



INVESTIGATION REPORT

Accident to the Pitts S2-B
registered **F-GEAL**
on 8 December 2013
at Meaux Esbly (Seine-et-Marne)

BEA

Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

Ministère de la Transition Écologique et Solidaire

Safety investigations

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SPECIAL FOREWORD TO ENGLISH EDITION

This is a courtesy translation by the BEA of the Final Report on the Safety Investigation. As accurate as the translation may be, the original text in French is the work of reference.

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Glossary

AD	Airworthiness Directive
ATSB	Australian Transportation Safety Bureau
CAMO	Continuing Airworthiness Management Organisation
CASA	Civil Aviation Safety Authority
DSAC	Direction de la Sécurité de l'Aviation Civile (French civil aviation safety directorate)
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
IAC	International Aerobatic Club
NTSB	National Transportation Safety Board
OSAC	Organisme pour la Sécurité de l'Aviation Civile (Civil aviation safety organisation)
SB	Service Bulletin
SI	Service Instruction
SL	Service Letter
TAIC	Transport Accident Investigation Commission

Synopsis

Time	17:07 ⁽¹⁾
Operator	Private
Type of flight	General aviation, local flight, aerobatics
Persons on board	Pilot and one passenger
Consequences and damage	Aeroplane severely damaged

⁽¹⁾The times given in this report are local time.

In-flight separation of the propeller, damage to the tail fin, after an aerobatic flight, forced landing at aerodrome

On 8 December 2013, the pilot in command of a Pitts S2-B equipped with a Lycoming AEIO-540 engine and Hartzell two-blade metal propeller, took off for an aerobatic flight during which he performed several figures leading to a rapid variation in the orientation of the axis of rotation of the propeller.

Returning from the flight, in the downwind leg, the pilot felt vibrations which increased in intensity. He reduced engine power and declared an emergency. The assembly formed by the propeller and part of the crankshaft separated from the engine and struck the fin. Observing the appearance of smoke and the presence of oil on the windshield of the aeroplane, the pilot shut down the engine and performed a forced landing.

The accident resulted from progressive fatigue cracking and then the rupture of the crankshaft due to the propeller applying rotational bending loads to the crankshaft during certain aerobatic manoeuvres. The investigation showed that the combination of Lycoming AEIO-540 engines and Hartzell two-blade metal propellers, when used in aerobatic flights comprising certain manoeuvres with a strong gyroscopic effect, constituted a higher risk factor of crankshaft rupture.

In 1988, the engine manufacturer, Lycoming, issued a Service Bulletin (SB) recommending a visual inspection of all the crankshaft area situated between the oil seal and propeller flange. This inspection, which must take place every ten hours of aerobatic flight including figures in the "unlimited" category, requires the removal of the propeller, starter ring gear and oil seal. The complexity, frequent repetition and time required to carry out the tasks specified by this SB make its application restrictive and the operators taking it into account unrealistic.

This SB did not give rise to the publication of an Airworthiness Directive (AD) by the FAA, primary certification authority of the aeroplane, engine and propeller. The Australian and New Zealand civil aviation authorities imposed compliance with this SB by issuing an Airworthiness Directive. The BEA has recorded several accidents similar to that to the F-GEAL, concerning aerobatic aeroplanes equipped with a Lycoming engine and two-blade metal propellers. It is probable that their operators were not aware of this SB. The inspection specified by this SB was not carried out on F-GEAL.

On the basis of the safety investigation, the BEA has sent two safety recommendations to the FAA and one to EASA concerning aeroplanes equipped with the engines concerned by the given SB and Hartzell two-blade metal propellers.

1 - FACTUAL INFORMATION

1.1 History of the flight

On 8 December 2013, the pilot, accompanied by a passenger, took off from Meaux Esbly AD to perform an aerobatic flight. He was flying a Pitts S2-B equipped with a Lycoming AEIO-540 engine and Hartzell two-blade metal propeller. During this flight, he performed several figures leading to a rapid variation in the orientation of the axis of rotation of the propeller.

Returning to the aerodrome, in the downwind leg, the pilot felt vibrations. Their intensity increased, he reduced engine power and declared an emergency.

The assembly formed by the propeller and part of the crankshaft separated from the engine and struck the fin.

The pilot observed the appearance of smoke and the presence of oil on the windshield of the aeroplane. He shut down the engine and performed a forced landing.

1.2 Injuries to persons

The pilot and passenger were unharmed.

1.3 Damage to aircraft

The propeller and crankshaft were destroyed and found close to the aerodrome. The engine and part of the fin were substantially damaged.

1.4 Other damage

Not applicable.

1.5 Pilot information

The pilot had logged 2,206 flight hours of which around 1,500 aerobatic flight hours and 1,300 on type. He had performed around 6 h 30 min of aerobatic flight in the previous three months, all carried out on the F-GEAL.

1.6 Aircraft information

1.6.1 Airframe

The Pitts Special is a single-seat aerobatic biplane whose original model performed its maiden flight in September 1944. The first two-seat version (S-2A) flew for the first time in 1967. The table below summarizes some of the engine and propeller characteristics of the various models of the S-2 type:

S-2 version	Date added to type certificate	Engine (Lycoming)	Original propeller type (Hartzell, constant speed)
A	June 1971	AEIO-360	Two-blade metal
S	May 1981	AEIO-540	Two-blade metal
B	April 1983	AEIO-540	Two-blade metal
C	June 1998	AEIO-540	Three-blade composite

The table below gives information about F-GEAL:

Manufacturer	Christen Industries INC
Type	Pitts S-2B
Serial Number	5197
Entry into service	12 July 1991
Airworthiness certificate	No 108172 (obtained 4 January 2010)
Airworthiness review certificate	No 622013 (renewed 6 May 2013)
Operation as on 8 December 2013	1,234 flight hours

1.6.2 Engine

The table below gives information about the Lycoming AEIO-540-D4A5 engine installed on F-GEAL:

Serial Number	L-24455-48A
Date of manufacture	November 1990
Total operating time	1,234 h 45 min
Total number of cycles	2,468
Operating time since last inspection	42 h 33 min

The Lycoming Service Instruction No. 1009AV of 8 July 2013 states that the interval between two overhauls of an AEIO-540-D4A5 type engine is 1,400 operating hours. This instruction specifies in a note that:

"The reliability and service life of engines can be detrimentally affected if they are repeatedly operated at alternating high and low power applications [...]. Flight maneuvers which cause engine overspeed also contribute to abnormal wear characteristics that tend to shorten engine life. [...] therefore it is the responsibility of the operator to determine the percentage of time the engine is used for aerobatics and establish his own TBO. The maximum recommended is the time specified in this instruction."

The approved engine maintenance programme specifies the following routine inspections:

- ☐ Daily:
 - mainly composed of visual checks;
 - carried out during the pre-flight inspections.
- ☐ In addition to the daily inspection, every 50 operating hours:
 - inspections of ignition, fuel, lubrication, exhaust and cooling systems;
 - draining;
 - replacement or cleaning of lubrication system filters after searching for metal particles.

- ❑ In addition to the above tasks, every 100 operating hours or once a year:
 - inspections of electrical system, magnetos and engine mounting brackets;
 - inspections of accessories (pumps, probes, etc.);
 - inspection of injection system between the carburettor and injector nozzles.

Note: None of these routine inspections provide for the disassembly of the propeller or the inspection of the crankshaft.

1.6.3 Propeller

The aeroplane was equipped with a Hartzell, constant-speed, aluminium-alloy two-blade propeller (type HC-C2YR-4CF/FC8477A-4).

	Hub	Blade 1	Blade 2
Serial Number	AU10444B	H29849	H29846
Total operating time	507 h 34 min ⁽²⁾	1,234 h 45 min	
Operating time since last overhaul	42 h 33 min		

⁽²⁾ Hub changed in compliance with Hartzell SB No 61-227, after an operating time of 727 h 11 min, in June 2002.

The propeller owner's manual in its issue of 19 November 2013 states that the interval between two overhauls of a HC-C2YR-4CF/FC8477A-4 type propeller is 2,000 operating hours.

Additions to the original type certificate mean that the Pitts S-2B can be equipped with different types of propeller, the characteristics of which are summarized in the table below:

Manufacturer	Hartzell	MT Propeller	Hartzell		MT Propeller	
Hub model	HC-C2YR-4CF	MTV-9-B-C	HC-C3YR		MTV-9-B-C	
No of blades	2	3	-1A	-4A		
Blade model	C8477	C190-18a	7690 C or E	7690E	C188-18b	C203-46
Materials	Aluminium	Wood and fibreglass	Aramid		Wood and fiberglass	
Diameter	213 cm (84 in)	190 cm (74.8 in)	198 cm (78 in)		190 cm (74.8 in)	203 cm (80 in)
Weight	28 kg (62 lbs)	24kg (53 lbs)	27 kg (60 lbs)		24kg (53 lbs)	
Certification	Original model	1996	Between 1997 and 1998		Post 2001	

1.6.4 Maintenance and continuing airworthiness

1.6.4.1 Maintenance

The engine and propeller were overhauled between March and April 2013.

The propeller (hub and blades) was overhauled after a total operating time of 1,192 h 12 min and an operating time since the last overhaul of 246 h 58 min, in a Part 145 approved workshop.

The inspection report states that there is:

- ❑ substantial brinelling⁽³⁾ of the blade root raceways caused by substantial tensile loads;
- ❑ out-of-tolerance wear of the bore holes through which the pitch-change tube slides. This wear is caused by the tube's travel when the propeller pitch is changed and is observed on the hub front and rear bore holes.

⁽³⁾Wear from deformation.

The routine inspection of the engine (100 hour/yearly inspection) was carried out after an operating time of 34 h 52 min following the last annual inspection carried out in February 2012.

The engine and propeller were returned to service on 21 April 2013 by the owner-pilot who is also a Part 66 approved mechanic. There was no differed maintenance operation on the day of the accident.

1.6.4.2 Continuing airworthiness

The company, Société d'Études et de Gestion Aéronautique (SEGA), which holds sub-part G of Section A of Part M approval (EU regulation No 2042/2003) was responsible for continuing airworthiness.

The ADs applicable to the Lycoming engine installed on an aircraft registered in an EASA Member State are those issued by the FAA and EASA. At the time of the occurrence, there were 21 ADs⁽⁴⁾ issued by the FAA and concerning the AEIO 540 engine. Two concerned the crankshaft but the serial number of the F-GEAL engine was not concerned.

⁽⁴⁾Source: FAA document.

The aeroplane held a valid Airworthiness Review Certificate, renewed on 6 May 2013 by SEGA.

1.7 Meteorological information

The meteorological information was CAVOK with a light, south-westerly wind.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

The aeroplane was not equipped with a flight recorder; this is not required by the regulations.

1.12 Wreckage and impact information

Not applicable.

1.13 Medical and pathological information

Not applicable.

1.14 Fire

Not applicable.

1.15 Survival aspects

The control of the aeroplane was made difficult due to the loss of the propeller and a part of the crankshaft as well as to the damage to the vertical stabilizer.

1.16 Tests and research

Note: [The engine examination report is available on the BEA website.](#)

No malfunction (insufficient lubrication, fretting⁽⁵⁾, engine seizure, etc.) likely to cause the rupture of the crankshaft was found on the examined parts (crankshaft, connecting rods, bearings, casing, accessory section) during the engine examination.

The examination of the propeller showed that the pitch-change mechanism was functional.

The crankshaft broke into two parts at the base of the seat of the oil seal due to progressive cracking under rotational bending loads.

The fracture surface showed two fatigue cracks initiating on the outer edge and propagating inwards, from two areas of multiple-initiation that were diametrically opposed on the rear side of the propeller plane.

No machining scoring anomalies, tool marks, pitting or shaping faults were detected on the surface in line with the initiation areas.

The results of the hardness measurements and chemical analyses carried out on the crankshaft were compliant with the manufacturer's specifications.

1.17 Organizational and management information

At the time of the accident, the maintenance and continuing airworthiness conditions applicable to general aviation aircraft in France were defined by regulation (EC) No 2042/2003⁽⁶⁾. This Commission regulation divides the responsibilities and tasks related to the continuing airworthiness of an aircraft or equipment item between the manufacturer, the authorities and the operator.

⁽⁵⁾Small-amplitude oscillation applied to two surfaces in contact.

⁽⁶⁾Commission regulation (EC) No 2042/2003 of 20 November 2003 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks.

1.17.1 Role of type certificate holder

Lycoming, as the type certificate holder of the engine, is accountable to the FAA for any failure, incorrect operation, fault or other problem which it has been informed of and which led to or which may lead to conditions which could compromise safety.

Furthermore, the manufacturer issues information with the intention of improving the safety and reliability of its products through Service Bulletins (SB), Service Letters (SL) or Service Instructions (SI).

1.17.2 Role of authorities

1.17.2.1 State of design authority

Continuing airworthiness is ensured jointly by the manufacturer, Lycoming and by the State of Design, the FAA. The division of tasks and the continuing airworthiness principles are set out in Part 21 of Title 14 of the Code of Federal Regulations.

Paragraph 5 of Part 39 of Title 14 of the Code of Federal Regulations states the FAA issues an Airworthiness Directive (AD) addressing a product when it observes that:

- ☐ An unsafe condition exists in the product; and
- ☐ The condition is likely to exist or develop in other products of the same type design.

1.17.2.2 Role of EASA

EASA carries out on behalf of Member States, the functions and tasks of the State of Design, Manufacture or Registry when related to design approval of parts and equipment for which it carries out the oversight⁽⁷⁾. In this respect, EASA issues ADs in the form of Agency decisions.

The ADs issued by the authority of a State of Design which is not a member of EASA, are applicable to products designed in this State and installed on an aircraft registered in one of the Member States.

With respect to the Service Bulletins relating to ADs, EASA states⁽⁸⁾:

"It is common practice amongst a large number of DAH [...] to request actions to improve the safety level of their product, part or appliance by means of SBs, or any equivalent publications, explicitly classified as "mandatory". In most cases, the word "mandatory" either appears in the title of the document (e.g. "Mandatory Service Bulletin") or in the header or any other prominent part of the document.

This practice has repeatedly caused confusion and triggered questions [...] about the legal applicability and implications of such documents for the owners and/or operators of the aircraft to which the bulletin applies. [...]

SBs (or equivalent documents) issued by DAH do not have a legally mandatory character equivalent to an AD [...]. In this respect, any misleading wording in the title, the header or any other prominent part of the document should be avoided when issuing SBs. Only SBs related to ADs should be labelled "mandatory" by the DAH."

⁽⁷⁾In accordance with regulation (EC) No 216/2008.

⁽⁸⁾<https://www.easa.europa.eu/document-library/product-certification-consultations/easa-cm-21a-j-001>

1.17.2.2 Role of national authority

The Member States are responsible for the supervision of the production of aircraft and equipment, the continuing airworthiness of aircraft (maintenance programme, management of continuing airworthiness, maintenance, mechanics' licences, maintenance training organizations) and for issuing individual airworthiness documents.

In France, at the time of the accident, the competent airworthiness authority was the DSAC. The OSAC carries out on behalf of and under the supervision of the DSAC, the technical inspection and oversight activities in the aircraft production, maintenance and continuing airworthiness fields. In particular, OSAC is responsible for approving the aircraft maintenance programme and for granting approvals to Continuing Airworthiness Management Organizations (CAMO).

1.17.3 Continuing Airworthiness Management Organization

The management of the continuing airworthiness of F-GEAL was delegated to an M.A. Subpart G approved organization. As CAMO, this company must:

- ☐ have the aircraft type in the scope of its approval;
- ☐ draw up an aircraft maintenance programme;
- ☐ organize the approval of the aircraft maintenance programme⁽⁹⁾ by the authority;
- ☐ coordinate the programmed maintenance, ensure the Airworthiness Directives and Operational Directives are complied with, life-limited parts are replaced and aircraft parts are inspected;
- ☐ examine the airworthiness of the aircraft and issue the Airworthiness Review Certificate.

1.17.4 Role of owner

The owner of an aeroplane of less than 5,700 kg equipped with a piston engine and operated under general aviation rules, can sub-contract the management of continuing airworthiness to an approved organisation.

⁽⁹⁾ A maintenance programme describes the operations necessary for the safe operation of the aircraft to which it applies. It must comply with the manufacturer's maintenance programme and include the instructions from the authority and the continuing airworthiness instructions provided by the type certificate holder. This programme was approved by the operator's authority or its delegatee (OSAC).

1.18 Additional information

1.18.1 Lycoming Service Bulletin No 482

On 3 June 1988, Lycoming issued SB No 482 marked "mandatory" in red⁽¹⁰⁾. It was issued subsequent to "Reports from the field indicat[ing] that a few [...] engines have encountered cracking in the crankshaft area during unlimited category aerobatic maneuvers"⁽¹¹⁾ and concerns AEIO-540-D and IO-540 engines converted for aerobatic flight as well as all 540 engines equipped with a 2-3/8 in dia. oil seal "used in unlimited category aerobatic maneuvers" (Lomcovak, inverted flat spins or multiple snap rolls).

The bulletin states that these manoeuvres "produce severe bending loads on the propeller flange area. Exceeding the engine maximum rated speed and/or using the aircraft in maneuvers which produce rapid angular propeller centerline acceleration may result in crankshaft failure."

The SB requests, every ten hours of aerobatic flight involving "unlimited" category manoeuvres, that all of the crankshaft area situated between the oil seal and propeller flange are visually inspected after cleaning. The SB says to pay special attention to the crankshaft area to the rear of the propeller plane. To do this, the propeller, starter ring gear and oil seal have to be removed. Lastly, if the crankshaft is determined to be serviceable, it requires that the oil seal is replaced before installing the starter ring gear and propeller.

This SB did not give rise to the publication of an AD by the FAA or EASA.

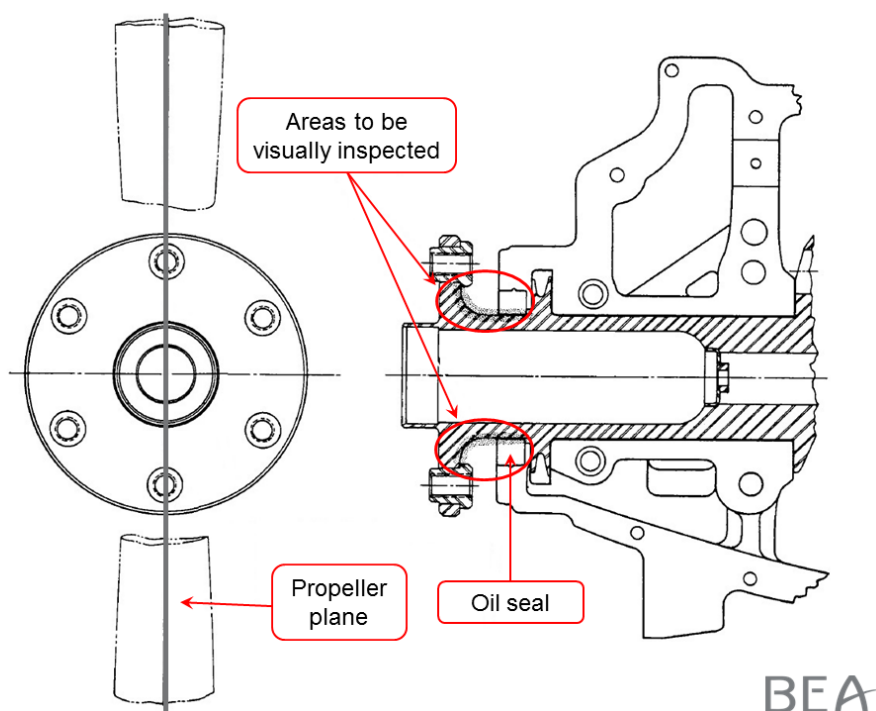


Figure 1: diagram taken from SB No 482

The support section of the Lycoming website presents a certain number of SBs (including those made mandatory by an AD), SLs and SIs.

The day of the accident, SB No 482 was available for sale or from a retailer but was not accessible on-line.

⁽¹⁰⁾Cf. Appendix 2.

⁽¹¹⁾In aerobatics, the "unlimited category" is a competition term. The misuse of language in this SB means that figures using gyroscopic effects are mistaken for "unlimited" category manoeuvres in aerobatic competition.

1.18.2 In service experience

1.18.2.1 Occurrence reported in specialized press

Technical Tips⁽¹²⁾, volume IV contains an article about crankshaft⁽¹³⁾ ruptures. It reports an occurrence (without specifying the date or registration) in the United States to a Pitts S-2B equipped with a Lycoming AEIO-540 engine. The pilot explained that he lost his propeller in flight on starting an inverted flat spin when he asked for an increase in engine power.

The article specifies certain information about the occurrence:

- ☐ it concerned an original S-2B model built in March 1985;
- ☐ the engine, manufactured in January 1985, had logged around 330 flight hours;
- ☐ the crankshaft was "reinforced" (the propeller flange did not have a lightening hole);
- ☐ the propeller was a two-blade metal propeller;
- ☐ the fatigue rupture occurred between the oil seal and front bearing;
- ☐ the aeroplane was used for aerobatics in the "unlimited" category.

The article states that it was not possible to visually inspect the rupture area as it was situated behind the seal. It concludes that for a crankshaft with solid propeller flange, the most likely area for a failure to occur is between the flange and the front main bearing in alignment with the propeller blades. These incipient fatigue cracks might be caused by rotational bending forces which occur in figures using gyroscopic effects (Lomcovak, inverted flat spin, multiple snap rolls, etc.).

One of the IAC safety managers said that there are other cases of crankshaft rupture on aeroplanes equipped with a two-blade metal propeller when used in aerobatic flight using gyroscopic effects. Lastly, it appears that numerous American pilots have chosen a lighter, three-blade composite propeller to reduce the bending loads applied to the crankshaft.

1.18.2.2 Occurrence on 29 March 2006 to Pitts S-2B registered VH-ZZZ (S/N 5005)

Information from the ATSB database indicated that a large quantity of oil was found on the aeroplane's sides and underside after an aerobatic flight. After disassembling the two-blade metal propeller, the examination of the crankshaft revealed a fatigue crack behind the propeller flange. It extended from the outer surface of the front bearing to the interior of the oil channel. The advanced condition of the cracking indicated the imminence of the rupture.

The ATSB specified that in consultation with the manufacturer, a metallurgical examination was not carried out. In addition, the pilot said that he had not complied with the CASA additional AD⁽¹⁴⁾, issued as a precautionary measure in 22 June 1988 and which made the Lycoming SB No 482 for aeroplanes registered in Australia mandatory.

⁽¹²⁾The International Aerobatic Club (IAC, responsible for the administration, management, and promotion of the sport of aerobatics in the United States) published four volumes of *Technical Tips* from 1981 to the beginning of the 1990s. These are principally re-issued *Technical Tips* articles from the *Sport Aerobatics* magazine.

⁽¹³⁾Cf. Appendix 3.

⁽¹⁴⁾Reference: AD/LYC/83.

1.18.2.3 Occurrence on 1 December 2004 to Pitts S-2S registered ZK-WIZ (S/N 3000)

The TAIC report⁽¹⁵⁾ concerns a Pitts S-2S aeroplane equipped with a Lycoming AEIO-540 engine and a two-blade metal propeller. It describes an oil leak discovered in the vicinity of the propeller flange during an inspection. This leak came from a fatigue crack in the crankshaft behind the flange. It was determined that the crack occurred as a result of the propeller applying gyroscopic forces on the crankshaft during aerobatic manoeuvres.

The TAIC indicated that the crankshaft had not been subject to a laboratory examination as Lycoming was already aware of this safety problem, a search having revealed the existence of Lycoming SB No 482 and the CASA AD.

The New Zealand civil aviation authority informed the BEA that the operator had not been aware of the SB and added that due to the concern that other affected operators may not be aware of the SB or may not be in compliance with its requirements, it wrote an AD.

The authority specified that Lycoming was informed of this incident and was able to examine the AD before its publication; the FAA was also notified. No response being forthcoming, the New Zealand authority issued an additional AD⁽¹⁶⁾ on 26 May 2005 making SB No 482 mandatory for aeroplanes registered in New Zealand.

⁽¹⁵⁾Occurrence report reference: 04/3932.

⁽¹⁶⁾AD reference: DCA/LYC/205.

1.18.2.4 Accident on 24 February 1995 to Pitts S-2B registered N49335 (S/N 5102)

In an inverted flat spin during an aerobatic flight, *"the propeller and crankshaft flange separated from the engine."* The NTSB⁽¹⁷⁾ report concluded that the accident was due to a fatigue rupture of the crankshaft and considered that a contributing factor was that the pilot had not performed the recurring inspection recommended by the manufacturer.

⁽¹⁷⁾Report reference: SEA95LA056.

1.18.3 Maintenance

The BEA contacted a Part-145 approved aircraft maintenance workshop for the servicing of piston engines (notably Lycoming) for their technical opinion with respect to the maintenance tasks recommended by Lycoming SB No 482.

One of the purposes of this request was to estimate the time required to carry out the peripheral inspection tasks. It was estimated that around three hours were required, divided up as follows:

- ☐ one hour for the removal of the propeller, removal of the oil seal and cleaning of the crankshaft;
- ☐ one hour to install a new oil seal;
- ☐ one hour to reinstall the propeller.

The workshop stated that these operations were complex and required suitable tools. It underlined the difficulty of inspecting this hard to access part of the crankshaft and recommended replacing a simple visual inspection with a dye penetrant inspection in order to more effectively detect a crack.

1.18.4 Pilot's statement

The pilot, owner of the aeroplane since 2003, held a Part 66 aircraft mechanics licence and carried out part of the maintenance tasks himself in the recurring 50 and 100 hour inspections. He specified that the management of F-GEAL airworthiness was delegated to a specialized organization. He added that he was not aware of the Lycoming SB No 482 recommendations.

He said that he carried out figures such as the inverted flat spin, multiple snap roll, torque roll and other figures using gyroscopic effects. He had not observed an oil leak during operations linked to the propeller overhaul (removal and reinstallation).

1.18.5 Other information

In the number of logged flight hours, it is not possible to determine the number of hours in aerobatic flight. This means that it is not possible to adapt the frequency of the engine inspections as required by Lycoming.

Since 1996, several three-blade composite propeller models have been certified for this type of engine. For these configurations, the BEA was not aware of crankshaft ruptures during aerobatic manoeuvres applying substantial loads on the crankshaft.

2 - ANALYSIS

2.1 Scenario

Performing aerobatic figures such as the inverted flat spin, multiple snap roll, torque roll, etc. leads to a rapid variation in the orientation of the axis of rotation of the propeller, i.e. the crankshaft, in space. This imparts torque, by gyroscopic effect, from the propeller to the crankshaft which subjects the latter to rotational bending loads.

It was under this alternating tensile and compressive loading that progressive fatigue cracking propagated flush with the crankshaft oil seal seat.

The maintenance programme complied with did not allow the cracking to be detected.

2.1 Detection of cracking

The planned inspection in SB No 482 was not carried out on F-GEAL or in any of the four similar occurrences quoted in paragraph 1.18.2. In two cases, the fatigue cracking was detected due to an oil leak from the crankshaft oil channel, between the flange and oil seal. In the other two cases, the fatigue cracking was not detected and led to an in-flight rupture of the crankshaft.

In the case of the F-GEAL crankshaft, the pilot had not observed an oil leak from the crankshaft during operations linked to the recurring maintenance of the propeller and engine which took place 42 operating hours before the rupture.

As in the previous cases, the F-GEAL crankshaft failed in the area of the oil seal seat. This area is difficult to access which makes its inspection difficult.

In the absence of an oil leak on the outer surface of the crankshaft, it is unlikely that a visual inspection would detect fatigue cracking similar to that which occurred on F-GEAL.

2.3 Circulation of information regarding continuing airworthiness

In the light of European regulations, the wording “*mandatory*” on Lycoming SB No 482 is not of the same binding character as when it is on an AD.

The F-GEAL occurrence as well as those quoted in paragraph 1.18.2 show that it is thus probable that the operators were not aware of SB No 482.

The interval of ten hours of aerobatic flight including figures in the “unlimited” category, between two crankshaft inspections specified by this SB is small compared with the other recurring inspection intervals (50 and 100 hours). In addition, the complexity and time required to carry out the tasks specified by SB No 482 make its application restrictive and it being taken into account by operators unrealistic.

Lastly, the notion of “unlimited” category figures refers to an aerobatic competition category to designate figures with gyroscopic effects. This may contribute to the confusion of operators carrying out such figures as a leisure activity outside of a competition.

2.4 Management of safety information by Airworthiness Authorities

Lycoming had knowledge of occurrences mentioning cracks in crankshafts following aerobatic manoeuvres with gyroscopic effects. Since its publication in 1988, SB No 482 has not been amended.

The investigation showed that the combination of Lycoming AEIO-540 engines and Hartzell two-blade metal propellers used in aerobatic flights comprising certain manoeuvres with a strong gyroscopic effect, constitutes an increased risk.

Despite two additional ADs being issued by two different authorities, the FAA did not reconsider this SB which made “mandatory” an impractical inspection, with a short interval and where the potential consequences if not complied with could be considered as catastrophic.

3 - CONCLUSION

3.1 Findings

- ❑ Lycoming published SB No 482 on 3 June 1988; it requires, in particular, a frequent visual inspection of an area of the crankshaft situated behind the propeller flange of Lycoming AEIO-540-D engines used in “unlimited” aerobatics.
- ❑ The Australian civil aviation authority (CASA) made compliance with Lycoming SB No 482 mandatory with an additional AD dated 22 June 1988.
- ❑ Following the occurrence on 1 December 2004 to the Pitts S-1S registered ZK-WIZ, the New Zealand civil aviation authority made compliance with Lycoming SB No 482 mandatory with an additional AD dated 26 May 2005.
- ❑ This authority informed Lycoming and the FAA of the issuing of the AD.
- ❑ The pilot held the necessary licences and ratings to carry out the flight. In addition, he held Part 66 approval.
- ❑ The aeroplane was serviced in accordance with the maintenance programme approved by the authority.
- ❑ The recommendations of SB No 482 did not appear in the approved maintenance programme.
- ❑ The aeroplane had a valid airworthiness review certificate.
- ❑ No oil leak from the crankshaft had been observed by the pilot, owner of the aeroplane and who carried out the aeroplane maintenance, during the overhaul of the propeller, around 40 flight hours before the accident.

3.2 Causes of the accident

The rotational bending loads during certain aerobatic manoeuvres, applied by the Hartzell two-blade metal propeller on the crankshaft, led to progressive fatigue cracking in the crankshaft and then its rupture, resulting in the loss of the propeller.

The circulation of information about the pre-existing risk by means of Lycoming SB No 482 of 1988, whether in terms of its target audience, its publicity or its accessibility was such that the operator and approved maintenance organisations were not aware of the recommendations in this bulletin. Moreover, it is unlikely that a visual inspection, as required by this SB, would have allowed the early detection of this type of fatigue cracking.

4 - SAFETY RECOMMENDATIONS

Note: in accordance with the provisions of Article 17.3 of Regulation No. 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation in no case creates a presumption of fault or liability in an accident, serious incident or incident. The addressees of safety recommendation shall inform the safety investigation authority which issued the recommendations of the actions taken or under consideration for their implementation, under the conditions described in Article 18 of the aforementioned regulation.

The crankshaft equipping the Lycoming AEIO-540 engine on F-GEAL ruptured due to fatigue following rotational bending loads applied by the Hartzell two-blade metal propeller during manoeuvres with gyroscopic effects.

The investigation showed that Lycoming, aware that there was a safety problem, published a Service Bulletin, numbered 482 and classed as "Mandatory", in 1988. This SB records that the location of the propagation area makes early detection of this fatigue cracking difficult and that it can occur quickly. Moreover, the recommended maintenance operations with a very short interval are unrealistic. What is more, the visual inspection stipulated seems insufficient.

The in-flight rupture of the crankshaft can be considered as catastrophic and other previous occurrences involving such a rupture had shown that the operators were not aware of the instructions in SB No 42 or of the associated risks they were running.

Similar occurrences may occur to other aerobatic aeroplanes equipped with similar crankshafts and propellers.

From 1996, several models of three-blade composite propellers were installed on this type of engine and used in aerobatic manoeuvres. The BEA is not aware of crankshaft ruptures with these configurations, linked to manoeuvres applying substantial loads on the crankshaft.

Consequently, the BEA recommends that:

- **The FAA prohibit "unlimited" aerobatic manoeuvres as defined by Lycoming Service Bulletin No 482 on aeroplanes equipped with the engines concerned by this SB and with Hartzell two-blade metal propellers.**
[Recommendation 2019-FRAN-031]
- **And that the FAA define appropriate oversight measures for aeroplanes equipped with the engines concerned by Lycoming Service Bulletin No 482 and Hartzell two-blade metal propellers and which carry out "unlimited" aerobatic manoeuvres as defined by Lycoming Service Bulletin No 482.** [Recommendation 2019-FRAN-032]
- **Without waiting for action by the FAA, EASA inform the operators of aeroplanes equipped with the engines concerned by Lycoming Service Bulletin No 482 and Hartzell two-blade metal propellers of the risks of crankshaft rupture associated with "unlimited" type aerobatic manoeuvres.** [Recommendation 2019-FRAN-033]

APPENDICES

Appendix 1

Lycoming Service Bulletin No 482

Appendix 2

Excerpt from the IAC Technical Tips

Appendix 1
Lycoming Service Bulletin No 482

TEXTRON Lycoming

652 Oliver Street
Williamsport, PA 17701 U.S.A.
717/323-6181

MANDATORY
SERVICE BULLETIN

DATE: June 3, 1988 Service Bulletin No. 482
Engineering Aspects are
FAA Approved

SUBJECT: Crankshaft Flange Area Cracking

MODELS AFFECTED: All AEIO-540-D series, IO-540 (250 & 260 horsepower) engines converted for aerobatic flight or any other 540 engines employing a 2-3/8 diameter main bearing seal used in unlimited category aerobatic maneuvers.

TIME OF COMPLIANCE: Visual inspection within next 10 hours and at each 10 hour interval of unlimited aerobatics or earlier at owner's discretion.

Reports from the field indicate that a few of the above mentioned engines have encountered cracking in the crankshaft area during unlimited category aerobatic maneuvers.

Textron Lycoming certified the "AEIO" engine models for prolonged inverted flight and for normal aerobatic maneuvers. In recent years, aircraft performance and competitive requirements have caused these maneuvers to become increasingly severe.

Unlimited category maneuvers such as multiple snap rolls, inverted flat spins, lomcevak, etc. produce severe bending loads on the propeller flange area. Exceeding the engine maximum rated speed and/or using the aircraft in maneuvers which produce rapid angular propeller centerline acceleration may result in crankshaft failure. Any engine which has been subjected to unlimited category aerobatic maneuvers must be inspected for cracks in the crankshaft flange area within the next 10 hours. See Figure 1.

After each additional 10 hours of aerobatic flight involving unlimited category maneuvers, close visual inspection for cracks in the crankshaft flange area back to the oil slinger is required. The proper

logbook entry should be made to indicate that these inspections have been completed.

VISUAL INSPECTION PROCEDURE

1. Make sure the ignition switch is in the "off" position.
2. Remove a spark plug from each cylinder to allow easier crankshaft rotation.
3. Remove the propeller and starter ring gear and using a black marking pen, mark the two bushings directly in line with the propeller blades as shown in Figure 1.
4. Remove crankshaft oil seal.

CAUTION

WHEN REMOVING THE CRANK-
SHAFT SEAL, USE EXTREME CARE
NOT TO SCRATCH THE CRANKSHAFT
OIL SEAL JOURNAL SURFACE.

5. Clean the area to be inspected by using Methyl-Ethyl-Ketone (MEK) or equivalent.

Page 1 of 2

6. Using an inspection mirror and suitable light, visually inspect the entire crankshaft flange area rotating the crankshaft 360 degrees. Pay special attention to the area behind the two bushings that were marked with black marking pen as instructed in step 3.

7. If the crankshaft is found to be cracked, it must be replaced. If crankshaft is determined serviceable,

install a new crankshaft oil seal. Refer to the latest edition of Service Instruction No. 1324.

8. Reinstall starter ring gear.

9. Reinstall propeller per airframe manufacturers instructions.

10. Reinstall spark plugs.

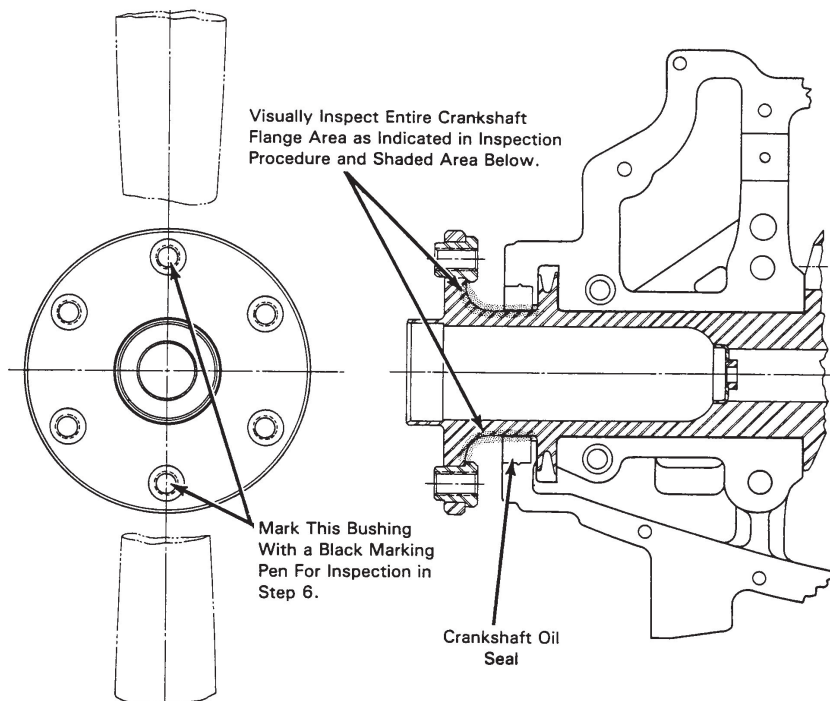


Figure 1. Visual Inspection of Crankshaft Flange Area

Appendix 2

Excerpt from the IAC Technical Tips

FLANGE BREAKAGE

was cracked radially. Consequently, I ended up overhauling the bottom end with a fresh crankshaft.

"In retrospect I realize I was lucky; all it cost me was money, not my life had I lost the prop. It also goes to show, as you have said before, even the littlest problem can be the tip of the iceberg."

Note that the nose seal was the first item suspected of causing the oil leak problem and it was replaced several times before the crankshaft was checked for cracks. This is the same drill that has been mentioned by other IAC members making reports of cracked crankshafts. Anytime an oil leak near the front of the engine develops, one must put "check crankshaft for cracks" as one of the first things to do.

In the above report, dye penetrant was first used to detect the cracks in the crankshaft, followed by magnetic particle inspection (magnafluxing). For a quick check that is easy to do and easy to clean up, first clean the area in question and then just spray the dye penetrant DEVELOPER over the suspect area. The developer will pull the oil out of the crack which will show up as a brown stain on the white developer. This is not as good as using the complete dye penetrant method (cleaner, penetrant, and developer) and it is not as good as magnafluxing. It is only mentioned as a quick and simple, somewhat effective inspection technique.

Many thanks to the IAC member who made the above report. The IAC brotherhood itself is our primary source of tech safety information. We must pool our experiences for our mutual benefit.

MORE ON CRANKSHAFT FAILURES

IACers are well aware of the series of tech safety articles in SPORT AEROBATICS related to crankshaft nose/flange breakage. The last article in this series was in the May 1988 issue. Since that time a couple more things have transpired.

First, the IAC Tech Safety Committee has received another report of a between-the-lightening-holes crank failure on an S-1S Pitts (no further details reported). Although we are not keeping an exact count, this last reported failure brings the total number of crank failures that IAC is aware of to about 35.

Secondly, our committee received some very interesting input from Gerd Muehlbauer, President of MT Propellers, located in West Germany. Gerd's letter is as follows:

"I just got the May 1988 issue of SPORT AEROBATICS magazine with your article about crankshaft failures. As you perhaps know, I have tried over the years to promote the use of propellers with wood-composite blades for acrobatic-type aircraft.

"As chief engineer at Hoffmann for years and now producing/developing my own propellers, I was well aware about the problem of crankshaft failures. When we designed the three-blade propeller for the ZLIN Z-50-L, the engine manufacturer (Lycoming) told us the limits of crankshaft stresses resulting from gyroscopic forces due to the high maneuverability of such acrobatic competition type aircraft.

"As far as I know, there was never a crankshaft failure over the past 10 years on the Zlin with the AEIO-540-() engine, no matter whether it was the 260 HP or 300 HP engine, and some of these aircraft have more than 1000 hours on.

CRANKSHAFT FAILURES

"As far as I also know, we have never heard about a crankshaft failure on aircraft using our two-blade propeller MTV-2-B-C/193-02 for the Lycoming AEIO-360 series or the three-blade propeller MTV-3-B-C/200-01 for the Lycoming AEIO-540 series engines. (We recommend the two-bladers for the four-cylinder and the three-blader for the six-cylinder engines.)

"Even with three blades, the MTV-3-B-C/200-01 with 79-inch diameter has only about 50% of the gyroscopic force than a two-blade propeller with metal blades and 80-inch diameter, as in general is used on such installations like the Pitts S-2-().

"We have these propellers available, and the three-blade MTV-3-B-C/200-01 is now LBA-approved (our airworthiness authorities in Germany) on the Lycoming AEIO-540-L1B5D, as used on the Zlin Z-50-LS. The new EXTRA 300 will use our newly developed MTV-9-B-C/C200-15 propeller which has about five pounds less weight than the MTV-3-B-C. This propeller is not yet approved, but the flight testing is on the way."

Based on members' reports, past IAC tech safety articles have tried to come up with a profile of an aircraft that might be considered as having a "high risk" of crankshaft failure. These articles noted that aircraft that have constant speed props should be monitored more closely for crankshaft nose/flange problems than aircraft that have fixed pitch props.

While those statements about propellers perhaps have the correct implications, they are really not precise enough. The concern is propeller weight (mass) and mass distribution and their effect on inertia or gyroscopic forces. Obviously, engine speed also affects the gyroscopic forces.

Props that are relatively heavy and have a relatively large amount of weight distributed some distance from the prop centerline and that are operated at high RPM will impose higher loads on the crankshaft nose/flange than will light props with a mass concentration on the prop centerline and operated at low RPM. In Gerd's letter he comments on these effects and clarifies the issue.

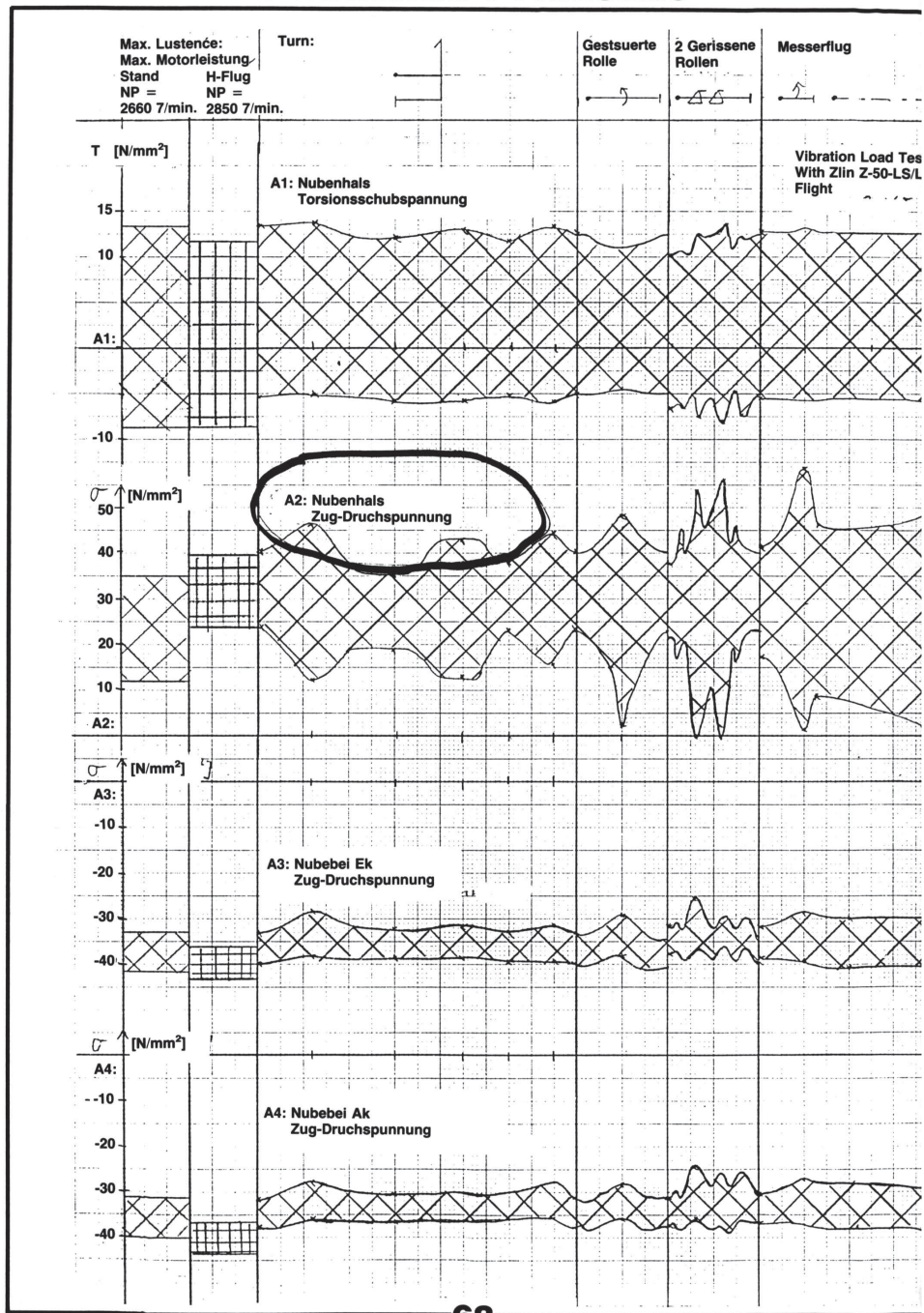
Many IACers have expressed their opinions as to what aerobatic maneuvers impose the greatest loads on the end of the crankshaft. In order, most usually say snap rolls, Lomcovaks, flat spins, and occasionally someone will suggest torque rolls. With his letter, Gerd enclosed a very interesting chart of vibration load and bending forces versus various aerobatic maneuvers for a Zlin 50 with an MT prop. And of the maneuvers shown, the torque roll imposed the highest loads on the prop hub.

The chart shows vibration (shear stress) and bending forces in Newton's per square millimeter. To convert N/mm^2 to pounds per square inch (PSI), units that many IACers may be more familiar with, just multiply $N/mm^2 \times 145.037$ to get PSI. For example, the torque roll bending forces run from a max of $+55 N/mm^2$ or 7,977 PSI to a minimum of $(-)13 N/mm^2$ or $(-)1,885$ PSI.

It should also be mentioned that the crankshaft failures that have occurred have been fatigue failures — not just a one-time catastrophic overload. A fatigue failure is the result of loading AND cycling. Gerd's chart shows only the loads incurred but does not show the frequency (or cycles per second or cycles per minute). However, if the loads are low enough it can take many, many cycles before a given component fails. Recall that the photos of the failed crankshaft that were in the May 1988 issue of SPORT AEROBATICS showed many failure initiation points, suggesting that the crank was subjected to very high bending loads.

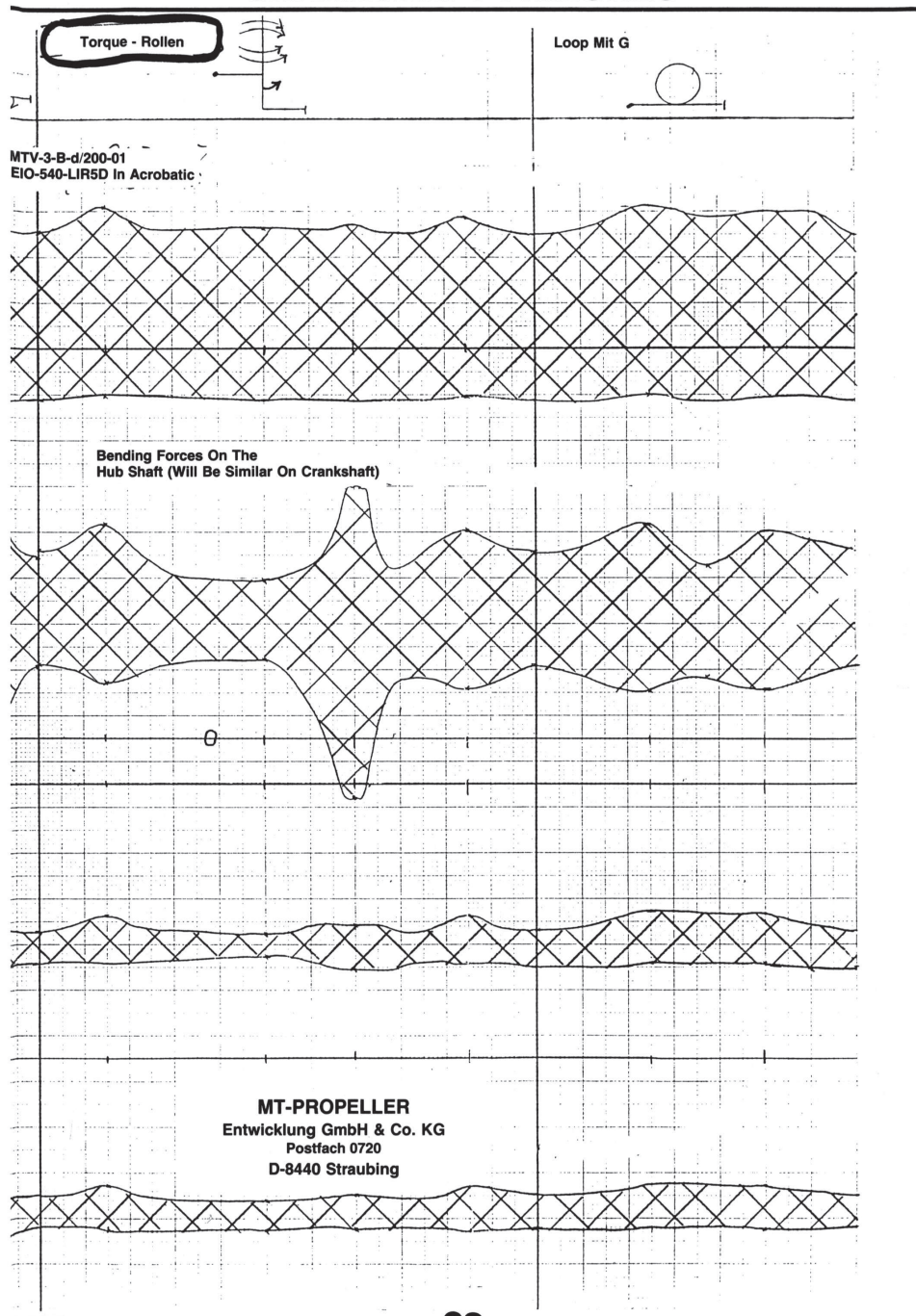
IAC thanks Gerd Muehlbauer/MT Propeller for the above input. Every piece of information gathered helps us to better understand the aerobatic environment and upgrades our safety level.

CRANKSHAFT FAILURES



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CRANKSHAFT FAILURES



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CRANKSHAFT FAILURE

The following report has just recently been received from an IAC member:

"On New Year's Day the crankshaft on my Pitts S-2B failed in flight. Fortunately, a safe landing was accomplished at my base airport and home, Willis Gliderport. The propeller, spinner, and the forward seven inches of the crankshaft landed in a harvested pepper field adjacent to the airport.

"I was just concluding a 15 or 20-minute aerobatic session when I climbed to 3,000 feet AGL to perform a flat inverted spin. I entered an inverted spin and advanced the power to full. The spin flattened out and had rotated about one turn at full power when I heard a loud 'THUNK!!' Then silence.

"Recovery from the flat spin was immediate, with no bad characteristics. I estimate the failure occurred at approximately 2,500 feet, as recovery was to level at 2,000 feet. The good news was that I was at 2,000 feet mid-field on a close downwind for runway 9 at Willis Gliderport.

"With the aft CG condition (three inches aft of the aft limit), aircraft controllability was excellent with only change in characteristic being a light elevator. Very noticeable, however, was the improved power off glide angle. An extended pattern and severe slipping was necessary to descend to a safe emergency landing.

"The particulars about the equipment:

— Stock Pitts S-2B manufactured March 1985.

— Lycoming AEIO-540 manufactured January 1985.

— 330.58 hours since new.

— Crankshaft was the new, beefed up, thick flange, no lightening hole configuration.

— Failure occurred BETWEEN the front oil seal and the front main bearing.

— The engine has been returned to Lycoming for evaluation.

— Aircraft flown in Unlimited category.

"Some opinions and observations:

— The Pitts S-2B has excellent flight characteristics in the event of propeller loss.

— Gyroscopic maneuvers impose heavy crankshaft loading.

— The beef up of the crankshaft may have moved the weak point to a hard-to-detect position aft of the oil seal.

— The availability of a reliable, durable, lightweight constant-speed propeller for the aerobatic application is essential to continued safety in the sport.

— Practice within gliding distance of a landing site whenever possible.

"Through cooperation from Lycoming and Christen Industries a replacement engine and propeller were obtained quickly. Thanks to Mike Mays of Southern Aerobatics, my 'B' was back in the air in record time.

"Until we sort out what caused the failure, it's no lumps or flat spins for me!!"

To give us a little better understanding of things, it might be helpful to relate some of the above input to some prior Tech Safety reports.

IACers are well aware that reported crankshaft failures seem to fall into two groups: (1) the crankshaft flange cracks between the lightening holes, or (2) the crankshaft cracks in the shank just aft of the flange. Most of the crankshaft failures reported to the IAC Tech Safety Com-



mittee have been cracks between the lightening holes. In an attempt to eliminate the crankshaft breaking problem Lycoming released some crankshafts with thicker prop mounting flanges and no lightening holes. As noted in the April 1984 issue of SPORT AEROBATICS, the Lycoming crank flange thicknesses are:

Engine	Flange Thickness (Inches)
O-235	.195-.205
O-320	.270 (old), .380 (new)
O-360	.380 (old), .440 (new)
O-540	.440

As far as the shaft area behind the prop flange goes, a quote from the November 1985 issue of SPORT AEROBATICS may be appropriate: "Lycoming has previously advised that the shaft wall thickness in the area behind the flange has NOT been increased. Several IACers have expressed concern that we may be chasing the problems from cracking between the lightening holes to shaft breakage just aft of the prop mounting flange."

The chasing the problem idea is pretty much the same conclusion the IACer who sent in the above safety report noted (item #3 under "Some opinions and observations"). While there have been a few reported crankshaft failures in the area aft of the prop flange, and while some persons have expressed the opinion that strengthening the flange may stop flange cracking but may also aggravate cracking of the shaft in the area behind the flange, it is very important to note that in the above report the crankshaft failed not only in the area behind the flange but also behind the front oil seal. This is the first report that IAC has of a crankshaft failing that far behind the prop flange. The area behind the front nose seal is visually "uninspectable."

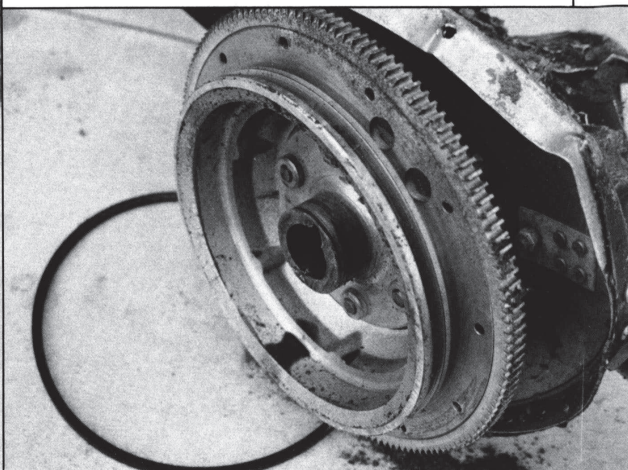
Also, after studying the photographs of the O-540 crank it appears that the crank failed due to reverse bending. A close examination reveals several ratchet marks at the outer edges of the crank cross section indicating the failure was initiated at multiple points. This would seem to indicate severe overloading.

Note how closely the failed crankshaft in this article resembles the failed crankshaft shown in the November 1985 issue of SPORT AEROBATICS. Both crankshafts had solid (holeless) flanges and both crankshafts failed aft of the prop mounting flange in what appears to be bending/fatigue failures.

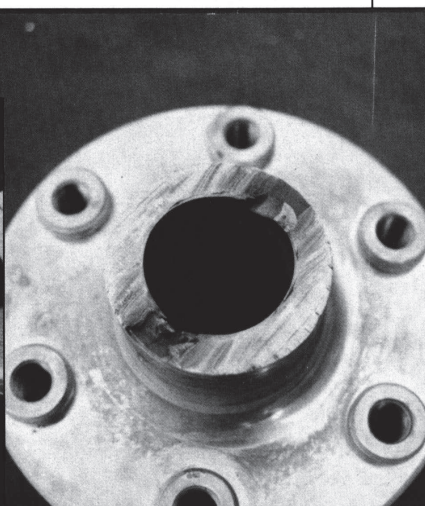
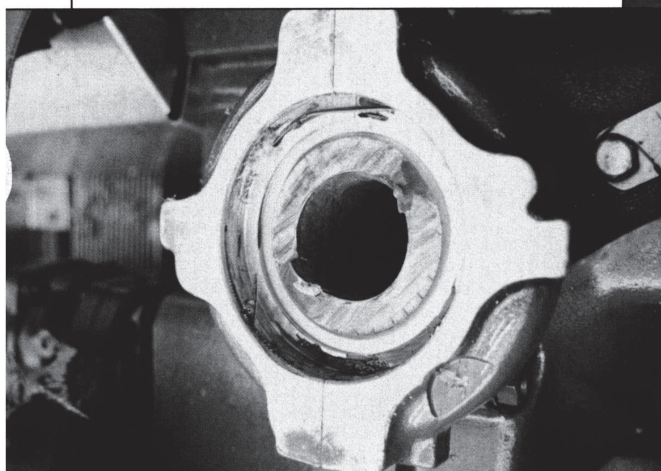
Based on reports of crankshaft breakage so far received, some best guesses might be:

CRANKSHAFT FAILURES

TECHNICAL SAFETY REPORT



Photos/IAC Member



CRANKSHAFT FAILURES

TECHNICAL SAFETY REPORT

(1) If the crankshaft has lightening holes in the prop mounting flange, the most likely failure will be cracks between the lightening holes, with the initial cracks starting in those holes aligned with the prop blades. The mode of failure will probably be reverse-bending.

(2) If the crankshaft has lightening holes in the prop mounting flange, the SECOND most likely failure will be the area to the rear of the flange between the flange and the nose seal — and sometimes under the nose seal. A failure in this area most probably will take the form of a longitudinal crack with a 45-degree runner on one or both ends. These failures seemed to be torsional mode type failures. The first clue in these failures may be an oil leak.

(3) If the crankshaft has a solid (no-hole) prop flange, the most likely area for a failure to occur is between the flange and the front main bearing. This failure would most probably be a reverse-bending type failure with the initiation points aligned with the prop. (Note the accompanying photos.) This best guess summary list may help point to the most highly suspect areas — areas that should warrant extra attention when inspecting the crankshaft nose/prop flanges. As more is learned the above guess list may change, but present knowledge seems to indicate the above noted trends.

Another important item to note in the above report is that although the aircraft's center of gravity (CG) moved very far aft after the separation of the prop, spinner and front section of the crankshaft, the plane remained controllable. Several IACers have stated that they were concerned about their aircraft possibly becoming uncontrollable (especially at low airspeeds where aerodynamic control forces would be lessened) if they lost a prop and had the CG shift very far aft.

One IAC member who did encounter crankshaft breakage and prop separation on a Pitts S-1T did advise that after the prop left, it took immediate full-forward stick to keep the aircraft's nose from pitching up. In this particular case, the plane was at very low altitude when the crankshaft broke, and a crash occurred shortly thereafter precluding very much testing of the effect of CG shift.

A third important issue mentioned in the above report was that of improved glide ratio. The improved glide ratio on the S-2B was no doubt in part due to the aft movement of the CG and in part due to drag reduction because of the departed propeller (as opposed to a stopped, windmilling, or idling prop).

IACers may recall a safety article written by T.J. Brown entitled, "Glide Ratio," which appeared in the June 1977 issue of SPORT AEROBATICS (also in TECH TIPS I) in which T.J. described an engine stoppage problem he encountered with an S-1 Pitts (no propeller separation). He stated, "... My glide ratio was cut in half at best." That dramatic reduction in glide ratio was attributed to the increased drag of a stopped propeller (as opposed to a windmilling, or idling prop).

If one encounters an engine related, in-flight emergency, the propeller condition — separated, stopped, windmilling, or at idle — may have a very pronounced effect on where you will eventually land.

A large IAC thank you is due the IAC member who made the above report of the failed crankshaft — and thanks also to those who have previously provided info that permitted the additional comments to the primary report. All of us working together can have a positive impact on the safety of our sport.

CRANK PROP FLANGE BREAKAGE

IAC members are well aware of the numerous articles in SPORT AEROBATICS related to crankshaft propeller flange breakage. The IAC Tech Safety Committee is not keeping a box score on this problem but we believe the number of failures that we are now aware of is somewhere near thirty. Therefore, it behooves all of us to closely monitor our engines for this potential problem. Recently, one IAC member made the following report of a failed crankshaft prop flange.

"(I) will relate (a) problem that might benefit the membership. The aircraft is a stock factory Pitts S1S, 620 hours on aircraft and engine. Most of these hours are aerobatic, the last 250 or more being in the Advanced category with no Unlimited time on aircraft or engine.

"The engine is the stock Lycoming aerobatic engine, Model AEIO360B4A. Oil is changed every 25 hours and oil usage is slightly less than one quart every 12 hours. It has been the best aircraft engine I have ever owned and has been run over the redline a lot of the time.

"Conforming to the Lycoming AD of a couple of years ago, I have regularly inspected the crank each 25 hours and magnafluxed each 50. The crankshaft is the old type with lightening holes in the flange where the prop is attached. Just aft of this a crack was found during magnaflux inspection a couple of weeks ago. So, even if your engine runs like a jewel, that last snap may have cracked the crankshaft."

A few points regarding the crankshaft problem maybe need to be reviewed.

First, most of the reported failed crankshafts are in S-1 series Pitts aircraft. The popular opinion is that snap (flick) rolls are the major contributing factor causing the cranks to crack and the high roll rate of the S-1 Pitts aggravates the situation.

This should not be taken to mean that if you fly something other than a Pitts you are guaranteed there will be no problems. It is just that now it is believed that aircraft with high roll rates and pilots using high snap roll entry speeds can be thought of to be in the high risk area regarding crankshaft flange/nose breakage.

Secondly, there seems to be two modes of breakage. Many of the failed crankshafts have cracks running between the lightening holes in the flange — kind of connect the dots. This type of failure is thought to be due to the prop flange bending. From what has been reported, cracks between the lightening holes usually start in the area aligned with the prop blades. The "new" heavy crankshafts have thicker flanges and no lightening holes. To date, the IAC Tech Safety Committee has not received any reports of failures of heavy-flanged cranks.

The second mode of failure is a crack in the crankshaft in the area between the prop mounting flange and the case nose seal. These cracks run parallel to the centerline of the crankshaft and then veer off with a 45° runner on one or both ends. Sometimes one end of the crack connects with a lightening hole. This appears to be a torsional type of failure. One of the first clues of this failure is often an oil leak. And often, at first, the oil leak is thought to be due to a bad crankshaft nose seal when, in fact, the oil leak is due to the crank being cracked.

As usual, a thank you is due the IACer who took the time and made the effort to share his crankshaft experiences with the rest of us. This kind of spirit and interest is the driving force behind the IAC Tech Safety Program. Everyone's help and input is needed.



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