the aircraft on the slopping down terrain.

Recommendations

33. The investigators make the following recommendations based on their findings :-

- a. Chief Engineer (Quality Control), PIAC should consult the manufacturer of Hydraulic Pump Relay to determine the cause of rapid deterioration of the relay. On an immediate basis this relay which was OC (On-Condition) be made a HT (Hard-Time) and fixed at 1000 hours pending re-evaluation of the situation by the manufacturer.
- b. Chief Engineer (Quality Control) PIAC should review the operating range of the pressure switch keeping in view the CUT-IN Pressure of 1400 PSI with CUT-OUT Pressure of 1575 PSI which increases the duty cycle of the pump and the relay thereby deteriorates faster than normal. The need for reducing the CUT-IN Pressure to 1225 PSI to reduce the duty cycle of the Hydraulic Pump be examined to remove the variance in Component Maintenance Manual and Aircraft Maintenance Manual.
- c. Chief Engineer (Quality Control) should examine the possibility of installing a caution light in the cockpit which would indicate to the pilot that Hydraulic Pump has failed to energize when hydraulic pressure falls to below the CUT-In Pressure.
- d. Director Flight Operations, PIAC is to ensure that all pilots are briefed that they should monitor the Hydraulic System Pressure Indicators very carefully during critical phases of flight.
- e. APM Muzaffarabad to survey the area around the Runway 13 and recommend measures to be taken to level the slopping down terrain.

APP 'C'



APRON, RW 13 AND AIRCRAFT AT SCENE OF INCIDENT.



AIRCRAFT CAME TO A STOP AGAINST BIG STONE



AN OTHER VIEW OF AIRCRAFT AT FINAL STOP POSITION



AN OTHER VIEW OF AIRCRAFT AT FINAL STOP POSITION



AIRCRAFT AT FINAL RESTING POSITION



AIRCRAFT AT FINAL RESTING POSITION