AAIB Bulletin No: 5/2003 **Ref: EW/A2001/6/1** **Category: 1.2**

Aircraft Type and Registration:	Vickers-Supermarine Spitfire PR.XI, G-PRXI (PL983)	
No & Type of Engines:	1 Rolls-Royce Packard Merlin 266 piston engine	
Year of Manufacture:	1944	
Date & Time (UTC):	4 June 2001 at 1455 hrs	
Location:	Near Rouen, Vallee de Seine Airport, France	
Type of Flight:	Private (aerial display)	
Persons on Board:	Crew - 1	Passengers - N/A
Injuries:	Crew - 1 (Fatal)	Passengers - N/A
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	56 years	
Commander's Flying Experience:	1,926 hours (of which about 48 were on type)	
Information Source:	See below	

The following is an account of an accident that occurred in France and which was subject to an investigation by the Bureau d'Enquetes et d'Analyses pour la Securite de l'Aviation Civile (BEA) and the French judiciary. The AAIB were asked to conduct and oversee a strip inspection of the Rolls-Royce Packard Merlin engine on their behalf. The findings of this examination are considered sufficiently important that they should be promulgated within the United Kingdom, at least, as there are many engines of this type in operation or under maintenance.

The operational circumstances are relatively brief and are principally based on information made known to the AAIB by other pilots participating in the display and by observation of a witness video recording. Readers are also referred to the BEA report on the accident, which is due to be published at approximately the same time as this Bulletin.

Background

Rouen, Vallee de Seine Airport has a main, paved, Runway 04/22 and a shorter, grass Runway 05/23 (Figure 1). During the pre-display briefing, pilots were advised to make use of the latter in case of emergency.

G-PRXI was joining one of four 'vics' of aircraft forming-up to the south-east of the airfield at crowd rear. The aircraft was observed to join-up, as briefed, on the extreme right of one of the 'vics'. The pilot maintained the correct position for a few minutes before he was seen to slowly drop back about 50 yards and also to move out a distance of about four wingspans from the ideal position. There were no visible signs of any problems with the engine or airframe. Eventually he went out of sight to the 'vic' leader and was heard to call on the radio "GOT A PROBLEM, RETURNING TO THE AIRFIELD". Then he transmitted "GOING FOR THE GRASS". At some point, the Tower controller suggested that Runway 05 was available, but there was a quartering tailwind for that runway and it appeared that the pilot, having sufficient height available, opted for the reciprocal Runway 23.

The leader, and others, saw the aircraft descending towards the grass strip on a base leg and it appeared that it was fairly well set up for a landing. The pilot was then heard to call "THERE'S PEOPLE ON THE RUNWAY" in what was described as a 'calm, if surprised voice'. The formation leader confirmed this visually, noting that the numbers he saw being likened to "that seen during a cricket match, with most of the people at the north-eastern end".

A witness video, broadcast in an edited form on UK television, showed the aircraft apparently extending the base leg to make an approach to Runway 22 with the landing gear down and the flaps extended. The propeller was rotating at some indeterminate speed as the aircraft headed towards the camera. As it approached abeam the camera in almost level flight, a puff of dense black smoke was seen to issue from the exhaust stubs and the propeller seemed to slow rapidly after an initial burst of power is heard (note: a detailed analysis of video and audio information was conducted by the BEA and a summary is contained in their report). Almost immediately, the right wing dropped and the aircraft rolled inverted before diving into the ground almost vertically. An immediate fireball followed and much of the airframe was subsequently consumed by fire.

A post-mortem report carried out when the pilot's body was returned to the UK showed that he had died instantly on impact from severe multiple injuries.

Aircraft history

PL983 saw wartime and some post-war service with the Royal Air Force (RAF). In 1948 it was donated to a museum and thence sold to a private owner, requiring considerable restoration before flying again in 1984. In January 1990, a zero-timed engine, which was still fitted at the time of the accident, was installed. In 1992, the aircraft was put into storage.

In early 2000, the aircraft was sold to its current owner and, after assembly, an Annual Inspection was carried out for the issue of a Permit to Fly. A second Annual Inspection followed in May 2001.

At that time, the engine had 220 hours total time since overhaul. The Inspection included the requirement to check the magneto contact breaker points and to oil the cam lubrication pads.

Engine examination

The engine was despatched to the Battle of Britain Memorial Flight (BBMF) at RAF Coningsby, who kindly agreed to act as independent technical consultants to the AAIB during the strip examination.

The engine was remarkably intact, considering the impact and subsequent severe fire which destroyed the airframe. It was evident that the engine had detached and bounced clear of the major fire zone and was thus scarcely affected. Visible external damage comprised a partially detached reduction gearbox and punctures of the supercharger casing. The carburettor had also detached.

There were no obvious signs of major mechanical failure and subsequent internal inspection did not reveal any mechanical reason for a loss of power. The conclusions reached were that it appeared to be in good condition, consistent with its declared relatively low running time since complete overhaul in the United States. As subsequent investigation revealed, the reason for its loss of power lay outside the basic engine mechanics.

The Stromberg pressure type carburettor was of a type unfamiliar to the BBMF but, with limited technical documentation, a strip examination was undertaken. There was no sign of debris in the system, all jets and orifices were clean, as was the fuel filter. The accessory drives and fuel pump could all be turned. It was remarked that there was no sign of any wet fuel anywhere in the system. This, despite being unusual, may be explicable by the length of time the engine lay, in an unusual attitude, on the ground before the AAIB recovery and by the fact that the main fuel delivery line from the carburettor to the injector nozzle had been broken during the impact.

Magneto testing

The Rotax magnetos are identified as left (exhaust) and right (inlet). Both seemed mechanically undamaged and were removed for testing. Since the BBMF test rig was temporarily unavailable, the covers were removed from the Low Tension points housing for inspection and anomalies were immediately observed.

On the right magneto, there was a considerable degree of oil/grease contamination around the points but the wick, which conducts oil from a reservoir in the cap to lubricate the cam, was missing (see Figure 2, photograph 3). The points gap appeared to be excessive (about 0.018 inches). However there was also a small ‘nib’ caused by spark erosion which probably reduced the effective gap to about 0.015 inches (Figure 2, photograph 4). Turning the magneto by hand did not result in any spark.

On the left magneto, it could be seen that the points had closed up almost completely such that, even on the lobe of the cam, there was no appreciable points gap (Figure 2, photographs 1 & 2). The wick was present but was dry. In both cases the reservoirs were completely devoid of oil. Turning by hand did not produce a spark.

When the performance test rig became available, both were subjected to a test at representative running speeds. The rig adjusts the magneto speed between zero and 5,500 RPM (magneto speed is a factor of 1.5 times the engine RPM). The technician advised that they expect full and normal sparking to be established at 600 magneto RPM and to continue faultlessly up to maximum RPM. The left magneto appeared to produce no sparks until several hundred rpm above this figure and even then only 30% to 60% of the dummy plugs were firing. This improved somewhat at about 3,000 RPM but fell again as RPM increased. It was noted that the figure generally improved with running time, but it was clear that none of the plugs were firing correctly every time, even when a high percentage were actually producing sparks at some point. It was also noted that, after only a few minutes of running, the magneto casing was becoming warm and, when removed from the rig, the drive was too hot to touch.

The points gap was opened up to a nominally correct figure. The left magneto then generated sparks normally and consistently.

The right magneto did not produce any sparks at any RPM. This was initially thought to be due to the oil contamination. It, too, became abnormally hot during the few minutes that it was running.

Magneto strip-inspection

The right magneto was the first to be examined. After removal of the main cover plate, it was noted that the rubber insulator (manufacturer's Part Number (PN) N72791, RAF PN 37A10941) over the central spindle appeared to have evidence of electrical tracking down one side (a line of degraded rubber, Figure 2, photograph 5). The decision was made to replace it with a serviceable insulator and repeat the rig test. The magneto performed satisfactorily with the new item, but still got hot as before. Further strip examination revealed that a grease retention plate was missing from the assembly and that this was responsible for the oily deposits found throughout the magneto. The BBMF personnel were also of the opinion that the grease used was not of the type they knew as approved for use in this application.

The left magneto had an unusual blue coloured coating on the coil. This had melted and was found deposited around the inside of the casing. Both magnetos had internal corrosion, missing details such as tab washers, and worn bearings. In addition, the rubber sealing rings around the cover plates were seriously degraded.

A further anomaly was found in the ignition harnesses. In the original configuration, a series suppression resistor was fitted in the High Tension leads but modern spark plugs have this incorporated in each plug. Thus, the resistor is removed and replaced by a copper 'pellet' in modern installations. In G-PRXI, the inserts were found to be made of aluminium and bore signs of arcing (Figure 2, photograph 6). The effect of this on spark performance is unknown, but Rolls-Royce have stated that it is unsuitable due to the insulative effects of aluminium oxide and should be replaced with copper where found (see AAIB Safety Recommendation 2003-15 below).

Laboratory examination of the Insulator

The failed insulator, and four others from the BBMF (for reference), were subjected to laboratory examination. The latter four had been removed fairly recently from in-service magnetos and were awaiting inspection prior to re-installation. The accident insulator was found to have been badly degraded, with much surface cracking evident. It was no longer considered to be thermally stable. The reference mouldings also exhibited surface cracking, but to a lesser extent. One of the latter was found to be of a different material to the others, which were made of chlorinated rubber with a carbon filler.

Examination using a Scanning Electron Microscope (SEM) showed that the surface of four of the five insulators was contaminated with copper. Only the one moulded from different material showed no signs of copper. The contamination was largely concentrated in the surface cracks. Interestingly, one of the reference insulators had more surface copper present than the accident component. The precise source of the copper dust, which was not obvious by visual inspection, was not clear, but might have been expected to accumulate over an extended period, given the way that magnetos operate.

Summary and conclusions

It would appear that G-PRXI had been operating with one magneto which was performing adequately and one which was performing poorly and intermittently. It is not known why this was not detected by the pilot during his pre-flight 'magneto drop' checks. It would then appear that, during the accident flight, the tracking developed in the right magneto, disabling it completely. The left magneto, whilst just able to keep the engine running, but with significant power loss, was possibly only able to do so in the mid-RPM range (if it performed with the behaviour shown on the test rig). The puff of black smoke and reduction in propeller RPM, seen immediately before the right wing dropped, was probably due to an attempt by the pilot to increase power, which had the opposite effect due to a 'rich cut'.

Neither magneto fitted to the accident engine was airworthy. The engineer who certified the aircraft advised that they were the same units fitted to the engine when the aircraft was purchased and brought out of storage. He had assumed that the magnetos had been overhauled at the same time as the rest of the engine. Inspection of the documents accompanying the engine showed that its magnetos were overhauled concurrently, but neither serial number quoted in the documentation corresponded with the units actually found to be fitted.

Of more concern to continued airworthiness are the findings of the examination of the insulator. It is evident that these parts are not lifed and that no records are required to be kept of their age or flying hours. As there does not appear to be any source of newly manufactured insulators, it is possible that they may be in excess of 50 years old. Although the accident component was particularly badly degraded, possibly as a result of excessive heat generated in the particular magneto in which it was fitted, it was also evident that the reference units were approaching the end of their useful life and that copper contamination was generally present. It is also of concern that one of the reference insulators was of a different composition, the difference being unknown and undetectable by normal inspection methods.

At the time of the accident, there was no known source of newly-manufactured insulators (although some evidence suggested that 'home made' items were in circulation). However, the BBMF advised that they have now investigated a potential source of such items. They have negotiated with an approved supplier, who is in possession of the original drawing of the insulator, to commence manufacture. Their supplier is:

Retro Truck and Air (UK) Limited
Upthorpe Ironworks
Upthorpe Lane
Cam
Dursley
Gloucestershire GL11 5HP

Accordingly, the AAIB also makes the following Safety Recommendation:

Safety Recommendation 2003/15

It is recommended that the Civil Aviation Authority should issue a letter to all operators of Rolls-Royce Merlin powered aircraft, equipped with Rotax magnetoes, recommending that the insulator, P/No N72791, be replaced at magneto overhaul. In addition, the letter should draw the attention of operators to the following recommendations made by Rolls-Royce plc:

1. Magneto overhaul on low utilisation engines should be accomplished at about half the generally accepted 500 hour engine overhaul life.

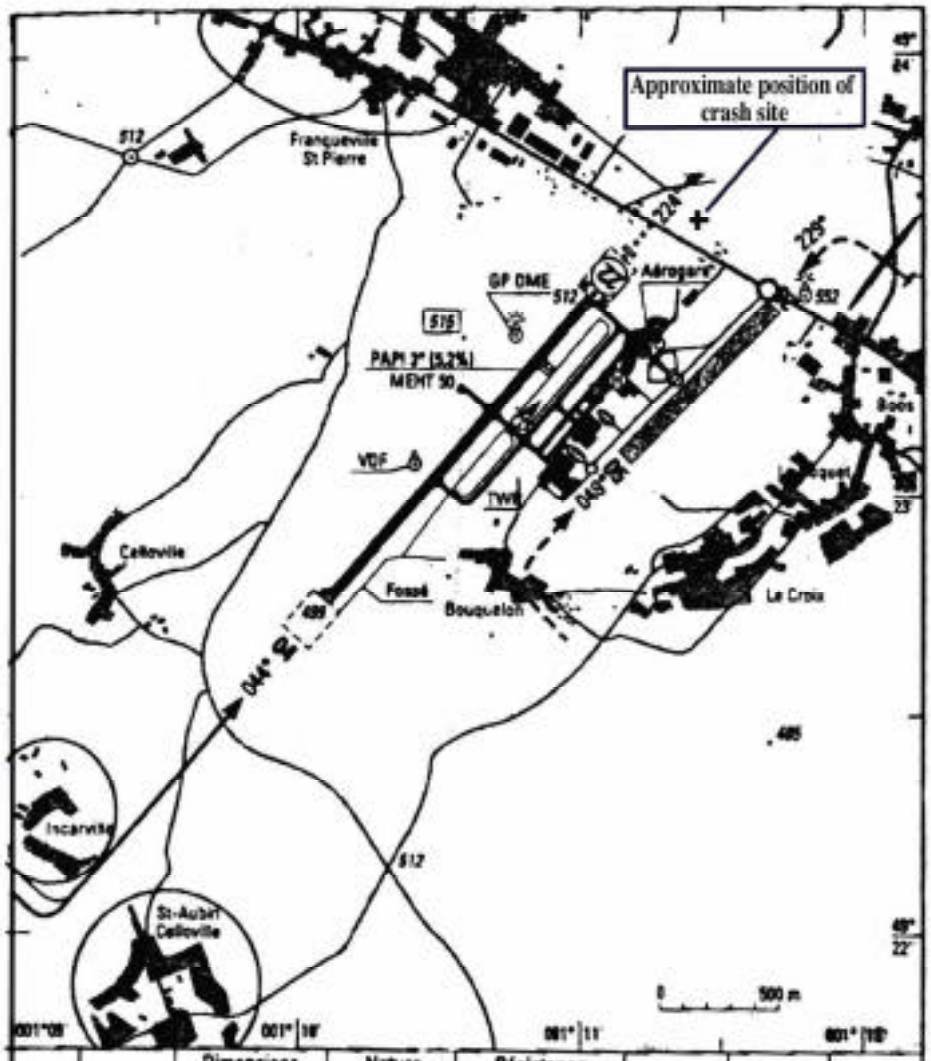
2. A magneto inspection should be performed on all Merlin engines within 50 hours/one year, and thereafter at yearly intervals, which should include visual checks of:

    a) Points setting, condition and function
    b) Insulator condition
    c) Correct lubrication
    d) Anti-tracking paint condition
    e) Other apparent faults and signs of deterioration

3. A once-off check should be performed to ensure that copper inserts are used in the high-tension leads rather than aluminium or any other metal.

Figure 1

ROUEN VALLEE DE SEINE LFOP



RWY	QFU	Dimensions *Dimension*	Nature *Surface*	Résistance *Strength*	TODA	ASDA	LDA
04	044	1700 x 45	Revêtue *Paved*	32 F/B/W/T	1900	1700	1700
22	224				1900	1700	1700
05	049	900 x 80	Non revêtue *Unpaved*		900	900	750
23	229				900	900	570

Figure 2