AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:	CA18/3/2/8482	
Aircraft Registration	ZS-MZS	**Date of Accident**	22 April 2008	**Time of Accident**	1020Z
Type of Aircraft	Robinson R44 Raven ll – Helicopter	**Type of Operation**	Private		

Pilot-in-command Licence Type	Private	**Age**	43	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	68.8		Hours on Type	16.3

Last point of departure	Farm Driehoek, Hoedspruit – Limpopo Province
Next point of intended landing	Nelspruit – Mpumalanga Province

Location of the accident site with reference to easily defined geographical points **(GPS readings if possible)**

Approximately S24°29' 50" E030°53' 32" Elevation 2375ft and 10 nm from the departure point.

Meteorological Information	Wind: 5-10 knots / South; Temperature: 24°C; Visibility: Good				
Number of people on board	1+2	**No. of people injured**	1	**No. of people killed**	0

Synopsis

The pilot and two passengers took off from a farm in Hoedspruit on a flight to Nelspruit. After about 4 to 5 minutes into the flight, the cylinder head temperature increased, although still in the green band, and the low rotor RPM alarm sounded. The pilot executed a precautionary landing on a tar road and vehicles travelling on the road stopped approximately 100 metres from the helicopter. The pilot stated that he did all the necessary checks, established that everything was normal and decided to continue the flight. He took off into the wind and in the hover, everything was fine. He went into transition and as the helicopter picked up speed and altitude, the low rotor RPM alarm sounded again. The helicopter then lost altitude and the main rotor impacted with wooden pallets that were stacked on a stationary truck parked about 100 metres from where the helicopter had taken off. The helicopter then crashed into the ground, causing damage to the skids, main rotor, tail rotor, tail boom and fuselage.

One of the passengers sustained injuries.

During further investigation it was found that the colour of the fuel in the helicopter tanks was different to the colour of the fuel that the helicopter was rated to use.

Probable Cause

Utilization of an incorrect grade and type of fuel resulted in a loss of power, resulting in two forced landings. During the second power loss the helicopter blades made contact with pallets on a stationary truck and the helicopter crashed.

Contributory Factor/s

i) The pilot did not ensure by fuel colour verification, that the fuel uplifted was of the correct grade and type.

ii) Failure by the fuel supplier to ensure correct labeling as to the type of fuel contained in the supplied sealed drums.

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner/Operator	**:** Dotcom Trading 524 (PTY) LTD
Manufacturer	**:** Robinson Helicopter Company
Model	**:** R44 II
Nationality	**:** South African
Registration Marks	**:** ZS - MZS
Place	**:** Hoedspruit – Limpopo Province
Date	**:** 22 April 2008
Time	**:** 1020Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

*In terms of Regulation 12.03.1 of the Civil Aviation Regulations (1997) this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and **not to establish legal liability**.*

Disclaimer:

This report is given without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 The helicopter was purchased by the owner for the purpose of flying between his business in Hoedspruit (South Africa) and Mozambique. After it was assembled at an Aircraft Maintenance Organisation (AMO) in Durban on 20 February 2008 and the Certificate of Airworthiness was issued on 14 April 2008, the pilot flew the helicopter from Durban to his farm in Hoedspruit via Wonderboom Aerodrome, where he refuelled prior to continuation of the flight with Avgas 100LL. The pilot then did recreational flying in the farm area. Approximately 50 litres of fuel had remained in the helicopter fuel tanks. No difficulties were experienced with the operation of the helicopter during these flights.

1.1.2 On 31 March 2008 the pilot bought three 200 litre (L) sealed drums of Avgas 100LL which had expired 3 weeks before, from a fuel distributor in Hoedspruit. On the morning of 22 April 2008 he refuelled the helicopter with approximately 120 L of fuel from one of the drums.

1.1.3 After refuelling, the pilot and two passengers took off from a farm, Farm Driehoek in Hoedspruit, to fly to Nelspruit. The pilot stated that about 4 to 5 minutes into the flight the cylinder head temperature increased, although still in the green band, and the low rotor RPM alarm sounded. The pilot executed a precautionary landing on a public road, the R531 road from Hoedspruit to Klaserie. The vehicles travelling on the road stopped approximately 100 metres from the helicopter. The pilot stated that he completed all the necessary checks, established that everything was normal and decided to continue the flight. He took off into the wind and in the hover everything was fine; he went into transition and as the helicopter picked up speed and altitude the low rotor RPM alarm sounded. The helicopter then lost altitude and the main rotor impacted with wooden pallets that were stacked on a stationary truck parked about 100 metres from where the helicopter had taken off. The helicopter then crashed into the ground. At the time of the accident, the helicopter had accumulated 12.7 airframe hours since new.

1.1.4 The accident occurred during daylight conditions at a geographical position determined to be approximately S24°29' 50'' E030°53' 32'' elevation 2375 feet AMSL (Above Mean Sea Level).

Photo 1. A view of the accident site.

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	1	-
None	1	-	1	-

1.3 Damage to Aircraft

1.3.1 The helicopter sustained damage to the skids, main rotor, tail rotor, tail boom and fuselage.

1.4 Other Damage

1.4.1 The truck sustained minor damage and its cargo load (empty pallets) was damaged.

Photo 2. A view of the damage of the truck and pallets after the accident.

1.5 Personnel Information

Nationality	South African	Gender	Male	Age	43
Licence Number	****************	Licence Type	Private		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	None				
Medical Expiry Date	31 April 2008				
Restrictions	None				
Previous Accidents	None				

Flying Experience:

Total Hours	68.8
Total Past 90 Days	24.8
Total on Type Past 90 Days	16.3
Total on Type	16.3

1.6 Aircraft Information

Airframe:

Type	Robinson R44 II	
Serial Number	12180	
Manufacturer	Robinson Helicopter Company	
Date of Manufacture	2008	
Total Airframe Hours (At time of Accident)	12.7	
Last MPI (Hours & Date)	4	04 April 2008
Hours since Last MPI	8.7	
C of A (Issue Date)	13 April 2008	
C of R (Issue Date) (Present owner)	02 April 2008	
Operating Categories	Normal	

Engine:

Type	Lycoming IO-540-AE1A5
Serial Number	L-32638-48E
Hours since New	12.7
Hours since Overhaul	Not yet reached

1.6.2 The helicopter was authorized to use Avgas 100LL. According to the pilot, the helicopter had approximately 50 L of fuel remaining and approximately 120 L of fuel was uplifted prior to takeoff. The Fuel uplifted originated from one of the sealed drums marked Avgas 100LL. The total quantity of the fuel on board was approximately 170 litres and the only fuel burnt off at the time of the accident was that involving the two takeoffs.

1.6.3 The helicopter's wreckage was recovered to an AMO at Grand Central Aerodrome. Whilst draining the helicopter's fuel tanks, it was discovered that the colour of the fuel in the fuel tanks was different to the Avgas 100LL that the aircraft are rated to use.

1.6.4 Weight and Balance

(i) The following weight and balance calculation was done with Avgas 100LL and Aviation Turbine Fuel, as the two types of fuel have different Specific Gravity weights.

(ii) Avgas 100LL in tanks.

	Weight (lbs)	Arm (inches)	Moment (lbs-inches/1000)
A/C empty weight	1544	107.0	165.2
Pilot	245	49.5	12.1
Fwd passenger	220	49.5	10.9
Aft passenger	110	79.5	8.75
Baggage	0	79.5	0
Fuel main tank	168	106.0	17.8
Fuel aux tank	102	102.0	10.4
At time of accident	**2389**	**94.1**	**225**

- The maximum certificated takeoff mass for the helicopter as stipulated in Section 2, page 2-3 of the POH (Pilot's Operating Handbook) is given as 2500 pounds.
- Centre of gravity = 94.1
- The helicopter's weight at the time of the accident was calculated to be 111 lbs below its maximum certified takeoff weight.

(iii) Aviation Turbine Fuel in tanks.

	Weight (lbs)	Arm (inches)	Moment (lbs-inches/1000)
A/C empty weight	1544	107.0	165.2
Pilot	245	49.5	12.1
Fwd passenger	220	49.5	10.9
Aft passenger	110	79.5	8.75
Baggage	0	79.5	0
Fuel main tank	188	106.0	19.93
Fuel aux tank	114	102.0	11.63
At time of accident	**2421**	**94.6**	**229**

- The maximum certified takeoff mass for the helicopter as stipulated in Section 2, page 2-3 of the POH is given as 2500 pounds.
- Centre of gravity = 94.4
- The helicopter's weight at the time of the accident was calculated to be 79 lbs below its maximum certified takeoff weight.

(ii) Both calculations above indicate that at the time of the accident, the helicopter was below the maximum certified takeoff weight.

1.7 Meteorological Information

1.7.1 The weather information was obtained from the Pilot Questionnaire.

Wind direction	South	Wind speed	5-10knots	Visibility	Good
Temperature	24°C	Cloud cover	none	Cloud base	none
Dew point	unknown				

1.8 Aids to Navigation

1.8.1 No malfunctioning of the navigational aids was reported.

1.9 Communication

1.9.1 No malfunctioning of the communication equipment was reported.

1.10 Aerodrome Information

1.10.1 The pilot executed a precautionary landing on the R531, a public road, from Hoedspruit to Klaserie and the accident subsequently occurred during the takeoff from the road at approximately 10 nm from the departure point at a geographical position of S24°29' 50" E030°53' 32", elevation 2375ft.

1.10.2 As indicated on the photograph, on the left-hand side of the wreckage and road is a ditch and trees. On the right-hand side of the road is a rise in ground elevation, trees, pylons and telephone overhead wires.

Photo 3. The area where the accident occurred.

1.11 Flight Recorders

1.11.1 The helicopter was not fitted with a Cockpit Voice Recorder (CVR) or a Flight Data Recorder (FDR) and neither was required by regulations to be fitted to this type of aircraft.

1.12 Wreckage and Impact Information

1.12.1 The low rotor RPM alarm sounded and the pilot executed a precautionary landing on a public road. The vehicles travelling on the road stopped approximately 100 metres from the helicopter. No obvious defect could be identified and the pilot decided that all parameters were normal to continue the flight. The helicopter took off into the wind; in the hover everything was fine; but when going into transition and as the aircraft picked up speed and altitude, the low rotor RPM alarm sounded again. As the helicopter lost altitude the main rotor impacted with wooden pallets that were stacked on a stationary truck parked about 100 metres from where it had taken off. The helicopter then crashed into the ground.

1.12.2 The helicopter sustained damage to the skids, main rotor, tail rotor, tail boom and fuselage.

1.12.3 The wreckage was moved approximately 2 metres to the side of the road by the South African Police Services, to give access to vehicles to pass.

Photo 4. A view of the helicopter after it was moved out of the road.

1.13 Medical and Pathological Information

1.13.1 One of the passengers sustained injuries.

1.14 Fire

1.14.1 There was no evidence of fire in flight or after the impact.

1.15 Survival Aspects

1.15.1 The occupants were properly restrained at the time of the accident by the equipped safety harnesses which subsequently prevented further injuries. This accident was considered survivable.

1.15.2 During the impact sequence, the left skid pierced the helicopter cabin floor and went into the aft left seat.

Photo 5. The skid that pierced the cabin floor and seat.

1.16 Tests and Research

1.16.1 A sample was taken of the fuel from the Avgas 100LL labelled drum that had been used to refuel the helicopter. The sample was analyzed by the SABS to determine the grade of the fuel. See Photo 6 below.

The SABS test concluded the following:

Test DERD 2485: Avgas 80, Avgas 100 and Avgas 100LL
The sample failed to comply with the requirements of specification DERD 2485 in respect of the test carried out on distillation, freezing point, vapour pressure and colour. The sample did not distil on Avgas program.

Test Mil-T-5624: Turbine fuel, aviation, (Grade GP5)
The sample complied with the requirements of specification Mil-T-5624 in respect of the test carried out.

As stated above it was concluded that:

- The helicopter had been refuelled with Grade GP5 Aviation Turbine fuel instead of Avgas 100LL.
- The fuel that was sampled from the drum was found to be yellow in colour.
- The label on the fuel drum indicated that the contents were Avgas 100LL and blue in colour. Also see Photo 6 below.

The SABS report is attached as Appendix A of this report.

It could not be determined if any other drums were incorrectly labelled Avgas 100LL within the suppliers control that contained Grade GP5 Aviation Turbine fuel. No other reports of incorrectly labelled drums were however reported.

1.16.2 It was decided not to disassemble the helicopter engine, as there was sufficient evidence to determine the cause of the engine power loss.

Photo 6. The Avgas 100LL labelled fuel drum that contained the Grade GP5 Aviation Turbine fuel with which the aircraft was refuelled. Note expiry date displayed.

1.17 Organisational and Management Information

1.17.2 The last maintenance that was carried out on the aircraft prior to the accident was conducted by an AMO in possession of a valid AMO Approval Certificate to perform the required maintenance.

1.17.3 The fuel distributor that sold the incorrectly labelled fuel to the pilot was contacted to establish their procedures to ensure that the correct fuel type is sold. They advised that they buy sealed drums of fuel from the supplier, and sell it still sealed to the customer. They stated that they accept sealed fuel drums from the supplier as the correct fuel type, as they only sell Avgas. After this incident, they stopped selling aircraft fuel to prevent this incident from recurring.

1.17.4 As the production, distribution and control of aviation fuel is industry regulated, the onus rests on the pilot to ensure that the correct grade and type of fuel is uplifted. The fuel supplier was, however, contacted to discuss the occurrence with the intention of preventing a recurrence. No feedback was received from the supplier.

1.18 Additional Information

1.18.1 Regarding the effects of using Jet A-1/ Aviation Turbine fuel instead of Avgas in the Lycoming IO-540-AE1A5 engine, the following information was received from the engine manufacturer:

"the engine would run very hot……….head of the pistons severely melted away. Running an AVGAS engine on Jet A or any jet fuel can cause stretching of the intake valves. You might also see the center electrodes of the spark plugs much thinner than normal as they are melted from the high temps."

The above information from the engine manufacturer is attached as Appendix B of this report.

1.18.2 The pilot's responsibility regarding refueling:

(i) Reference: SACAA Aeronautical Information Circular (AIC) 21-1 Dated 15 April 2002

- *When refuelling from drums or other containers, carefully inspect, identify and check the contents for contamination.*
- *Do not use fuel which has a cloudy appearance or which is "off-colour".*
- *Use only the fuel recommended by the engine manufacturer.*

(ii) The identification of fuel by its colour:

- Grade 100LL is blue in colour
  Reference: Wikepedia - http://en.wikipedia.org/wiki/Avgas#100LL
- Jet fuel (Jet A-1, Aviation Turbine fuel) is clear to straw in colour
  Reference: Wikepedia - http://en.wikipedia.org/wiki/Aviation_fuel

1.18.3 The SACAA issued an Advisory Circular after the accident occurred. The Advisory Circular, CA AOC-AC-005 alerts the aviation community to the potential hazards of inadvertent mixing or contamination of turbine and piston fuels, and provides recommended fuel control and servicing procedures. The Advisory Circular, CA AOC-AC-005 states the following (Annex C):

- Advisory Circular CA AOC-AC-005 Paragraph 7:

  Careful instructions in operating procedures should be given to all personnel involved in fuelling……the flight personnel in procedures and marking with particular emphasis on use of the proper type of fuel.

- Advisory Circular CA AOC-AC-005 Paragraph 11.a:

  Refuelling from drums or cans should be considered as an unsatisfactory operation and one to be avoided whenever possible. All containers of this type are to be regarded with suspicion and the contents carefully inspected, identified, and checked for water and other contamination.

1.18.4 <u>Landing on a public road</u>

The South African Civil Aviation Regulations (SA-CARS) 91.06.01 states:

No pilot shall use a public road as a place of landing or take-off in an aircraft, except:

(a) in the case of an emergency involving the safety of the aircraft or its occupants;
(b) for the purpose of saving human lives; or
(c) when involved in civil defence or law-enforcement operations:

Provided that at all times reasonable care is taken for the safety of others with due regard to the prevailing circumstances.

1.18.5 In this case where the pilot noted that the cylinder head temperature increased, with an accompanying low rotor RPM alarm, he had no alternative but to execute a precautionary landing on the R531 public road, which he considered to be the most suitable place to land. The pilot has to assess and ensure that reasonable care is taken during any subsequent takeoff from such a road.

1.18.6 A subsequent settlement was reached between the pilot/owner of the helicopter and the fuel supplier as to the incorrect identification of the type of fuel contained in the sealed drums.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 The pilot bought the helicopter and approximately a week prior to the accident took delivery of it in Durban, from where he flew it to his farm in Hoedspruit. The pilot then did recreational flying. According to the available evidence, no maintenance defects with respects to the helicopter were recorded and occurred that could have contributed to, or caused the accident.

2.2 The pilot bought three sealed drums of what was labelled as Avgas 100LL which had expired 3 weeks before from an aviation fuel distributor. He refuelled the helicopter with approximately 120 litres of fuel from one of the sealed drums.

2.3 After refuelling the helicopter, the pilot and two passengers took off from a farm in Hoedspruit on a flight to Nelspruit. Approximately 4 to 5 minutes into the flight, the cylinder head temperature increased, although still in the green band. The low rotor RPM alarm sounded and the pilot executed a precautionary landing on a tar road in Hoedspruit. Vehicles travelling on the road stopped approximately 100 metres from the helicopter.

2.4 No obvious defect could be identified and the pilot decided that all parameters were normal to continue the flight. The pilot again took off from the tar road. The decision to take off from the road after no cause could be found for the abnormalities could have been made due to pressure to move the helicopter off the road and to make way for traffic travelling on the road.

2.5 He took off into the wind and as the helicopter picked up speed and altitude, the low rotor RPM alarm sounded again. The helicopter lost altitude and the main rotor impacted with wooden pallets that were stacked on a stationary truck. The helicopter then crashed into the ground.

2.6 During the investigation it was found that the Avgas 100LL labelled drum contained fuel that was different in colour from the Avgas 100LL that the helicopter was certified to use. The expiry date displayed on the label indicated that this date was exceeded by the time the helicopter was last refuelled from this particular drum. It is the opinion of the investigator that the pilot accepted the fuel from the Avgas 100LL labelled drum as correct, as it was sealed and came from a reputable supplier. He thus did not properly inspect and identify the colour of the fuel in the drum or gave any attention to the expiry date. Analyses later also revealed that the fuel from the drum was Grade GP5 Aviation Turbine fuel and yellow in colour.

2.7 Currently the CARs only require that when a student pilot is involved in an emergency landing in an area other than an aerodrome, only the holder of a commercial or airline transport pilot’s license, or another pilot approved for the purpose in writing by the Director, may fly that aeroplane out of that area. However, the CARS do not provide for other cases, such as this occurrence.

3. CONCLUSION

3.1 Findings

(i) The pilot was in possession of a valid private pilot’s licence and had the aircraft type endorsed in his logbook.

(ii) The helicopter had a valid Certificate of Airworthiness and according to available records, it was in a serviceable condition.

(iii) The pilot had bought three sealed drums of fuel labeled Avgas 100LL from a fuel distributor and had fuelled the helicopter from one of the sealed drums.

(iv) The fuel sampled from the fuel drum that was used to fuel the helicopter was found to be Grade GP5 Aviation Turbine fuel, and yellow in colour.

(v) The pilot did not ensure visually by fuel colour verification, that the fuel uplifted was of the correct grade and type and the expiry date had already been exceeded.

(vi) The helicopter had a sufficient quantity of fuel for this flight leg.

(vii) The weight of the helicopter at the time of the accident was calculated to be below the maximum certified takeoff weight.

(viii) After taking off from a farm and approximately 4 to 5 minutes into the flight, the pilot did a precautionary landing on a road after an increase of the cylinder head temperature and low rotor RPM alarm.

(ix) The decision to take off from the road after no cause could be found for the abnormalities could have been made due to pressure to move the helicopter off the road and to make way for traffic travelling on the road.

(x) During this takeoff, the engine again lost power due to the incorrect fuel grade and the helicopter lost altitude and the pilot again had to execute a forced landing.

(xi) The helicopter's main rotor blades contacted wooden pallets on a stationary truck and crashed.

(xii) The passenger sustained minor injuries.

3.2 Probable Cause/s

3.2.1 Utilization of the incorrect grade and type of fuel resulted in a loss of power, resulting in two forced landings. During the second power loss, the helicopter blades made contact with pallets on a stationary truck and the helicopter crashed.

3.3 Contributory Factor/s

3.3.1 The pilot did not ensure by fuel colour verification, that the fuel uplifted was of the correct grade and type.

3.3.2 Failure by the fuel supplier to ensure correct labeling as to the type of fuel contained in the supplied sealed drums.

4. SAFETY RECOMMENDATIONS

It is recommended that the Director of Civil Aviation should require that:

4.1 The Flight Operations Department of the SACAA review the adequacy of the current requirements to address actions to be taken following a forced landing.

4.2 The Airworthiness Department to study and review whether the industry quality control on the distribution and control of compliance of fuel specifications and standards for aviation use do still ensure an acceptable level of safety. The study should also address the need for the introduction of regulatory requirements or not for the distribution and control of fuel for aviation use.

5. APPENDICES

5.1 Appendix A: SABS Fuel Analyses Report
5.2 Appendix B: Information from Lycoming engine manufacturer
5.3 Appendix C: SACAA Advisory Circular CA AOC-AC-005.

Report reviewed and amended by the Advisory Safety Panel 8 February 2011.

-END-

Appendix A:

SABS Fuel Analyses Report

(10)

TEST REPORT

SABS

Aviation Assessing Service
Attention: Mr V Hodges
P.O. Box 69946
Bryanston
2021

Order No.	Q124/2008
Our ref:	N 1
Enquiries:	S L Nzimakwe
Tel:	(012) 428-7094
Date:	2007-05-27
Page No:	1 of 2
Report No:	2112/N4045

1. Sample description

5l Avgas samples

The sample was received in a condition suitable for testing.

Date received: 2008-05-16
Date tested: 2008-05-16
Date completed: 2008-05-27

2. TEST REQUESTED

DERD 2485: Avgas 80, Avgas 100, and Avgas 100LL

3. DISCLAIMERS

Tests marked "Not SANAS" Accredited in this report are not included in the SANAS schedule of accreditation for this laboratory.

Opinions, interpretations and conclusions expressed herein are outside the scope of SANAS accreditation.

1 Dr Lategan Road Groenkloof, Pretoria Private Bag X191 Pretoria 0001, Tel: +27 (012) 428-7911, Fax: +27 (012) 344-1568.

TEST REPORT

SABS

Aviation Assessing Service
Attention: Mr V Hodges
P.O. Box 69946
Bryanston
2021

Order No.	Q124/2008
Our ref:	N 2
Enquiries:	S L Nzimakwe
Tel:	(012) 428-7094
Date:	2007-05-27
Page No:	1 of 2
Report No:	2112/N4045

1. Sample description

5l Jet Fuel samples

The sample was received in a condition suitable for testing.

Date received: 2008-05-16
Date tested: 2008-05-16
Date completed: 2008-05-27

2. TEST REQUESTED

Mil-T-5624: Turbine fuel, aviation, (Grade GP5)

3. DISCLAIMERS

Tests marked "Not SANAS" Accredited in this report are not included in the SANAS schedule of accreditation for this laboratory.

Opinions, interpretations and conclusions expressed herein are outside the scope of SANAS accreditation.

1 Dr Lategan Road Groenkloof, Pretoria Private Bag X191 Pretoria 0001, Tel: +27 (012) 428-7911, Fax: +27 (012) 344-1568.

SABS COMMERCIAL (Pty) Ltd

Report No. 2112/N4045

4. Results:

Property	**Sample**	**Requirements of MIL-T-5624**
*Appearance	Clear	**
Viscosity (IP 71), at - 20°C, mm^2/s	4,955	8,5 max
*Distillation (IP 123): b) Temperature, °C for: 10 % $(^v/_v)$ recovery 20 % $(^v/_v)$ recovery 50 % $(^v/_v)$ recovery 90 % $(^v/_v)$ recovery c) Final boiling point, °C d) Residue, % $(^v/_v)$ e) Loss, % $(^v/_v)$	 194,9 193,3 204,0 234,8 265,4 1,0 1,5	 206 max Report Report Report 300 max 1,5 1,5
*Flash point (IP 34), °C	69,0	60 min
*Density at 15 °C (IP 365), kg/l	0,8235	0,788 min
*Freezing point (IP 16), °C	-51,0	- 46 max
Smoke point (IP 57), mm	26	19 min
Copper strip corrosion, 2h at 100 (IP 154), classification	1	1 max
Existent gum (IP 131), mg/100ml	3,7	7,0 max
Water separation (IP 289) a) Interface rating	1b	1b

*SANAS accredited tests.

**Clear, bright and free from solid matter and undissolved water at normal ambient temperature.

CONCLUSION

The sample complied with the requirements of specification MIL-T-5624 in respect of the tests carried out.

S Nzimakwe
Test Officer: Petroleum

C van Wyk
Test Officer: Petroleum

The item(s) in question and the test results do not apply to any similar item that has not been tested. (Refer also to the complete conditions printed on the back of official test reports.)

Appendix B:

Information from Lycoming engine manufacturer

From: Erikson, Gregory [GErikson@lycoming.textron.com]
Sent: 21 July 2008 04:39 PM
To: Andrew Torres
Subject: RE: IO-540-AE1A5

Hello Andrew,

Your request for information has been forwarded to me. In answer to your question I can tell you the engine would run very hot. Depending on what the percentage of Jet A to AVGAS was all surfaces in the combustion area would be either coated with a gray sooty substance or would be void of any soot or combustion deposits. If the percentage of Jet A was high, you could very well see evidence of pre-ignition or detonation on the pistons. We've seen the head are of the pistons severely melted away and the top of the cylinders around the valves smooth and clean. Running an AVGAS engine on Jet A or any jet fuel can cause stretching of the intake valves. You might also see the center electrodes of the spark plugs much thinner than normal as they are melted from the high temps.

Hope this is the information you were looking for. Do you have a serial number for this engine? I'd like to have it for our records. You may reply directly to me.

Gregg Erikson
Manager, Air Safety
Lycoming Engines
630-513-0642, office
630-558-8760, cell
gerikson@lycoming.textron.com

Appendix C:

SACAA Advisory Circular CA AOC-AC-005

Aircraft
Fuel Control
Advisory Circular

Subject: AIRCRAFT FUEL CONTROL CA AOC-AC-005
Date: 01/05/2008

1. PURPOSE.
This Advisory Circular alerts the aviation community to the potential hazards of inadvertent mixing or contamination of turbine and piston fuels, and provides recommended fuel control and servicing procedures.

2. REFERENCES.
For more detail than is contained herein, see American Petroleum Institute Bulletins, Numbers 1523 Fourth Edition, 1542 Second Edition, 1581 First Edition, and the National Fire Protection Association Pamphlet "Aircraft Fuel Servicing 1975" and the American Society for Testing and Materials, "Standard Specification for Aviation Gasolines, D 910-75."

3. BACKGROUND.
Since the introduction of jet aircraft fuel, there have been several instances of inadvertent fuelling of piston-powered aircraft with jet fuel. Aviation fuel can only serve its ultimate purpose when the proper fuel is delivered into the aircraft as free from contamination as it was the day it left the refinery. Unless care and attention are given to its handling, servicing, and storage, the many precautions taken in its manufacture and transportation are wasted. Close attention to compatibility of fuel and aircraft as well as faithful adherence to good housekeeping practices, is necessary to prevent possible disaster as well as costly contamination. A review of accidents attributed to fuel problems reveals that many power failures were due to use of improper fuel or careless servicing – fuelling aircraft from poorly filtered tanks, particularly small tanks or drums, improper mixing of fuel additives, improper pre-flight action by the pilot, and storing aircraft with partially filled tanks, etc., which invites condensation and contamination of the fuel. It is well to remember that the consequences of using leaded gasoline in jet engines can be as damaging as the use of jet fuel in reciprocating engines.

4. TURBINE (JET) FUEL VERSUS GASOLINE.
Investigation of a malfunctioning reciprocating engine disclosed that it had been inadvertently serviced with jet fuel. Examination of this engine revealed extensive cylinder assembly damage that required complete overhaul. Proper attention to refueling would have prevented this damage. Frequency of improper fuelling will diminish if owners, operators, and personnel servicing aircraft maintain vigilance. Should the occasion arise where the tanks in an aircraft are accidentally filled with jet fuel, it is suggested the following procedures be followed:

a. If the engines were not operated subsequent to the refueling with jet fuel, drain the fuel tanks, lines, and system completely. Refill the tanks with the proper grade of aviation gasoline, and run the engines for approximately five minutes.

b. If the engines were operated subsequent to the refueling with jet fuel, investigate any abnormal engine operating conditions such as those related to the fuel mixture and cylinder operating temperatures. In addition, accomplish the following:

(1) Perform a compression test of all cylinders.
(2) Completely borescope inspect the interior of cylinders, giving special attention to the combustion chamber and the piston dome.
(3) Drain the engine oil and check the oil screens.

***NOTE**: When accomplishing (1), (2), and (3), further investigate and correct any unsatisfactory condition found.*

(4) Completely drain the fuel tanks and the entire fuel system including the engine carburetor.
(5) Flush the fuel system and carburetor with gasoline and check for leaks.
(6) Fill the fuel tanks with the proper grade of aviation gasoline.
(7) If the engine inspection was satisfactory, complete an engine run up check.

5. AVIATION GASOLINE GRADES AND COLOUR CODES.

Pilots and refueling personnel should be familiar with aviation gasoline (avgas) grades and respective colour codes in order to assure proper servicing of engines. Three grades of avgas are now produced for civil use; grades 80, 100LL (low lead) and 100. These grades replace 80/87, 91/96, 100/130, and 115/145 avgas.

a. The Standard Specification for Aviation Gasolines, Specification D 910-75, developed by the American Society for Testing and Materials, established that grade 80 should be red in colour and contain 0.5 milliliters (ml.) maximum of tetraethyl lead per gallon. Grade 100LL is blue in colour and contains 2.0 ml. maximum per gallon. Grade 100 is green in colour and contains 3.0 ml. maximum per gallon (with a probable increase to 4.0 ml. maximum per gallon in the next specification revision). The lead quantity or concentration of lead in aviation gasoline is expressed in terms of milliliters (1/1000 of a liter) per gallon of avgas.

Grades 100LL and 100 represent two aviation gasolines that are identical in antiknock quality but differ in maximum lead content and colour. The colour identifies the difference for those engines that have a low tolerance to lead.

b. Continuous use of higher lead fuels in low compression engines designed for low lead fuels can cause erosion or necking of the exhaust valve stems and spark plug lead fouling.

6. MARKING.

a. Aircraft fuel filler openings should be marked to show the word "FUEL" and the minimum fuel grade or designation for the engines. In order that these markings retain their effectiveness, washing and occasional painting will be necessary toretain clear legibility.

b. It is equally important that tank vehicles be most conspicuously marked to show the type of fuel carried. It is suggested that the marking be of a colour in sharp contrast to that of the vehicle and in lettering at least 12 inches tall. This marking should be on each side and on the rear of the tank vehicles. Additionally, it is suggested that the tank vehicle hose lines be marked by labels next to the nozzle and every six feet. The label lettering should be at least 3/4 inches in height, be of sharp colour contrast, be permanently attached, and indicate the type of fuel dispersed by that hose. A further suggestion is that the refueling nozzles be conspicuously marked with the appropriate colour code. This is especially important in that the person doing the refueling will have the colour coded nozzle in his hands during the process with an additional reminder of the fuel type being dispensed. All of the aforementioned markings should be kept clean, fresh, and clearly legible at all times.

7. TRAINING.

Careful instructions in operating procedures should be given to all personnel involved in fuelling. This applies to flight as well as ground personnel. The ground personnel should be thoroughly indoctrinated in the facilities, procedures, equipment, and the types of fuel being dispensed - the flight personnel in procedures and marking with particular emphasis on use of the proper type of fuel. It is further suggested that all personnel be retrained periodically with suitable records maintained to reflect the training. Only trained competent personnel should perform fuel servicing.

8. FUEL CONTAMINATION

Fuel is contaminated when it contains any material that was not provided under the fuel specification. This material generally consists of water, rust, sand, dust, microbial growth, and certain additives that are not compatible with the fuel, fuel system materials and engines.

9. CAUSES OF FUEL CONTAMINATION?

a. Water. All aviation fuels absorb moisture from the air and contain water in both suspended particle and liquid form. The amount of suspended particles varies with the temperature of the fuel. Whenever the temperature of the fuel is decreased, some of the suspended particles are drawn out of the solution and slowly fall to the bottom of the tank. Whenever the temperature of the fuel increases, water is drawn from the atmosphere to maintain a saturated solution. Changes in fuel temperature, therefore, result in a continuous accumulation of water. During freezing temperatures, this water may turn to ice, restricting or stopping fuel flow.

b. Rust. Pipelines, storage tanks, fuel trucks, and drum containers tend to produce rust that can be carried in the fuel in small size particles. A high degree of filtration is required to remove the liquid water and rust particles from the fuel.

c. Dust and sand. The fuel may be contaminated with dust and sand through openings in tanks and from the use of fuel handling equipment that is not clean.

d. Microorganisms. Many types of microbes have been found in unleaded fuels, particularly in the turbine engine fuels. The microbes, which may come from the atmosphere or storage tanks, live at the interface between the fuel and liquid water in the tank. These microorganisms of bacteria and fungi rapidly multiply and cause serious corrosion in tanks and may clog filters, screens, and fuel metering equipment. The growth and corrosion are particularly serious in the presence of other forms of contamination.

e. Additives. Certain oil companies, in developing products to cope with aircraft fuel icing problems, found that their products also checked "bug" growth. These products, known as "biocides," are usually referred to as additives. Some additives may not be compatible with the fuel or the materials in the fuel system and may be harmful to other parts of the engine with which they come in contact. Additives that have not been approved by the manufacturer and FAA should not be used.

10. FIELD TESTS.

Three gallons of water were added to the half full fuel tank of a popular make, high wing monoplane. After several minutes, the fuel strainer (gascolator) was checked for water. It was necessary to drain ten liquid ounces of fuel before any water appeared. This is considerably more than most pilots drain when checking for water. In another test, simulating a tricycle geared model, one gallon of water was added to the half-full fuel tank. It was necessary to drain more than a quart of fuel before any water appeared. In both of these tests, about nine ounces of water remained in the fuel tank after the belly drain and the fuel strainer (gascolator) had ceased to show any trace of water. This residual water could only be removed by draining the tank sumps.

11. CONTAMINATION CONTROL.

The presence of any contamination in fuel systems is dangerous. Laboratory and field tests have demonstrated that when water was introduced into the gasoline tank, it immediately settled to the bottom. Fuel tanks are constructed with sumps to trap this water. It is practically impossible to drain all water from the tanks through the fuel lines, so it becomes necessary to regularly drain the fuel sumps in order to remove all water from the system. It may be necessary to gently rock the wings of some aircraft while draining the sumps to completely drain all the water. On certain tail wheel type aircraft, raising the tail to level flight attitude may result in additional flow of water to the gascolator or main fuel strainer. If left undrained, the water accumulates and will pass through the fuel line to the engine and may cause the engine to stop operating. The elimination of contaminants from aviation fuel may not be entirely possible, but we can control it by the application of good housekeeping habits.

a. Servicing.
Storage and dispensing equipment should be kept clean at all times - free from dirt and other foreign matter. Fuel having a "cloudy" appearance or definitely "off colour" should be suspected of contamination or deterioration and should not be used. When additives are used, it is important that they are dispensed in accordance with the aircraft manufacturer's instructions. Refueling from drums or cans should be considered as an unsatisfactory operation and one to be avoided whenever possible. All containers of this type are to be regarded with suspicion and the contents carefully inspected, identified, and checked for water and other contamination. Extraordinary precautions are necessary to eliminate the hazards of water and sediment. It is advisable when fuelling from drums to use a 5 micron filtered portable pumping unit, or the best filtering equipment available locally, or, as a last resort, a chamois skin filter and filter funnel. Infrequently used fuel tanks should have their sumps drained before filling. Agitation action of fuel entering the tank may suspend or entrain liquid water or othercontaminants - which can remain suspended for many minutes and may not settle out until after the aircraft is airborne.

b. Preflight action.
Drain a generous sample of fuel - considerably more than just a trickle - into a transparent container from each of the fuel sumps and from the main fuel strainer or gascolator. (Remember that it was necessary to drain ten ounces in the field tests.) On certain aircraft having fuel tanks located in each wing, positioning of the fuel tank selector valve to the "BOTH ON" position may not adequately drain the system. This is due to the fuel taking the path of least resistance. In this case, the fuel selector valve should be positioned at each tank in turn. Examine the fuel samples for water and dirt contamination. If present, it will collect at the bottom of the container and should be easily detected. Continue to drain fuel from the contaminated sump until certain the system is clear of all water and dirt. "The use of quick drain valves in the sumps and gascolator makes it practical to keep tanks free of significant quantities of water and other contaminants."

c. Post flight.
An effective method to prevent contamination from condensation would be to completely fill the fuel tank at the end of each day's flying. This procedure is practical only on a few types of light aircraft. Generally, the type of aircraft, length of proposed flight, number of passengers and weight and balance limitations dictate the amount of fuel to be added.

d. Routine maintenance.
In addition to the preflight and post flight actions, certain precautionary or routine maintenance should be performed on the aircraft at periodic intervals. These precautions include the inspection and cleaning of pertinent fuel tank outlet finger strainers and carburetor screens (filters), and flushing of the carburetor bowl.

12. JET FUELS.
Turbine powered aircraft, better known as "jet" or "prop jet," generally use a wide cut gasoline or aviation kerosene as fuel. Basically, the same rules and precautions in handling aviation gasoline apply to the jet fuels. As with gasoline, we are concerned with the matter of cleanliness. Turbine fuels are more dense and have a greater viscosity (resistance to flow) than gasoline. It will hold and retain in suspension impurities such as water, fine particles of rust, and other foreign material. These particles can take from five to ten times as long, or even longer, to settle in kerosene as it does for them to settle in gasoline. Turbine engine fuel controls and pumps are generally more sensitive than the fuel systems of the piston engine. Their fuel feed and pumping systems must work harder. Tolerances are closer and fuel pressures higher. Fine contaminants may block fuel supply systems and erode critical parts of engine and fuel control systems. Water freezing at high altitudes may plug fuel screens. Because of these, the tolerable contamination levels for jet fuels are much lower than previously considered necessary for aviation gasoline. Even with the same contamination levels, the greater volume of fuel used by turbines results in greater amounts of contaminants being deposited in the turbine engine system.

a. Test for contamination. Commercial products to test for fuel contamination are available. Here is a simple test to detect contamination of jet fuel. This procedure has proved to be both effective and inexpensive.

- Obtain an unchipped, clean, white enamel bucket (approximately ten quart size).
- Drain about four to five inches of fuel, from the sump to be tested, into the bucket.
- With a clean mixing paddle, stir the fuel into a swirling "tornado shaped" cone. Remove paddle. As the swirling stops, the solid contaminants will gather at the centre of the bucket bottom.
- Add several drops of household red food dye. The dye will mix with water and the solids in the bottom of the bucket. It will not mix with fuel. If no water is present, the dye will settle in the bottom of the bucket.

13. CONTAMINATED FUEL.

Normally, upon finding that water or other foreign matter contaminates your fuel, the procedures noted under paragraph 12, Contamination Control, should suffice. Should contamination persist, or if there is any doubt about it, the aircraft fuel system must inspected by a qualified person.

14. SUMMARY.

- Turbine fuels for turbine engines - gasoline of the proper grade for reciprocating engines.
- Use only the fuel recommended by the engine and aircraft manufacturer.
- Don't use additives that have not been approved by CAA.
- If feasible, keep fuel tanks full. Water condenses on the walls of partially filled tanks and enters the fuel system.
- Filter all fuel entering the tank.
- Drain fuel sumps regularly.
- Periodically inspect and clean all fuel strainers (screens) and occasionally flush the carburetor bowl as recommended by the aircraft manufacturer. The best insurance against fuel problems - whether aviation gasoline or jet fuel - is to practice good housekeeping in your routine maintenance and be constantly alert.