Piper PA-34-220T, G-NJML, 6 March 1997

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Aircraft Type and Registration: Piper PA-34-220T, G-NJML
No & Type of Engines: 2 Continental TSIO-360-KB piston engines
Year of Manufacture: 1983
Date & Time (UTC): 6 March 1997 at 2104 hrs
Location: 3½ miles North East of Southend Airport
Type of Flight: Freight
Persons on Board: Crew - 1 - Passengers - 1
Injuries: Crew - Serious - Passenger - Fatal
Nature of Damage: Aircraft destroyed
Commander's Licence: Commercial Pilot's Licence
Commander's Age: 55 years
Commander's Flying Experience: 4,750 hours of which 2,070 were on type
Last 90 days - 79 hours
Last 28 days - 19 hours
Information Source: AAIB Field Investigation

History of the flight

The aircraft was to operate a chartered flight delivering aircraft spares from Southend to Ostend. It was a night flight. The pilot was accompanied by a friend who sat in the First Officer's seat but had no flying experience and took no part in the proceedings. The aircraft was fitted with a single vacuum driven artificial horizon and as a backup to this instrument the aircraft was also fitted with an electrically driven turn co-ordinator. The pilot requested taxi clearance at 2056 hrs and was cleared to the holding point for Runway 06. The route to the holding point included a number of turns during which the pilot had the opportunity to complete a full instrument check. At 2059:37 hrs the pilot announced that he was ready for departure and was given an air traffic clearance to turn
right on track to Ostend and climb to 3,400 feet; he was then cleared to take off. The time of take off was logged by the controller as 2101 hrs.

At 2102:10 hrs the pilot transmitted "LOOKING FOR A LEFT HAND TURN AND BACK TO THE AIRFIELD WE GOT A HORIZON FAILURE". At this stage the controller could see the lights of the aircraft, he acknowledged the RTF call, and asked if the pilot wanted to position for Runway 24. The pilot confirmed that this was his intention and the controller then asked for clarification of the problem. The pilot replied "LOOKS LIKE WE GOT A HORIZON FAILURE". At this stage the controller alerted the Airfield Fire Service and brought them to local standby. At 2102:55 hrs the pilot made a further transmission saying "THERE IS A SERIOUS PROBLEM HERE WE'LL HAVE TO GET BACK ON THE ILS". The controller acknowledged this call and requested a further transmission in order to establish the bearing of the aircraft. The resulting track from the aircraft to the airfield of 210 M was passed to the pilot who was then asked to "REPORT ESTABLISHED ON THE ILS FOR RUNWAY 24". He replied "WILCO" and this transmission, at 2103:20 hrs, was the last from the aircraft. During this final RT exchange with the pilot the controller could no longer see the aircraft lights. From 2105:21 hrs the controller made repeated RT calls to the aircraft but received no response.

The aircraft had crashed into a field on a bearing of 029 M three and a half miles from the threshold of Runway 24. A few moments before impact the aircraft was seen flying very fast at an estimated height of 15 to 20 feet in a 90° bank turn to the right. Shortly afterwards it went behind a stand of trees, still turning to the right, and the witness heard a dull thud as it impacted the ground. The passenger was killed on impact and the pilot received serious injuries. He has little recollection of the accident flight but he has been able to describe the symptoms of the artificial horizon failure.

Meteorology

An aftercast obtained from the Meteorological Office described a weak ridge of high pressure advancing across the area from the south. Visibilities were generally deteriorating and were probably around 5,000 metres, the cloud structure was assessed as scattered to broken stratus with a base of 500 feet and an overcast layer with a base of 2,500 feet. The meteorological forecast for Southend which was given to the pilot during his pre-flight preparation accurately reflected this situation and included a 30% probability of 3,000 metres visibility with a cloud base of 400 feet.

The next aircraft to depart Southend was airborne at 2147 hrs and the pilot of this aircraft described the cloud base as between 300 to 400 feet with poor visibility below the cloud and no clear horizon. At 2215 hrs the SAR helicopter arrived overhead Southend and then flew to the crash site at between 200 to 500 feet, the crew described the in-flight visibility as between 1,000 to 1,500 metres with no discernible horizon or cultural lighting and there was no moonlight.

Pilot experience

The pilot had obtained his Private Pilot's Licence (PPL) in 1979 and over time he added a night rating, a multi engine rating and an IMC rating. By 1991 he had accumulated 1,870 hours and was offered employment as an air taxi pilot. He completed an Instrument Rating (IR) and was issued with a Commercial Pilot's Licence in October of that year. His exposure to 'limited panel' (flight without reference to a primary attitude instrument) had consisted of a brief introduction during his PPL training followed by the 2 hours required during training for the IMC rating. His limited panel instrument flying was then checked during subsequent IMC renewals, which are
required every 25 months. The final formal check of his ability to fly on limited panel had been during the General Flying Test 3 (GFT3) which was undertaken in October 1991 in order to obtain his CPL. For pilots who have passed the GFT no limited panel flying is presently required in the IR test.

Following an EMB 110 Bandeirante accident on 24 May 1995 where the pilots apparently suffered a failure of an attitude indicator, this pilot decided to conduct some revision of limited panel flying for his own reassurance. This consisted simply of two 5 minutes sessions conducted to remind himself of the problems and the required techniques.

The majority of his flying has been in Northern Europe and he has had no significant breaks from flying for at least 5 years and hence was in good flying practice at the time of the accident. His IR was valid. This pilot was also authorised by the CAA to conduct air tests for annual renewal of airworthiness certificates on both twin and single engine aircraft.

Engineering

The aircraft had been imported into the UK from the USA at 1521 airframe flying hours and was first registered in the UK Transport (Passenger) Category on 23 May 1991. The current Certificate of Airworthiness was valid until 15 June 1997.

The aircraft wreckage was distributed over a trail of approximately 90 metres on a southerly heading on level ground in a large field. The right wing tip had made contact with the ground at the start of the trail, and the left wing tip contacted at around 50 metres. The aircraft attitude at initial impact was assessed as a roll angle to the right close to the vertical and a flight path angle of 15° nose down. Eight propeller slash marks were identified near the initial impact point, which gave an aircraft speed of approximately 140 kt. The ground marks throughout the majority of the trail did not exceed 2 metres in width and were characteristic of an aircraft which had cartwheeled.

The right wing had fragmented into many pieces and the main item of wreckage comprised the cockpit, the left wing from fuselage to engine and the tail. This large piece was heavily crushed and had come to rest upside down.

Secondary Flight Instruments

The secondary flight instruments were taken to an overhaul facility to determine their serviceability before the accident:

Altimeter (Kollsman 671CK-010): A calibration check on the altimeter showed that it had an error of 3.5 mb ata QFE of 1030 mb and was a bit sluggish, showing an error of -45 feet at 4,000 feet (allowable calibration tolerance on overhauls ±35 feet.). However vibration from the aircraft would have helped to correct that error. The altimeter followed pressure altitude adequately and would have been satisfactory for use.

Standby Altimeter (United Instruments 5934PAD-1): When recovered this instrument had lost its pointer, and the case, glass and glass bezel were damaged. The mechanism looked undamaged, but could not be tested in the old case. The instrument was therefore fitted in a new case and the needles were replaced. A leak check was not possible (due to the damage to the old case), but a functional check showed the remounted instrument to be satisfactory.
Air Speed Indicator (United Instruments 8125): The ASI was found to be within calibration tolerances, with no lag on reducing airspeed.

Vertical Speed Indicator (United Instruments 7000): When first examined the VSI had an initial offset of +380 ft/min. When checked at +2000 ft/min the needle went to the stops satisfactorily and then returned to +340 ft/min; it reached the -2000 ft/min stop satisfactorily. The instrument capsule was very fragile and the misplaced datum was probably due to capsule damage during the impact.

Turn Co-ordinator (Electric Gyro Corp., 1394T100- (7Z): The turn co-ordinator ran up to speed in 10 seconds, but indicated slightly left wing down. The effect of this initial error was that during a rate one turn the instrument slightly overrated to the left - by about 3 mm. The instrument appeared to be generally old and worn, but, apart from the initial 3 mm error, satisfactorily indicated in the correct sense.

In summary, examination of the secondary flight instruments after the accident did not reveal any significant defects.

Vacuum System

The aircraft was equipped with two air pump systems providing vacuum to the attitude indicator and pressure to pneumatic de-ice boots. Each of the two engines drove an air pump connected through a vacuum regulator and a check valve to a central vacuum manifold. Each vacuum regulator, which was capable of adjustment, controlled the vacuum pressure applied to the attitude indicator to achieve a value of between 4.5 to 5.2 inches of mercury, as specified in the maintenance manual. The air inlet to the attitude indicator was protected by a paper element filter.

The system is designed such that if either the left or right-hand vacuum supply failed, it would be isolated from the vacuum manifold by the check valve, allowing the attitude indicator to be fed by the remaining serviceable system. The aircraft was provided with lights on the annunciator panel to show if either pump failed. A vacuum gauge was installed in the instrument panel to display the vacuum supplied to the attitude indicator in inches of mercury.

The components of the vacuum system were removed and examined externally at the AAIB facility at Farnborough. No damage to the connecting hoses was found that could have caused a loss of vacuum. The components were then sent to their respective manufacturers or overhaul agents for examination:

Air Pumps: Both pumps were in an operational condition apart from the ingress of soil during the accident. When this had been removed the pumps were tested between 1,000 and 2,700 RPM and, whilst showing normal in-service degradation, were capable of providing enough vacuum to handle the requirements of the attitude indicator.

Vacuum Regulators: The regulators were originally equipped with a foam filter on their air inlets, with a manufacturer's recommended life of 100 hours; the filter was missing from the left-hand regulator and its vacuum switch was defective. Both regulators contained small internal leaks, but showed vacuum settings of 6.7 in Hg instead of the 5.0 in factory setting. The effect of a higher vacuum to the manifold would have been to increase the speed of the attitude indicator gyro from its design speed of 28,000 RPM.
Vacuum Manifold: A check valve on one end of the manifold had been bent, allowing air to leak past the rivets, it is probable that this damage was caused by the accident.

Filter: The filter from the inlet to the attitude indicator was tested over a flow rate from 2 to 10 cubic ft/min and had a slightly higher pressure drop across the range than a new filter. This was not considered significant.

In summary, the evidence indicated that the attitude indicator was receiving an adequate vacuum supply. The failed vacuum switch on the left hand regulator meant that it would not have operated the vacuum warning light on the annunciator panel, however the system was duplicated and a vacuum pressure gauge was available to the pilot.

Attitude indicator

The attitude indicator, which had not been severely damaged in the impact with the ground, was taken to the company holding the design rights. The instrument casing had been slightly dished in the impact and, after the casing was removed, it was seen that both erection vanes had been displaced but no other internal damage was apparent. The vanes were refitted and the instrument was tested using 5.2 psi air pressure, but the gyro failed to accelerate. One of the gyro bearings had been contaminated by a black residue which caused a 'rough spot' during rotation. The gyro had come to rest against this spot and the air pressure was not able to rotate the gyro through it. There were no outstanding Service Bulletins or modifications which could have affected the bearing failure.

The gyro had been re-manufactured in March 1987 and the manufacturer's seal was still intact showing that it had not been opened since that date. Although the aircraft records from the USA were not available to show when the attitude indicator had been fitted to the aircraft, it was estimated that the gyro had operated for some 1,900 hours before failure. The manufacturer did not define a design life for the instrument, but typically this class of instrument, with a similar gyro, is designed for 1,000 hours operating life. This type of instrument has no specified overhaul life and is treated as an 'on condition' item, that is, it is left in the aircraft until reported as unserviceable by the flight crew. The indications are that this particular instrument had achieved a better than average in-service life.

The symptoms of gyro failure described by the accident pilot: "after the take-off the attitude indicator presentation lurched violently and repeatedly in both pitch and roll similar to the initial motions during the erection sequence" were an accurate description of nutation, which is essentially a low speed gyro rotor phenomenon involving an oscillation of the gyro axis. It is only noticeable at low speed because the energy required to displace the gyro at high speed is too great. The contaminated gyro bearing therefore provided a satisfactory explanation of the attitude indicator problems seen by the pilot.

Analysis

This pilot was in current flying practice and held a valid rating for the aircraft being flown on which he had considerable experience, he also held a current IR. He took off in inclement weather, at night, and suffered a single instrument failure. He subsequently lost control of the aircraft and crashed.

During this investigation the emphasis was directed to the requirements for the training and checking of pilots in their ability to fly safely on 'limited panel'. It was considered that more
exposure to this demanding flying skill would be appropriate for pilots engaged in operating aircraft where the backup to the single attitude indicator is a turn co-ordinator or a turn and slip indicator. Meanwhile, changes to the IR test were already planned as a consequence of the adoption of the Joint Aviation Requirements for Flight Crew Licensing (JAR FCL). These changes, to be introduced with effect from 1 January 1998, will incorporate 'limited panel' flying into the IR test for single pilot operations of single and multiengine aeroplanes. The 'limited panel' element of this revised test will include: straight and level flight, climbing and descending turns, turns onto a defined heading and recovery to straight and level flight from unusual attitudes. It is anticipated that these significant changes to the IR test will increase the proficiency in 'limited panel' instrument flying of those pilots involved in the operations of aircraft where the backup to the attitude indicator is a turn co-ordinator or a turn and slip indicator.

**Recommendation 97-56**

It is recommended that the CAA, irrespective of any delays in the adoption of other elements of JAROPS, adopt the changes to the Instrument Rating test in line with the proposed JAR FCL with effect from 1 January 1998.