Report 98-002

Piper PA 32-260

ZK-EKS

engine fire on ground

Ashburton Aerodrome

20 January 1998

Abstract

On the afternoon of Tuesday 20 January 1998 the pilot/owner of ZK-EKS was completing pre-take-off checks at Ashburton Aerodrome, at the commencement of a flight to West Melton Aerodrome, when he became aware of an unusual smell similar to exhaust fumes. He shut the engine down without delay, and he, and the three children accompanying him, vacated the aircraft.

On removing the upper cowl, flames and smoke erupted from the rear of the engine, the grass beneath the aircraft began to burn, and within a few minutes the engine and nosewheel assembly, the cockpit, and a major portion of the cabin of the aircraft, had been destroyed by fire.

Insufficient evidence remained for the Police to determine whether or not the fire resulted from malicious tampering. An alternative possibility existed that a defect in one of the flexible hoses supplying fuel to the fuel pump and carburettor had allowed fuel vapour or raw fuel to accumulate within the engine compartment, which had subsequently ignited.

A safety issue identified related to the limitations of "On-condition" maintenance, as a means of ensuring the continuing serviceability of fuel hoses within the engine compartments of general aviation type aircraft, and the desirability of a policy whereby such hoses should be removed and new hoses installed, on a basis of total time in service and/or a calendar period, as appropriate.

Transport Accident Investigation Commission

Aircraft Incident Report 98-002

Aircraft type, serial number and registration:	Piper PA 32-260, 32-7300018, ZK-EKS
Number and type of engines:	One Lycoming O-540-E4B5
Year of manufacture:	1973
Date and time:	20 January 1998, approximately 1515 hours[1]
Location:	Ashburton Aerodrome Latitude: 43° 54.2'S Longitude: 171° 47.8'E
Type of flight:	Private
Persons on board:	Crew: 1 Passengers: 3
Injuries:	Crew: Nil Passengers: Nil
Nature of damage:	Substantial
Pilot in Command's licence:	Private Pilot Licence (Aeroplane)
Pilot in Command's age:	38
Pilot in Command's total flying experience:	1100 hours 450 hours on type (approximately 20 hours in last 90 days)
Investigator-in-Charge:	D G Graham

[1] All times in this report are in NZDT (UTC + 13 hours)

1. Factual information

1.1 On Tuesday 20 January 1998, the pilot, who was also the owner, had arranged to fly ZK-EKS, a Piper PA32-260, from Ashburton Aerodrome to West Melton Aerodrome, near Christchurch. An agreement had been signed with a North Island buyer, for the purchase of the aircraft, and the purpose of the afternoon flight was to position ZK-EKS at an approved maintenance and overhaul facility so that an engine top overhaul could be completed prior to delivery of the aircraft to the new owner.

1.2 Although the aircraft had been hangared previously, a recent lack of available space had required that it be kept outside, tied down near the hangar. The location of the aircraft in the open meant that it was potentially vulnerable to interference by any party so inclined, since no formal system of security existed at the aerodrome.

1.3 Before the flight, the pilot carried out a routine pre-flight inspection. The top cowl was removed and the portions of the engine and accessories that could be viewed were confirmed to be free from any traces of birds' nests, which had been a problem on earlier occasions. Nothing unusual was noted in the engine compartment. A litre of oil was added to the engine.

1.4 The aircraft was refuelled with approximately 60 litres of Avgas 100, to bring the total quantity of fuel on board to about 100 litres. The aircraft had an inboard (main) fuel tank and a tip tank in each wing. The pilot reported that, after refuelling, both tip tanks were full, with a nominal quantity of fuel only, in the inboard tanks. He positioned the fuel selector so that fuel was being supplied to the engine from the right tip tank. Fuel drain checks were carried out, and the pilot verified that the drains had shut off properly.

1.5 When the refuelling and pre-flight inspection had been completed, the pilot assisted his two children and the child of a friend, who were accompanying him on the flight, to board the aircraft.

1.6 The pilot employed his standard procedure for starting the engine of ZK-EKS. This comprised operating the engine primer six times, and using two "pumps" on the throttle if required, while cranking the engine. The engine started without any difficulty and ran satisfactorily. The electric fuel pump had been 'ON' during the start procedure then turned 'OFF'. The pilot taxied ZK-EKS from near the hangar, over the smooth grass surface of the aerodrome, to a position at the southern side of grass vector 06 some 170 m east of the displaced threshold. In the tailwind conditions the engine was operated at a low power setting, or at idle, during most of the taxiing period.

1.7 The pilot turned the aircraft into wind and commenced a combined engine run-up and pre-take-off check. The electric fuel pump was selected 'ON'. All indications, including fuel pressure, were normal at 1800 rpm, and also at 2200 rpm when the pilot increased rpm to successfully clear an apparently fouled sparkplug. However, when he reduced power to check idle rpm, he smelt something like exhaust fumes. He said to the three children, "I can smell something, as if something's burning, can you?". The three replied "Yes, we can". Without delay the pilot shut the engine down by placing the mixture control in idle cut-off, opened the door, and told the children to vacate the cabin quickly.

1.8 After ensuring that the children were at a safe distance, the pilot unlatched the right side of the top cowl, then the left side, lifted the cowl off and placed it on the ground. On turning to examine the engine more closely he saw flames and smoke coming from the rear of the engine compartment. He decided against re-entering the cockpit to get the fire extinguisher as molten material had fallen beneath the engine and ignited the dry grass. The brisk wind was already fanning the flames under the left wing of the aircraft, creating risk of an explosion from the fuel tanks.

1.9 The pilot made a 111 call using his cellphone, to alert emergency services concerning the incident. A worker at the aerodrome, who had observed smoke, brought a fire extinguisher to the aircraft, and the Ashburton Fire Service and Police attended the scene with a minimum of delay.

1.10 The fire took hold so quickly and was so intense, however, that the whole engine, nose wheel assembly, and forward portion of the cockpit of the aircraft including the instrument panel and controls, were completely burned out. The remainder of the cabin and rear fuselage was severely damaged by the flames and smoke. The grass fire spread across the vector and burned an area of about one hectare. The fire was extinguished before it affected stock in an adjacent paddock.

Investigation

1.11 The aircraft was kept under Police surveillance overnight and inspected the next morning. The Police arranged for specialist examination of components from the lower left rear of the engine compartment, where it appeared likely the fire had originated.

1.12 There was some evidence of a minor oil leak from the number 6 cylinder rocker cover oil return line onto the left exhaust. The intensity and duration of the fire, however, indicated that whatever the initiating factor, combustion, once established, was probably sustained by aviation fuel from one or both of the flexible hoses which comprised the main fuel supply lines to the engine, between the firewall and the carburettor.

1.13 Detailed inspection of the remains of the two fuel hoses, the oil return line, and a primer line from the number 4 cylinder, failed to disclose evidence either to confirm or deny that malicious tampering had taken place. All fuel hose connections were firm. The connection between the engine driven fuel pump and the flexible hose to the carburettor required the least torque to disassemble, possibly due to localised intense heat. The initiating event(s) which led to the destruction of ZK-EKS by fire, and the ignition source, could not be determined.

1.14 The unusual smell which prompted the pilot to shut down the engine and vacate the aircraft did not immediately indicate an engine fire. As a result, he did not complete a full emergency "engine fire on ground" procedure which would have included turning off the electric fuel pump, the fuel selector, and the magneto and master switches. These actions were likely to have assisted in reducing the severity of the fire, and containing it within the engine bay.

1.15 In the circumstances, the possibility could not be discounted that a defect had developed in the fuel hose between the firewall filter and the engine driven fuel pump, or the fuel hose between the engine driven fuel pump and the carburettor. Experience over many years has shown that these items, and similar flexible hoses, which provide the main fuel supply to the engine in a wide variety of general aviation aircraft types, are vulnerable to in-service deterioration.

1.16 Elevated temperatures, vibration, and other adverse features of the operating environment within an engine compartment, in conjunction with the effect of normal, or accelerated, ageing and varying internal fuel pressures, has contributed to porosity, or direct leakage, creating a consequent hazard of fuel vapour, or raw fuel, requiring only a means of ignition to promote a serious, potentially catastrophic, fire.

1.17 At the time of the incident, the aircraft had accumulated a total time of approximately 5711 hours. The engine had a total time since new of approximately 8936 hours, and a time since overhaul of 1913 hours. The most recent periodic maintenance had comprised a 500 hour inspection carried out on 25 March 1997. The next maintenance inspection was not due until 25 March 1998, or the attainment of 5739 airframe hours. The most recent unscheduled maintenance had involved a cylinder change carried out on 25 September 1997.

1.18 The aircraft had been operating satisfactorily. It had last been flown, two days before the incident, on an extended trip to the West Coast and return. Nothing abnormal had been noted within the engine compartment, and no problems had been experienced with the engine, during start, or in flight.

1.19 ZK-EKS had a standard Certificate of Airworthiness which was non-terminating. The aircraft, at the time of the incident, was not approved for Air Transport, but was used for private and aerial work operations only. Consequently, required maintenance consisted essentially of an Annual Inspection, and periodic 100 hour inspections, the latter to take place at intervals not exceeding 12 months.

1.20 Logbook entries indicated that new flexible fuel supply lines had been fitted to ZK-EKS during a major inspection in December 1987, at a total airframe time of 4610 hours. This suggested that they had accumulated about 1100 hours, but had been in service for some 10 years. A general requirement to pressure test hoses every four years, which existed prior to the introduction of the new New Zealand Civil Aviation Rules (NZCARs), had been complied with, most recently, on 23 December 1992.

1.21 Due to known problems, a number of existing Airworthiness Directives (ADs) apply to the fuel and oil system hoses in certain engine or aircraft installations, requiring special inspection or replacement. In addition, particular batch numbers, or part numbers, of hoses produced by specific manufacturers are also the subject of ADs.

1.22 However, under the new NZCARs Part 43 General Maintenance Rules, unless affected by an AD, or addressed specifically as a replacement item in a manufacturers progressive/periodic maintenance schedule which may not necessarily be chosen as the maintenance programme for the aircraft, many engine bay fuel hoses installed in general aviation aircraft types now come into the category of items to be maintained "On-condition".

1.23 Advisory Circular 43 (AC 43), in clarifying some of the changes in aviation maintenance philosophy under the new Rules, describes "On-condition maintenance" as a preventive process in which an item is monitored either continuously or at specified periods. It is made clear that the fundamental purpose of "On-condition maintenance" is to remove an item before it fails in service. It is not intended to be a philosophy of "fit until failure" or "fit and forget".

1.24 The processes currently used in the maintenance of general aviation aircraft, under the new CARs, include a combination of "Airworthiness Limitations", "Hard Time maintenance", and "On-condition maintenance". AC 43 describes 'Hard Time maintenance' as a process where the known deterioration of an item is limited to an acceptable level by maintenance actions at given periods of time. These periods are usually set in relation to calendar time, number of cycles, number of landings, or aircraft hours in service. Maintenance actions would include overhaul, partial overhaul, and parts replacement.

2. Analysis

2.1 The "On-condition maintenance" concept, while of proven value in many general aviation maintenance applications, is arguably unsuitable for the maintenance of fuel hoses in an engine compartment as it means that, unless provided by a manufacturer and brought to the attention of the owner in some way, little guidance may be available to a Licenced Aircraft Maintenance Engineer (LAME) regarding a recommended life for the item, and no requirement exists, in practice, for other than periodic external visual inspection.

2.2 A visual check of the fuel hoses in-situ, while an important part of any engine maintenance inspection, cannot be guaranteed to disclose all defects, some of which may only occur under certain operating conditions. Pressure testing has proved a more reliable method, but the effectiveness of revealing a fuel hose unserviceability in a timely manner again cannot be guaranteed and is likely to depend on the period between such tests, or on the judgement of the LAME in requiring a pressure test to be carried out.

2.3 In view of the potential hazard resulting from undetected deterioration in service of engine compartment main fuel supply hoses, it is suggested that such items should be subject to "Hard Time maintenance" rather than "On-condition maintenance" procedures. A policy involving replacement of such fuel hoses on a basis of accumulated time in service, and/or at the end of a defined calendar period, as appropriate, appears preferable to an indefinite "On-condition" service life for these vital, yet vulnerable, items.

3. Findings

Findings and any safety recommendations are listed in order of development and not in order of priority.

3.1 No conclusive reason could be determined to account for the fire in the engine compartment of ZK-EKS which resulted in the partial destruction of the aircraft.

3.2 The aircraft had been maintained in accordance with current maintenance requirements, and was operating within the maintenance period and airframe hours specified in the Technical Log.

3.3 The procedures followed by the pilot in preparing the aircraft for flight, starting the engine, taxiing, and carrying out subsequent pre-take-off checks, followed standard aviation practice and, under normal circumstances, should not have contributed to an engine fire.

3.4 Completion of an emergency "engine fire on ground" procedure at the time of engine shut-down was likely to have reduced the severity of the ensuing engine fire.

3.5 If malicious tampering was not responsible for the fire, the most likely cause was a defective main fuel supply hose.

3.6 An "On-condition maintenance" procedure, while acceptable for many items in general aviation aircraft, is inappropriate for engine compartment main fuel supply hoses due to the vulnerability of such hoses to deterioration or defect resulting from their operating environment, and the limitations of "On-condition maintenance" in revealing any unserviceability in a timely manner.

3.7 Maintenance using a "Hard Time maintenance" process, involving replacement at an appropriate total time in service or calendar period, would reduce the likelihood of engine compartment fuel hoses deteriorating, or developing a defect, in service and presenting a consequent hazard to the safety of an aircraft and its occupants.

Report approved for publication 10 June 1998

Hon. W P Jeffries
Chief Commissioner

Glossary of aviation abbreviations

AD	Airworthiness Directive
ADF	automatic direction-finding equipment
agl	above ground level
AI	attitude indicator
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
amsl	above mean sea level
AOD	aft of datum
ASI	airspeed indicator
ATA	actual time of arrival
ATC	Air Traffic Control
ATD	actual time of departure
ATPL (A *or* H)	Airline Transport Pilot Licence (Aeroplane *or* Helicopter)
AUW	all-up weight
^{o}C	degrees Celsius
CAA	Civil Aviation Authority
CDI	course deviation indicator
CFI	Chief Flying Instructor
C of A	Certificate of Airworthiness
C of G (*or* CG)	centre of gravity
CPL (A *or* H)	Commercial Pilot Licence (Aeroplane *or* Helicopter)
DME	distance measuring equipment
E	east
ELT	emergency location transmitter
ETA	estimated time of arrival
ETD	estimated time of departure
^{o}F	degrees Fahrenheit
FAA	Federal Aviation Administration (United States)
FL	flight level
g	acceleration due to gravity
GPS	Global positioning system
HF	high frequency (3000 to 30 000 kHz)
hPa	hectoPascal
HSI	horizontal situation indicator
IAS	indicated airspeed
IFR	Instrument Flight Rules
IGE	in ground effect
ILS	instrument landing system
IMC	instrument meteorological conditions
kg	kilogram(s)
kHz	kilohertz
KIAS	knots indicated airspeed
km	kilometre(s)

LAME	Licensed Aircraft Maintenance Engineer
LF	low frequency
LLZ	localiser
Ltd	Limited
m	metre(s)
M	Mach number (e.g. M1.2)
°M	degrees Magnetic
MAP	manifold absolute pressure (measured in inches of mercury)
MAUW	maximum all-up weight
METAR	aviation routine weather report (in aeronautical meteorological code)
MF	medium frequency (300 to 3000 kHz)
MHz	megahertz
mm	millimetre(s)
N	north
NDB	non-directional radio beacon
nm	nautical mile
NOTAM	A notice containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.
NTSB	National Transportation Safety Board (United States)
NZDT	New Zealand Daylight Time (UTC + 13 hours)
NZGA	New Zealand Gliding Association
NZMS	New Zealand Mapping Service map series number
NZST	New Zealand Standard Time (UTC + 12 hours)
OGE	out of ground effect
okta	eighth of sky cloud cover (e.g. 4 oktas = 4/8 of cloud cover)
PAR	precision approach radar
PIC	pilot-in-command
PPL (A *or* H)	Private Pilot Licence (Aeroplane *or* Helicopter)
psi	pounds per square inch
QFE	an altimeter subscale setting to obtain height above an aerodrome
QNH	an altimeter subscale setting to obtain elevation above mean sea level
RCC	Rescue co-ordination centre
RNZAC	Royal New Zealand Aero Club
RNZAF	Royal New Zealand Air Force
rpm	revolutions per minute
RTF	radio telephone or radio telephony
S	south
SAR	Search and Rescue
SSR	secondary surveillance radar
°T	degrees true
TACAN	Tactical air navigation aid
TAF	aerodrome forecast
TAS	true airspeed

UHF	ultra high frequency
UTC	Coordinated Universal Time
VASIS	visual approach slope indicator system
VFG	Visual Flight Guide
VFR	visual flight rules
VHF	very high frequency
VMC	visual meteorological conditions
VOR	VHF omnidirectional radio range
VORTAC	VOR and TACAN combined
VTC	Visual Terminal Chart
W	west