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GABINETE DE PREVENÇÃO E INVESTIGAÇÃO DE ACIDENTES COM AERONAVES

FINAL ACCIDENT REPORT

AERO CLUBE DE PORTUGAL

TECNAM P-96 GOLF

CS - UOO

Praia da Aguda

Fontanelas

SINTRA

December, the 15th, 2010

GPIAA

Homologo, nos termos do nº 3 do artº 26º do D. L. 318/99, de 11 de Agosto de 1999

29.MAY.2013

O Director,

Fernando Ferreira dos Reis

FINAL ACCIDENT REPORT Nr. 19/ACCID/2010

NOTES

In accordance with Annex 13 to the Convention on International Civil Aviation Organization, Chicago 1944, with European Parliament & Council Regulation nr 996/2010, from 20/10/2010, and nr 3 of art 11th of Decree Law Nr 318/99, from 11th of August, the investigation, analysis, conclusions and recommendations of this report are not intended to apportion blame or liability but, and only, to determine the causes of such accident and formulate recommendations that may prevent its repetition and to spread the lessons retrieved and capable of prevent futures accidents.

GPIAA has been notified of this accident by 15:45, that day.

Investigator on duty, Artur Pereira, was appointed as Investigator In Charge (IIC) by GPIAA Director, as per art. 12º, nº 1 of Decree-Law Nº 318/99, from August 11th and travelled immediately to the accident site, starting the investigation process.

Once this Investigator terminated his office performance on 01-01-2011, the investigation passed to Investigator Fernando Lourenço, as IIC, until he left the office on 01-01-2012, being, then, the Investigator Antonio Alves appointed as IIC.

This Final Report represents the summation of all the investigation efforts developed by the successive IICs who managed this investigation process.

This report has been released in Portuguese and English Languages. In case of conflict, Portuguese version will take precedence.

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SYNOPSIS

On the 15th of December, 2010, by 15H10 UTC[1], Tecnam P-96 Golf, s/n 285, registration CS-UOO ultralight aircraft took-off from Cascais Municipal Aerodrome (LPCS) for a leisure flight, towards North, expecting to perform a touch-and-go at Tojeira airfield (Fontanelas, Sintra). On board there were two male persons, the pilot and a passenger.

By 15:22, in radio contact with Air Force Base Nr. 1 (Sintra) Approach Control and monitored by Flight Information Service (FIS) radar (Lisbon Military), the pilot made a *Mayday … Mayday … Mayday …* call declaring he got a total engine failure and he couldn't reach Tojeira airfield. Asked about his real position, the pilot requested to attend for his confirmation, but he contacted Sintra Air Base controller never again.

Meanwhile, by 15:26, a training flight crew, flying in that area, reported the sight of a crashed aircraft on Aguda beach.

As a consequence of the accident the passenger died and the pilot suffered serious injuries, being transported to hospital by helicopter. The aircraft became damaged beyond repair and was considered destroyed.

On site appeared Colares Fire Brigade (BVC) Maritime Police (PM) officials and a Medical Emergency National Institute (INEM) team.

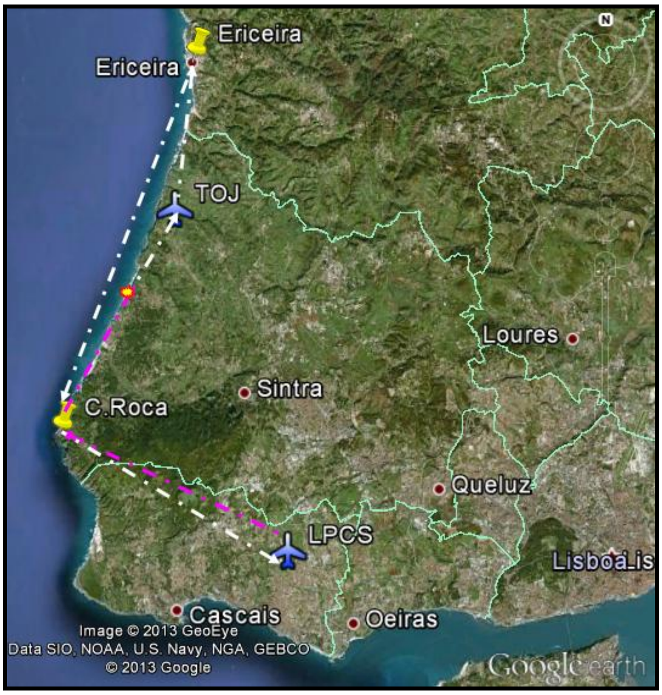
[1] - All times referred in this report, except other information, are UTC times (Universal Coordinated Time). On that date, local time, in Portugal mainland, was equal to UTC time.

1. FACTUAL INFORMATION

1.1 History of the Flight

On the 15th of December, 2010, an ultralight aircraft model Tecnam P-96 Golf, with s/n 285 and Portuguese registration CS-UOO, took-off from Cascais Municipal Aerodrome (LPCS) at 15:11. On board there were two people performing a leisure flight, at 1500ft altitude, flying North of the aerodrome, to Roca Cape, Tojeira airfield (for a touch-and-go landing), Ericeira and back, by Roca Cape, to LPCS (*picture nr 1*).

Estimated time for this trip was 1:15, with the aircraft carrying fuel enough for an endurance of 3:00 and having a call sign **CLP357** (*Charlie-Lima-Papa-Three-Five-Seven*). Flight Information Service (FIS) attributed the code **3236**, which was introduced in onboard transponder. The aircraft passed Roca Cape at 1000ft (AMSL) and was transferred to Sintra Air Base Approach Control (APP), being the pilot instructed to report Ericeira and, on pilot request, cleared to climb to 1500ft towards Tojeira airfield, for a touch-and go landing.



Picture Nr 1

At 15:22, the pilot broadcasted *Mayday* … *Mayday … Mayday …,* maintaining communications with Sintra APP for 49 seconds and informing that the engine had stopped and he couldn't reach Tojeira airfield for a powerless landing. Answering the APP request to precise his real position, the pilot asked to stand-by on frequency but he never more contacted with APP. An alert was issued and requested the cooperation of all other aircrafts flying in the area. Aircraft with call sign WEY308 reported there was an aircraft on Aguda beach, upside-down and two people in its proximity.

In fact, near the accident site, there was a couple walking on the beach, a surfer and a sport fisherman, that run to give assistance. Those testimonies declared the aeroplane approached seaside, coming from the sea, turned right heading South and touched down at the middle of the beach, on three wheels. It jumped about 5m high and continued flying towards the end of the sand stripe, where, being some rocks protruding there, it touched the ground again and jumped, turning to the right, into the sea. When the aircraft collided with the water, it nosed over and remained afloat about 15m far from wave breaking point, swinging according seasaw motion.

Three of those testimonies tried to drag the aircraft to the shore, into the dry sand zone, pulling through the tail and left-hand flap (*picture nr 2*).

Picture Nr 2

Due the great opposition to the movement, not only by wave reflux but the sand load that entered the cabin (aircraft upside-down and splinted canopy), they were not succeeded in removing the aircraft and freeing the occupants, which could be done only after the arrival of Colares Fire Department (BVC) life saving team, warned by one passer-by that saw the accident.

The victims were then freed from aircraft cabin and life recovery techniques were applied by BVC first-aid assistants, to which the pilot only reacted positively, being later transported to hospital by helicopter. The passenger was declared dead on site by a doctor from Medical Emergency National Institute (INEM) present on the scene.

1.2 Injuries to Persons

The passenger was declared dead on site while the pilot suffered serious injuries and was transported to hospital by helicopter.

Injuries	Crew	Passengers	Others
Fatal	0	1	0
Serious	1	0	0
Light/None	0	0	0

Table Nr 1

1.3 Damage to Aircraft

The aircraft impacted directly with the sand and sea waves, which caused substantial damage to its structure, namely the cabin and fuselage, wings, horizontal & vertical stabilizers, propeller, engine & engine mountings and cowlings (*picture nr 3*). When removing it from the sea and pulling it to a recoverable place, more damage was caused and the aircraft became destroyed.

Picture Nr 3

1.4 Other Damage

There is no third part damage reported.

1.5 Personnel

There were two people on board the aircraft, the pilot and a passenger, with following references:

1.5.1 Pilot

Male, 20years old, Portuguese nationality, the pilot was an Aeroplane Commercial Pilot License (CPL(A)) holder, issued by Portuguese Civil Aviation Authority (INAC) on 28-01-2010, with Single Engine Propeller (SEP), Instrument Flying (IR) and Flight Instructor (FI) qualifications. Under the cover of this License a Sport Pilot License (PU) was issued, on 07-10-2010, valid for Multi-Axe, Advanced, Group 3 (MEA-G3) ultra light aircrafts piloting. Both licences were valid at the time of the accident.

Pilot's Flight Logbook showed the following flight experience, at the date of the accident (*table nr 2*):

Flight Experience (hours):	GA Aircrafts	Ultra Light Aircrafts
Total:	449:35	04:10
Last 90 days:	48:10	02:05
Last 28 days:	15:05	01:25
Last week:	05:25	01:25
Last 24 hours:	01:25	00:25

Table Nr 2

On Ultra Light aircrafts, the pilot had only two training sorties, on a 02:00 total flight time, on the 5th and the 6th of September, 2010 (just before his License was issued), flying again, this time as instructor pilot, on days 08, 11, 13 & 14 of December, 2010.

His last medical examination was on 24-02-2010 and he got a class 1 rating with the limitation to use corrective lenses and carry a spare pair of spectacles (VDL).

1.5.2 Passenger

Male, 22 years old, Portuguese nationality, the passenger was also a pilot, holding an Aeroplane Private Pilot License (PPL(A)), issued on 05-11-2010 by INAC, with an accumulated flight experience of 45:00, with the restriction to fly only under Visual Conditions (VFR), by day, on Single Engine Propeller Aircrafts (SEP).

No evidence was found suggesting he was operating the aircraft flight controls at any phase of the flight.

1.6 Aircraft

1.6.1 General

The aircraft, manufactured by Tecnam, model P-96 Golf (*Picture nr 4*), is a single engine, single low wing and fixed tricycle landing gear, with two seats and a Maximum Take-Off Mass (MTOM) of 450kg (Ultra Light Advanced Multi-Axe, Group 3 aeroplane). Its cockpit accommodates two seats, side by side, and is covered by an acrylic canopy that slides rearwards to give access to the occupants.

Figura Nº 4

Aircraft s/n 285, with registration CS-UOO, belonged to Portugal Flying Club (AeCP) and presented the following references (*table nr 3*):

Reference	Airframe	Engine	Propeller
Manufacturer:	Tecnam	BRP-Powertrain GmbH	GT Propellers
Model:	P96 Golf	Rotax 912ULS	GT-2 166/146
Serial Nr:	285	5646121	GT-2/173/VRR-FW101SRTC
Year of manufacture:	2006	2006	2006
Flight Time (TSN):	996:00	996:00	996:00
Last Inspection Date:	25-11-2010	25-11-2010	25-11-2010

Table Nr 3

1.6.2 Mass & Balance

The aircraft was on its normal configuration and carrying two male people on board, having been refuelled with 40litres of AVGAS 100LL, which totalized a Take-Off Mass of 456kg (*table nr 4*), slightly above maximum allowed by legislation (450kg) and by Flight Certificate issued by INAC (358kg).

Reference	**Mass** (kg)
Aircraft empty	280
Fuel	026
People on board	150
Total	**456**

Table Nr 4

By design and in accordance with manufacturer certification, the aircraft was able to take-off with a Maximum Take-Off Mass of 550kg (MTOM) and comply with all indicated performance specifications.

Considering that the seats and fuel tanks were positioned close to Centre of Gravity localization, aircraft balance was not significantly affected by mass values indicated on table nr 4, which means the Centre of Gravity, at take-off, was well inside allowed take-off envelope, bringing no controllability constraints.

1.6.3 Engine

1.6.3.1 Description

Figura Nº 5

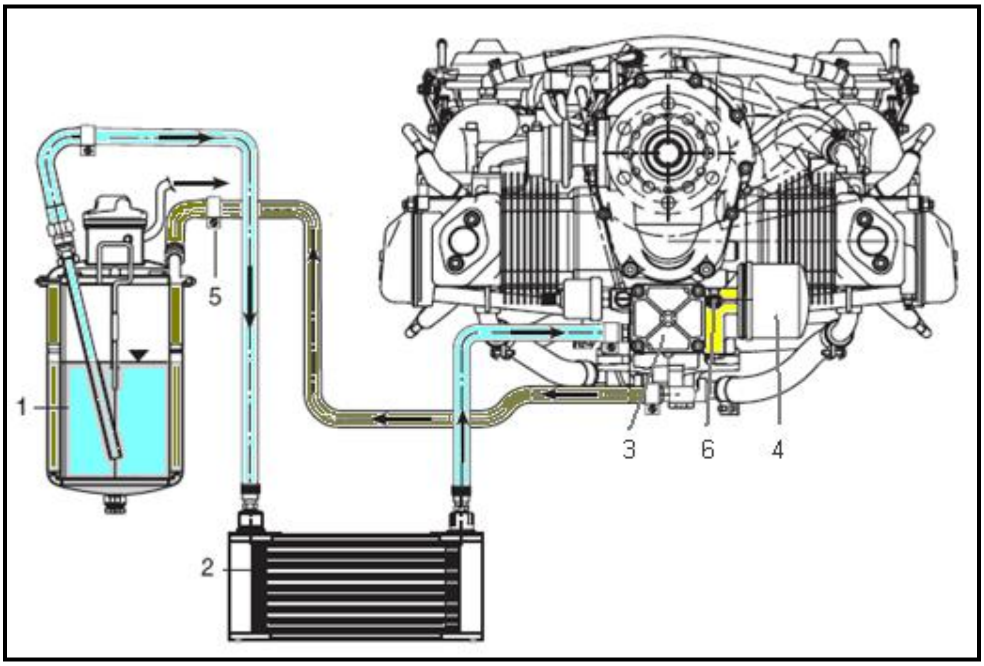
Rotax 912ULS engine (*picture nr 5*), equipping the aircraft, was manufactured by Austrian Enterprise BRP Rotax GmbH & Co. KG and it was a four stoke, four cylinder horizontally opposed, spark ignition engine with a nominal power output of 73,5KW (100HP) at 5800RPM at sea level standard conditions, coupled to a two blade wood propeller, through a reduction gear box with integrated shock absorber and overload clutch.

On its standard version the engine main features are:

- Four cylinders horizontally opposed, ram air cooled, with liquid cooled cylinder heads, central camshaft, push rods and OverHeadValve (OHV) command;
- Two magnets with dual breakerless capacitator discharge ignition;
- Two constant depression carburettors and one mechanical fuel pump;
- Electric starter motor (12V 0.7Kw);
- AC generator with external rectifier-regulator (12V 20A DC);
- Dry sump forced lubrication system with mechanical oil pump.

1.6.3.2 Lubrication System

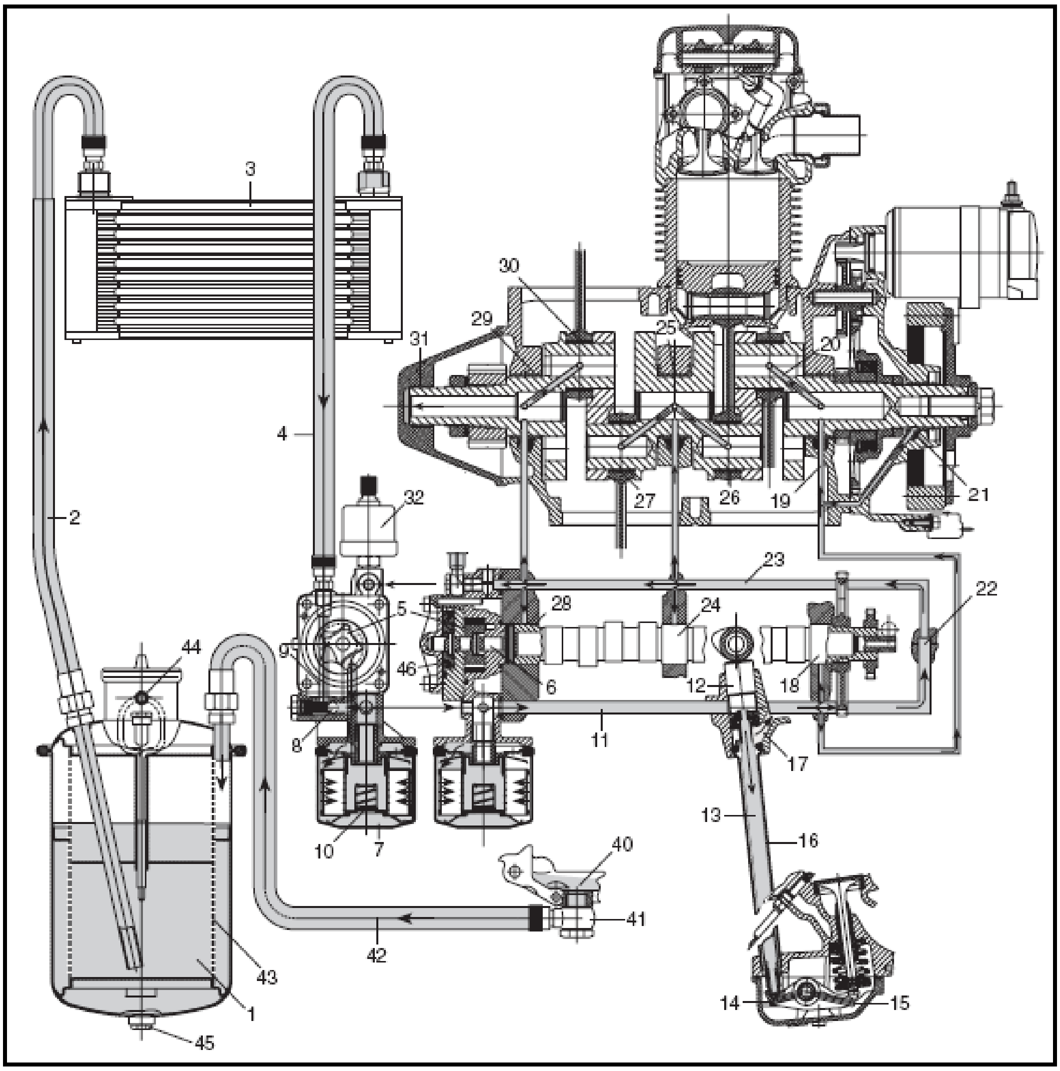
Rotax 912 engine lubrication system (*Picture nr 6*) is a forced one and comprises one oil tank (1), one radiator (2), one oil pump with incorporated pressure regulator (3) and an oil filter (4).



Picture Nr 6

In addition to pressure regulator, the system is protected by a ventilation bore (5) on top of oil tank and a temperature sensor (6) on oil pump flange. Oil pump is mechanically driven by camshaft.

To understand better the oil flow inside the engine, let's follow Rotax 912 Maintenance Manual diagram (*picture nr 7*) and description.



Picture Nr 7

Oil pump sucks the engine oil out of the oil tank (1) via line (2). The oil passes through the oil cooler (3) fitted on the suction side via the oil line (4) to the oil pump rotor (5), which is driven by the oil pump shaft (6). The pump forces the oil through the filter mat from the outside to the inside of the oil filter (7). The oil pressure from 1.5 to 5 bar (22 to 72 psi) is controlled by the pressure relief valve (8). The surplus oil returns to the oil pump rotor via the channel (9).

If the filter mat in the oil filter is completely clogged up, the pressure relief valve (10) will open and lube oil will flow unfiltered to the individual lubrication points.

The oil will then be pumped through the oil duct (11) in the left side of the housing. The four hydraulic valve tappets (12) for cylinders 2 & 4 are supplied with oil via this channel. Oil flows *to the rocker arm bearing via the hollow push-rod (13) and the oil duct (14). The oil emerging from bore (15) lubricates the valve mechanism and flows through the oil return line (16), into the channel (17) and back to the crankcase.*

Forced oil supply from oil duct (11) is also supplied to camshaft bearing (18) CC23, main bearing (19) CC13, the conrod bearing (20) of cylinder 4 and the bronze bush (21) of the backing bearing IH01 in the ignition housing.

In the crankcase sealing surface (22), the oil enters the right crankcase half. As a result, the camshaft bearing (24) CC22, the middle main bearing (25) CC12 and the two conrod bearings (26) and (27) of cylinders 3 & 2 are lubricated via the oil duct (23). This oil duct supplies the hydraulic valve tappets and the valve mechanism of cylinders 1 & 3.

The forced oil supply then reaches the camshaft bearing (28) CC21, the main bearing (29) CC11, the conrod bearing (30) of cylinder 1 and the backing bearing (31) GB01 in the gearbox housing. The electrical connection of the oil pressure gauge is at the oil pressure sensor (32).

The engine oil emerging from all lubrication points flows to the bottom of the crankcase (40) and is pressed back into the oil tank by the crankcase gases (blow-by gases) via the ring hose nipple (41) and the oil return line (42). The tangential feed of the returned oil effects separation of oil from air via the screen (43). As a result, the intake system (2) is supplied with oil which is to a large extent free of air.

The oil tank is vented via the connection (44) in the intake filter into a suitable receptacle or to the outside. The oil is drained by removing drain plug (45) in the bottom of oil tank.

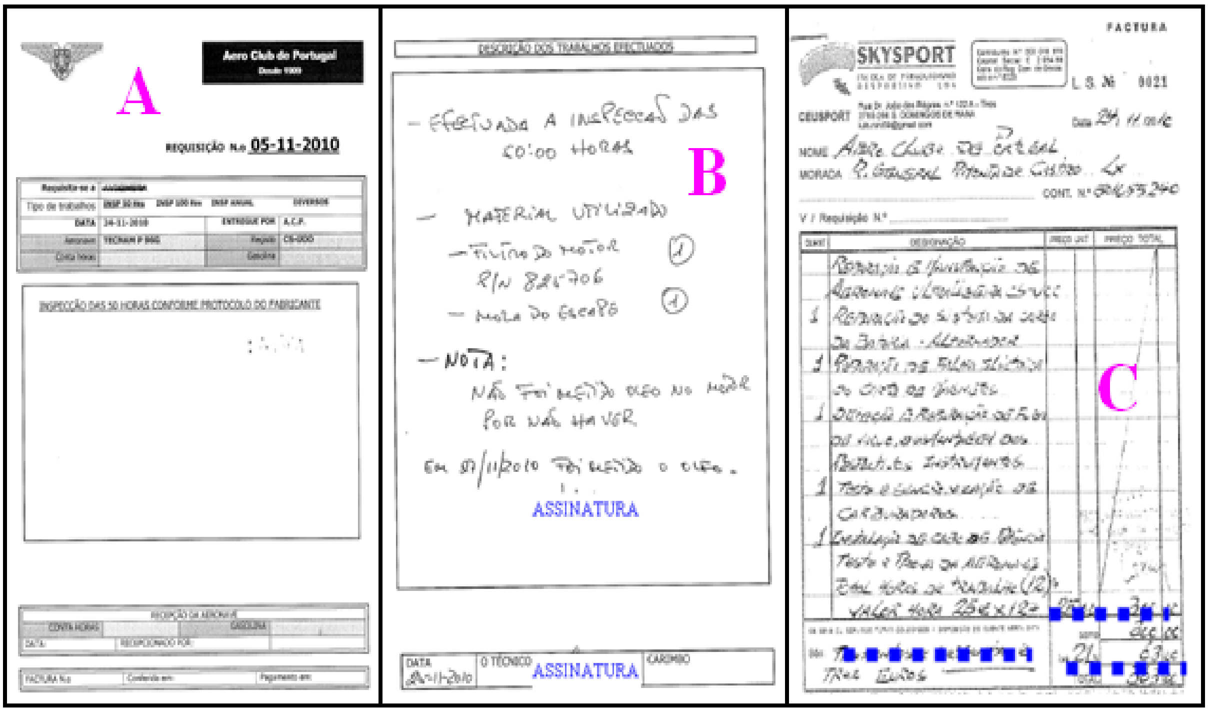
1.6.3.3 Maintenance

Engine Maintenance Manual, issued by manufacturer, specifies schedule inspections to be performed for every 50 hours intervals, with o tolerance of ± 10 hours, which are designated as 50, 100, 200 and 600 hour inspection. For new or overhauled engines an inspection after the first 25 hours of operation is recommended. After 1500 hours or 12 years of operation an engine overhaul must be performed. For every one of those inspection there are some works to be done, which are referred on respective inspection checklist.

All engine inspections and other maintenance works shall be registered on Engine Technical Log. In accordance with national regulation, maintenance works on this kind of aircraft (ULM) is not mandatory to be executed by certified personnel, being the pilot himself or someone on his behalf allowed to perform those actions.

Checking all available documents, a copy of Engine Technical Log was not found, neither any inspection checklist or working order, but only some hand written documents, confirming that a 50 hours inspection has been carried out on the 24^{th} and 25^{th} of November, 2010. Even so, these documents showed some disparity, which were not clarified, namely:

1. A 50 hours inspection was requested to a certified maintenance organization (*picture nr 8-A*) on 24-11-2010;
2. An inspection performed declaration was made (*picture nr 8-B*), apparently on the same request form, without authentication of technician performing the task;
3. There’s an invoice of another entity (*picture nr 8-C*), referring some repairs done on that engine, on same date.



Picture Nr 8

Mentioned repairs relate to alternator regulation, carburettors’ tuning, magnetos and ignition cables repair followed by engine ground test running.

Being not available, on inspection date (25-11-2010), engine oil was changed only two day later, using customary oil – “***CEPSA MOTO 4T RUTA 66 SINTÉTICO 10W-50***”, a 100% synthetic, super multigrade oil for 4 stroke, multivalve engines, specially recommended for sport and competition motorcycles. Engine manufacturer, on its Engine Maintenance Manual and Service Instruction SI-912-16R3, dated Jul 2010, recommended regular use of “***AEROSHELL SPORT PLUS 4***” lubrication oil.

Gathered information confirmed the operator used to run the engine on lead fuel AVGAS 100LL, instead of lead free or low lead content fuel, like MOGAS. In this case, it was recommended to change engine lubrication oil and oil filter more often, ideally at 25 hours intervals, instead of 50 hours periods, as it was routine when using low lead content or lead free fuel.

Being received by the operator (AeCP) on 13-01-2009, scheduled maintenance inspections carried out on this aircraft, as per information received, were performed according the calendar presented on table nr 5, bellow.

Inspection Type	Date	Engine Time
500 Hours	12-07-2008	510:05
050 "	11-02-2009	572:00
100 "	28-04-2009	624:00
050 "	11-07-2009	674:30
100 "	14-09-2009	696:00
050 "	14-12-2009	744:00
100 "	31-03-2010	826:05
050 "	14-06-2010	882:10
100 "	30-07-2010	918:10
050 "	25-11-2010	987:30

Table Nr 5

1.7 Meteorological

That day the sky was clear, with an Easterly moderate to strong winds (12kt, gusting 25kt), during the morning and noon, changing to North-Easterly moderate wind (12kt) in the afternoon, without gust. Air temperature was normal for that season (12ºC), with a 0ºC dew point, 50% humidity and high barometric pressure of 1023hPa.

Blowing from inland to the sea, the wind could originate some instability when passing shore line with high cliffs, creating turbulence and strong down drafts with windshear.

Meteorological observations registered that day at Sintra, Air Base Nr 1 Meteo Station, presented the following readings:

METAR LPST 151300Z 07013G23KT CAVOK 12/M01 Q1024
METAR LPST 151400Z 07012G22KT CAVOK 13/00 Q1023
METAR LPST 151600Z 06012KT CAVOK 12/01 Q1023
METAR LPST 151700Z 05011KT CAVOK 11/01 Q1024

1.8 Aids to Navigation

It was a VFR leisure flight in a well known region for the pilot and it was not expected to use radio navigation aids for the flight. Anyway, in accordance with NOTAMs and other information, all NAVAIDS in the area were operating properly and without limitations.

1.9 Communications

The aircraft was equipped with two-way radio communications on VHF and ATC Transponder. The pilot had normal communications with ATC controllers from Cascais aerodrome (Ground, Tower & Approach), with Flight Information Service (FIS) and with military controller on Air Base Nr 1 Approach Control (APP STR).

A transponder code has been issued and introduced on aircraft transponder (3236), allowing flight identification and radar tracking until it was lost, after engine failure. Last radar shot was registered at 15:21:00.

Pilot reported engine lost at 15:22 to Sintra Air Base Approach Control (APP STR) and stop communications at 15:23, without answer to any subsequent call. No further transmission from the aircraft was received by any other station or on emergency frequency (121:50mHz).

1.10 Accident Site

The accident occurred at Aguda Beach, near Fontanelas, Sintra, a narrow sand stripe with variable dimensions, according sea tide, from 800m to 430m long and 50m to 15m width, along a high cliff (20m < 40m) and located about 550m from the vertical of engine failure aircraft position (*picture nr 9*).

Picture Nr 9

Beach surface has a great slope towards the sea and there's a rocky soil at its southern extremity, with stratified layers, forming a flight of stairs of 60cm high steps into the sea, which becomes underwater with flood tide but was partially visible when the accident happened.

1.11 Flight Recorders

The aircraft was not equipped with any kind of flight recorder, which was not mandatory for this type of aircraft and operation.

1.12 Wreckage & Impact

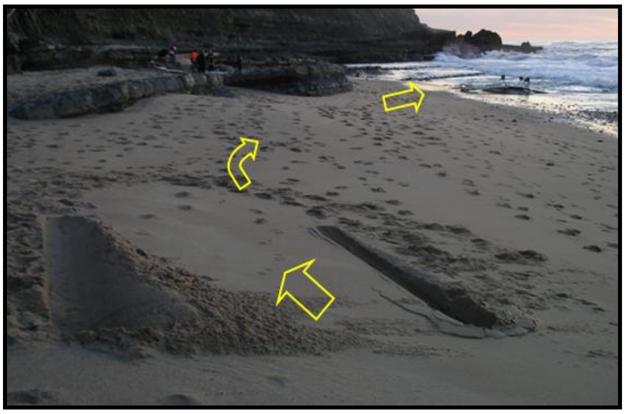
1.12.1 Impacts

The aircraft approached the beach from West (from the sea), on a right turn, trying to land on a southerly direction (*picture nr 9*).

First ground impact was more or less at mid-point of the sand stripe, on a three-point position (on three wheels), leaving three 5m long marks on the soil (*picture nr 10*).

Coming at high speed, the aircraft jumped to the air and flew about 250m prior to touch down again, this time on main wheels only (*picture nr 11*).

Picture Nr 10



Picture Nr 11

At this time we may notice the right wing was slightly down (*deep mark of right wheel*), in an effort to avoid the rocks and starting a deviation to the right towards the sea, the waves breakout area. With landing gear restrained by the water and the waves hitting the aircraft nose, the aircraft capsized and rested on an upside-down position, with nose pointing ashore.

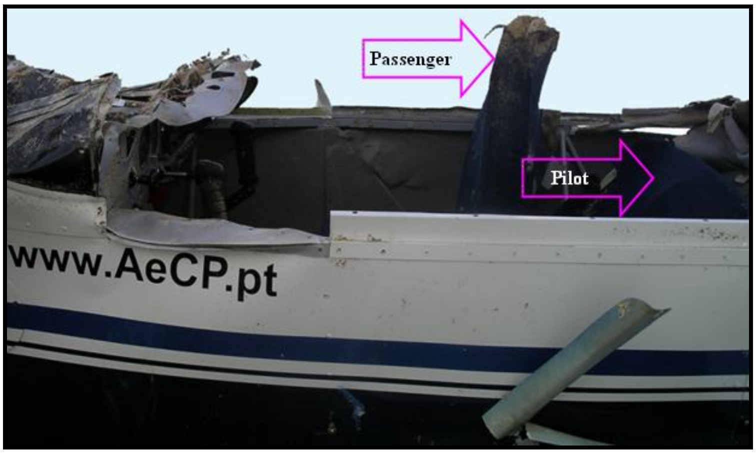
Sea waves movement (*flooding tide*) forced the aircraft to whirl (*weather vane effect*) placing it with tail pointing ashore, while the cabin top was dragged along the seabed, breaking-off and letting the sand go inside the cabin.

1.12.2 Wreckage

After nose over, the aircraft was still intact. When IIC arrived at the scene, he found the flap surfaces and vertical fin detached, torn away by people and fire fighters that tried to pull the aircraft out of the water.

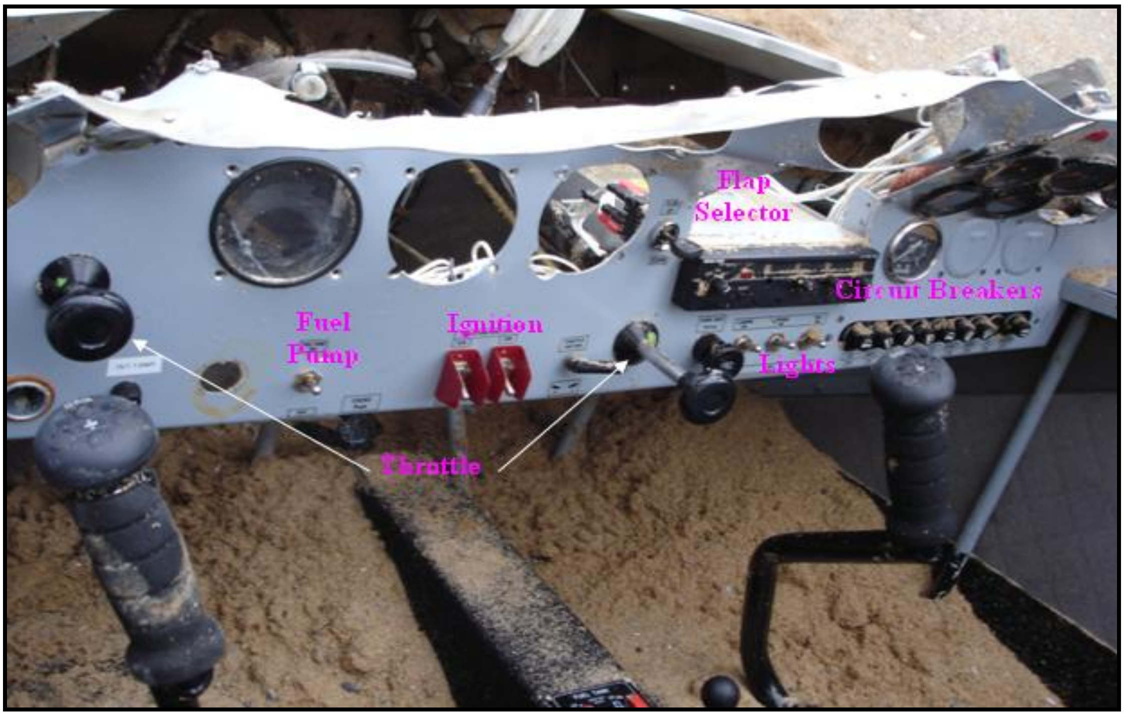
Sea damage was detected on wing and fuselage deformation, while landing gear remained in a good shape. Propeller blades were fractured by cleaving forces acting backwards, one severed by the hub and the other bent rearwards near the hub. Engine mounting was slightly bent with right side retreated against the fire-screen. Fuselage rear cone presented some dents and deformation, but horizontal stabilizer was normal. Cabin top was broken when it collided with the water and sea bed (*picture nr 3*).

Inside the cabin, after it was moved into normal position, passenger seat back was normal but with some damage on its top caused by dragging on the rocks, but pilot one was folded to the rear into baggage area (*picture nr 12*). Flight controls and respective trim wheels were in normal position and free of movement.



Picture Nr 12

On instrument panel (*Picture nr 13*), flap's selector was in neutral position and position indicator in "UP". Right-hand throttle was pulled full backwards and left-hand throttle pushed full forward. Ignition key and ignition switches were set "OFF", but electric fuel pump switch and exterior lights' switches were switched "ON". All circuit breakers were "IN".



Picture Nr 13

1.13 Medical & Pathological

Pilot was found unconscious and, after he was removed from the aircraft, life recovery procedures were applied. He expelled a great amount of water from his lungs and vital functions were recovered. Transported to hospital some dislodged ribs were found, not broken, and a general shock and partial memory loose condition was diagnosed, classified as "*Circumstantial Localized Dissociating Amnesia*".

The passenger was found unconscious, he was the first to be removed and subjected to recovery techniques application, namely to Basic Life Support (SBV) equipment, which included external defibrillator application. He never recovered vital functions and he was declared dead by the INEM doctor, present in the site. Autopsy report was never received and the cause of death could not be ascertained, being attributed to drowning even if there were some references to a possible neck fracture, considering the way his head reacted to the recovery techniques applied to him by the first-aid assistant.

1.14 Fire

There was no fire.

1.15 Survival Aspects

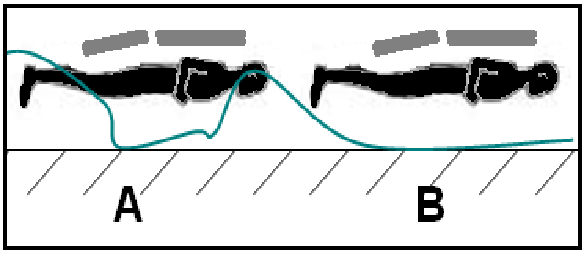
Considering the situation, it may be accepted as quick and efficient, the way rescue services answered to the accident. According testimonies, and BVC official report, the victims should have been less than 15 minutes in the water.

As the aircraft cabin was under water, it was necessary to pull it to shore, which was done by the first aid assistants and testimonies that first arrived to the scene. Only then the bodies could be removed from inside the cabin, after lifting aircraft's tail.

1.15.1 Pilot

The pilot was unconscious and presenting a great cyanosis[2] index. He was in a hypothermic condition, with respiratory arrest and feeble heart beating. He was facing down and his body extended, suspended by the seat belts that kept him tied to the seat, which back had been distorted and was leaning backwards (*picture nr 12*).

This must have contribute to his survival allowing the water ingested to his lungs, during the period the wave covered his mouth (*picture nr 14-A*), to be partially expelled by gravity, when the wave receded and the mouth became uncovered by water (*picture nr 14-B*).



Picture Nr 14

When dragged by an arm, the pilot started breathing and he expelled water from his lungs, together with his last meal. With recovering exercises, administered by first-aid assistants, he made an auto-recovery of respiratory & cardiovascular systems, gaining quickly his vital func-

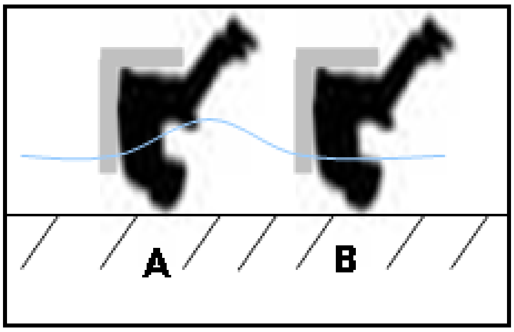
2 - Lack of oxygen in blood, characterized by cyan coloured skin, especially under the nails, on mucous membranes, lips, eyelids, etc.

tions, leaving hypothermic condition and regaining normal blood tension and heart beat rate in a short time.

Once stabilized, INEM doctor requested a helicopter to evacuate him to hospital.

1.15.2 Passenger

The passenger was unconscious, seated on his seat with seat belts fasten and his head resting on the ground, under water. In this position, sea water coming & going, with seasaw motion, covered his head, blocking his airway permanently (*picture nr 15*), preventing him from breathing and forcing him to swallow sea water into his lungs and stomach.



Picture Nr 15

As soon aircraft tail was raised, one first-aid assistant managed to sneak between the cabin and sea bed, to chop seat belts and pull out the passenger, who was the first one to be assisted with the administration of Basic Life Support (SBV) measures, using an External Automatic Defibrillator (DAE). Having no positive reaction to recovering exercises, SBV was maintained until the arrival of INEM doctor, who order to stop the exercises upon confirming the death. One assistant referred that, considering patient head reaction to movements, he should have a broken neck (cervical fracture). Being this true, such fracture could have been caused by head knocking on rocky sea bed or by dragging when the aircraft was pulled from the sea to the beach. The absence of autopsy report prevented to get a confirmation of such fracture and clarify its likely causes.

1.16 Tests & Research

1.16.1 Engine Examination

1.16.1.1 Preliminary External Inspection

Externally, Rotax 912ULS engine, s/n 5646121, looked normal, without evident signs of deformation or significant damage, but contaminated by sea water and sand (*picture nr 16*).

Picture Nr 16

Propeller shaft was not turning and propeller wooden blades had been fractured, with one bent rearwards, close to the hub and the other missing, chopped off from its root.

The engine was removed from the aircraft, engine fluids were preserved for analysis and the engine disassembled, looking for clues that could explain the reasons for its failure in flight.

1.16.1.2 Engine Fluids

Cylinder head refrigerating fluid was contained in its reservoir, there were no leaks and its quantity and properties were normal.

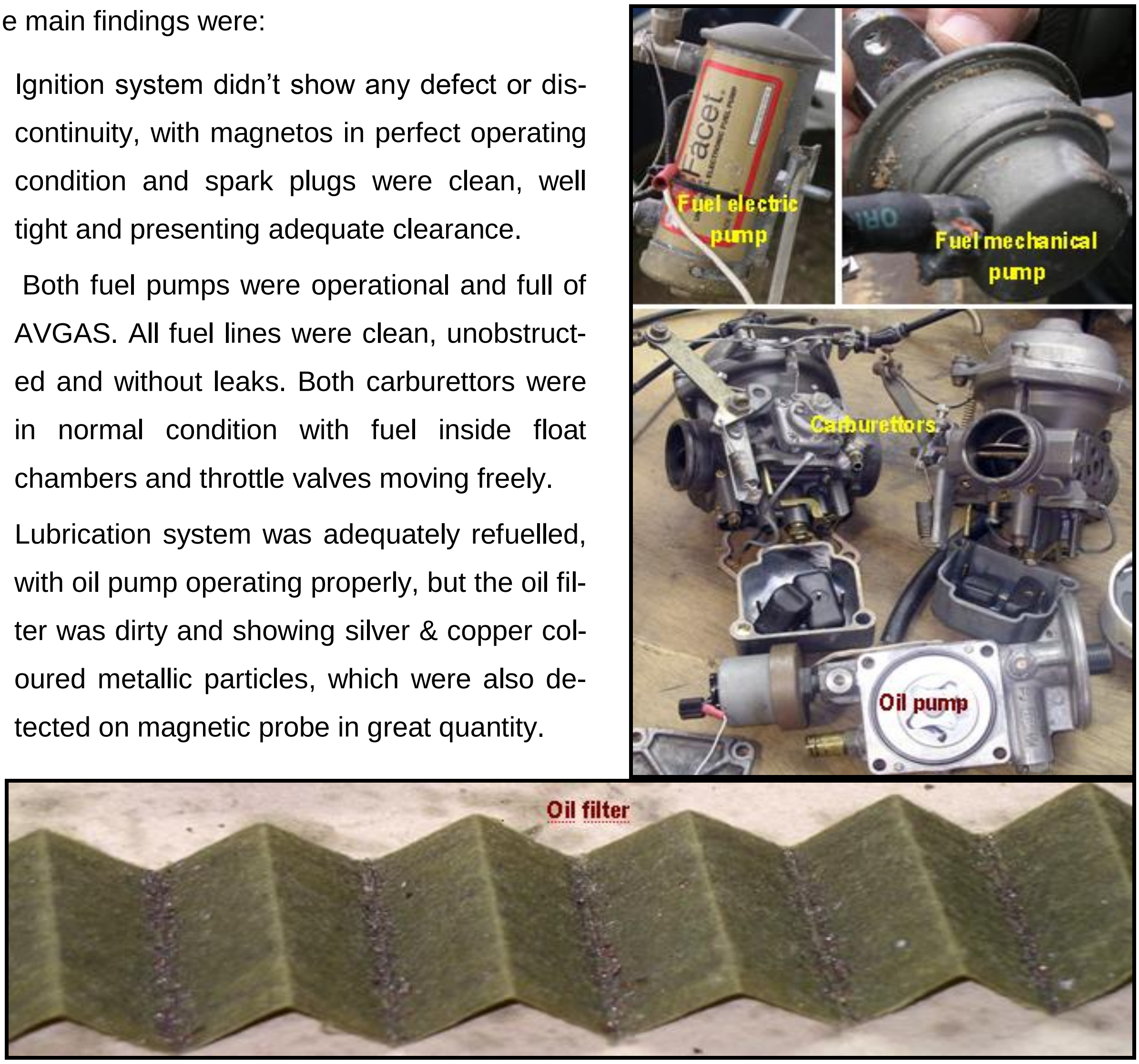
Engine lubricating oil was store in its tank, without leakage, being its quantity in accordance with recommended practices. Oil colour and viscosity looked satisfactory but there was a great amount of metallic particles present.

1.16.1.3 Engine Accessories

Engine disassembly started by removing engine accessories and checking for its condition.

The main findings were:

- Ignition system didn't show any defect or discontinuity, with magnetos in perfect operating condition and spark plugs were clean, well tight and presenting adequate clearance.
- Both fuel pumps were operational and full of AVGAS. All fuel lines were clean, unobstructed and without leaks. Both carburettors were in normal condition with fuel inside float chambers and throttle valves moving freely.
- Lubrication system was adequately refuelled, with oil pump operating properly, but the oil filter was dirty and showing silver & copper coloured metallic particles, which were also detected on magnetic probe in great quantity.



Picture Nr 17

1.16.1.4 Cylinders & Crankcase

Progressing with engine disassembly it was noted the cleanliness and proper general condition of cylinders, cylinder heads, rocking levers, valves and respective actuating rods, chambers, pistons, piston rings and connecting rods (*picture nr 18*).

Picture Nr 18

Coal and other deposits seen on piston heads and inside cylinder heads may be considered normal for the operating time accumulated by the engine (996 hours).

During disassembly process some difficulty was found when dislodging Cylinder #4 chamber, which prevented the separation of crankshaft case halves, being necessary to remove it by force, which caused some damage on it (brim fracture).

On interior wall of cylinder #4 chamber some grazing marks were found, together with large areas of colour variation and glazing, signalling it has been subjected to extremely high temperatures (*picture nr 19*).

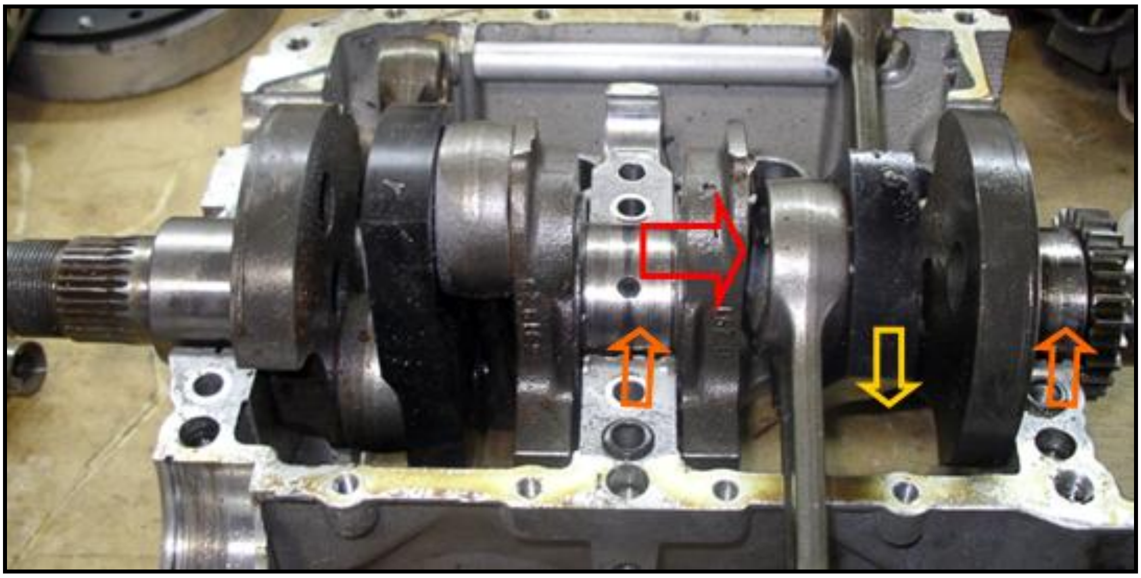
Picture Nr 19

Upon separation of both crankshaft case halves, a catastrophic crankshaft fracture struck the eye, just on cylinder #3 connecting rod bearing and adjacent counter weight coincidence zone (*picture nr 20 red arrow*).

Crankshaft showed some detrition marks, especially on centre and rear journals, probably caused by contaminated oil (*picture nr 20 amber arrows*).

Camshaft, even presenting some aggregated metallic particles, showed no significant wear.

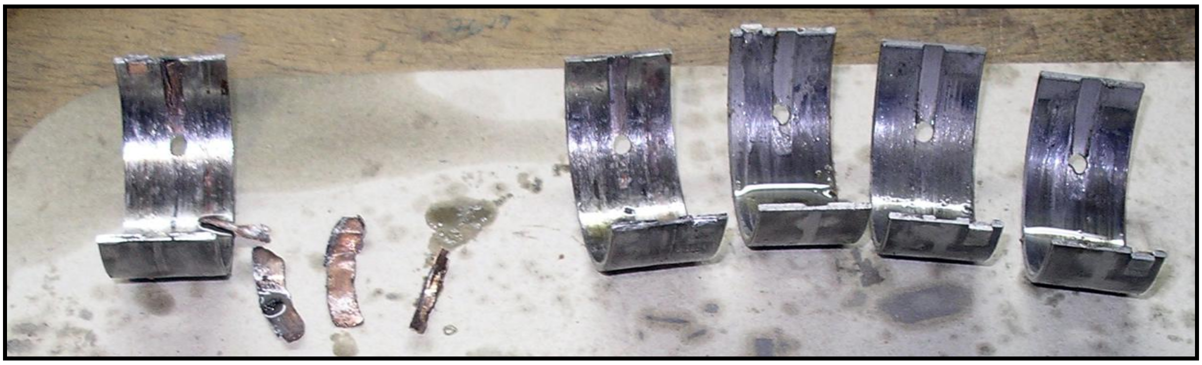
Inside the crankcase a great amount of dark slush was present, impregnated with metallic particles, also present in oil filter and propeller reduction gearbox (*picture nr 20 yellow arrow*).



Picture Nr 20

Slush found in crankcase is a characteristic by-product of lead oxide accumulation in lubricating oil, resulting from intensive use of high lead content fuels, like “AVGAS 100LL” gasoline, without care on reducing oil change periods to 25 hours intervals, instead of the usual 50 hours, when running on low or no lead content fuels, like “MOGAS” gasoline.

Cylinder #4 connecting rod was stiff and its bearings found practically destroyed. Looking for a probable cause for such damage, its head was cut to see the lubricating bore was unobstructed and oil passage was free.



Picture Nr 21

Detrition marks on crankshaft bearing journals (*picture nr 21*) seem to be the effect of a long lasting erosion by metallic particles carried in lubricating oil, probably deriving from #4 connecting rod destroyed bearing.

1.16.1.5 Conclusions

The engine exhibited internal damage which caused crankshaft catastrophic failure, with consequent engine stoppage in flight.

This damage may be related to several contributing factors, like:

- A continuous operation on high lead content fuel, the use of a lubricating oil not referred on manufacturer recommended oil list, with oil change at long and variable intervals, without an accurate monitoring of magnetic probe for indication of metallic particles presence in lubricating oil;
- Engine operation with misadjusted carburettors, causing misalignment and additional stress on the engine ;
- Engine vibration caused by a propeller not properly calibrated;
- Production defect.

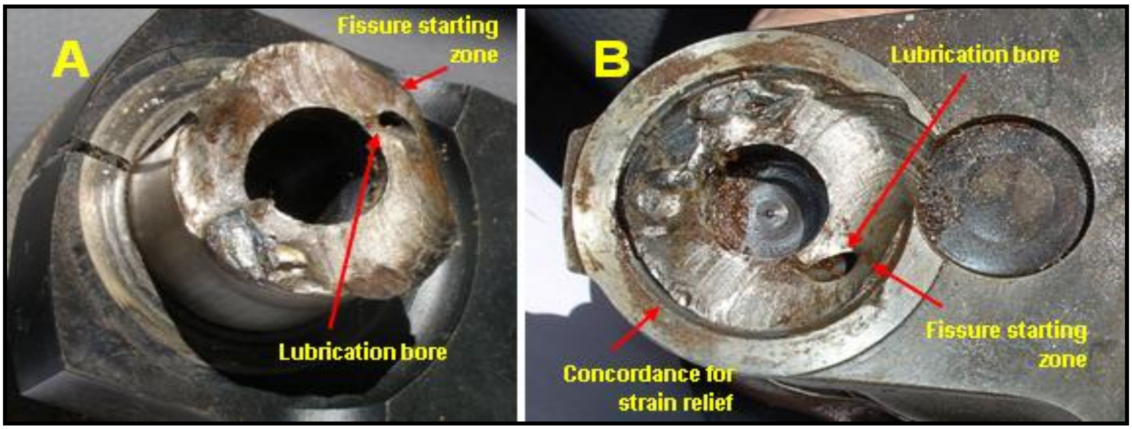
1.16.2 Crankshaft Fracture Examination

Trying to clarify the reason for crankshaft fracture, it was sent to Beira Interior University (UBI), where an Aero Spatial Science team, from Engineering Department, carried out appropriate tests and examinations in order to ascertain, based on scientific evidences, the destruction mechanism(s) concurrent to crankshaft catastrophic failure.

The result of that expert examination is presented on next paragraphs, transcribing part of technical expert's report, prepared by Professors José Miguel Almeida da Silva and Miguel Ângelo Rodrigues Silvestre.

1.16.2.1 Preliminary Visual Observation

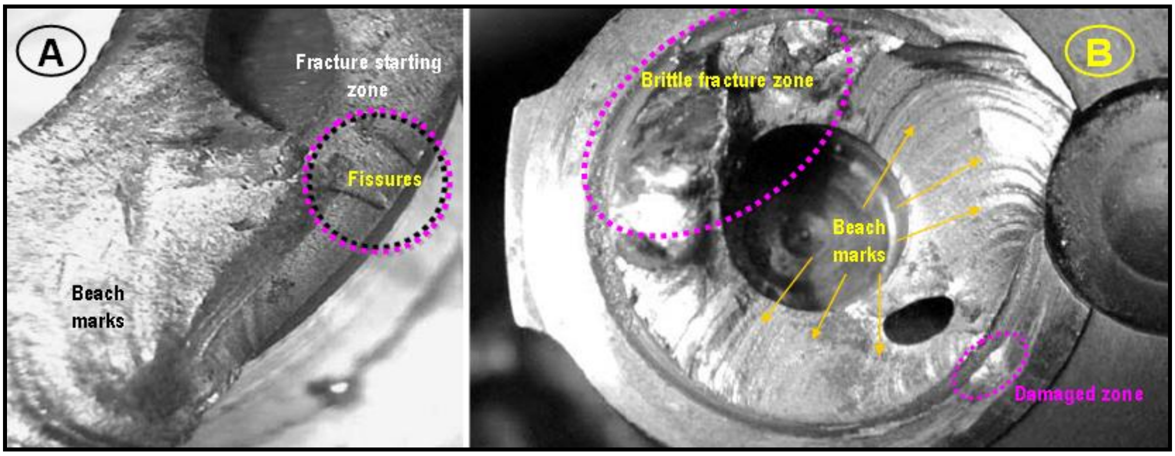
Fracture surfaces on both parts of component have been observed and it was confirmed an integral fracture along a perpendicular plane to connecting rod journal axe (*picture nr 22-A*), in concordance zone with adjacent counterweight web (*picture nr 22-B*).



Picture Nr 22

Even a naked eye can distinguish the evidence of a fissure propagation, compatible with the presence of destruction mechanisms subject to load cycles, starting at concordance in transition zone from connecting rod journal and adjacent counterweight crank web. This concordance is achieved by a machination process, by using a lathe, which drills a groove between connecting rod journal and adjacent counterweight crank web, with primary goal of promoting a reduction on mechanical stress concentration effects on that zone. A lubrication bore can also be seen in the area close to fissure starting point.

Resorting to an optical microscope, it was possible to detect beach marks on fracture surface (*picture nr 23*), compatible with the occurrence of a material fatigue process. These beach marks are the result of material's surface plastic deformation, due successive component starts and stoppings, imposed by running conditions, and they are a typical morphological characteristic of fractured surfaces, resulting from material fatigue, representing a continuous evolution of a destruction process, by the application of a cyclic load, like the one of a reciprocating engine running.



Picture Nr 23

The presence of these beach marks was seen on both fracture surfaces (A & B), covering almost 2/3 of entire surface. The remaining portion presented a different morphological pattern, characterised by a corrugated surface originated on a brittle fracture process, happening all of a sudden and anticipating component complete separation.

To note the beach marks uniform progress pattern, without change on crack pace direction by torsion effect, which means the fatigue process has been commanded by cyclic bending strains, induced by connecting rod, subjected to the effect of increased cylinder interior pressure on each power cycle.

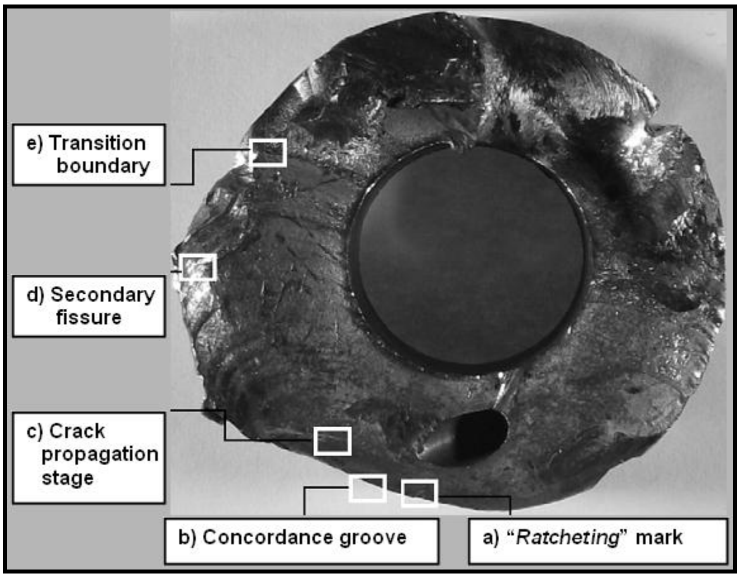
Connecting rod bearing interface with adjacent crankshaft counterweight is a critical zone in terms of strain concentration. In order to reduce the stress concentration factor in that zone, the manufacturer opted for a concordance groove. However, the presence of a lubricating bore in that zone contributed for a significant strain gradient to take place, due cumulative effect, leading to the formation of micro-fissures during the initial stage of fatigue cracking (*picture nr 23-A*), which will, eventually, converge and create steps known as "*ratcheting*" marks (*picture nr 25-A*).

During this examination a damage mark was noticed on fracture surface (*picture 23-B*) without symmetrical image, with identical characteristics, on correspondent counterpart, reason for considering this damage was not an original effect but probably done during transport or handling of the part and having no contribution, by no means, to the described fatigue process.

1.16.2.2 Scanning Electron Microscope (SEM) Examination

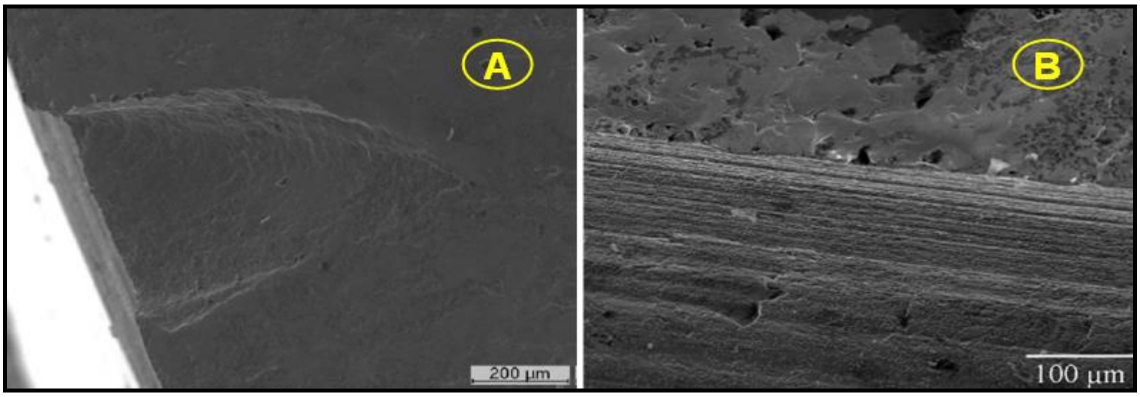
In order to perform a more detailed examination of fracture surface morphologic characteristics, using a scanning electron microscope (SEM), five different zones were selected along the entire area of bearing fracture surface (*picture nr 24*).

Each one of these zones was observed with different amplifications and the findings presented on following paragraphs.



Picture Nr 24

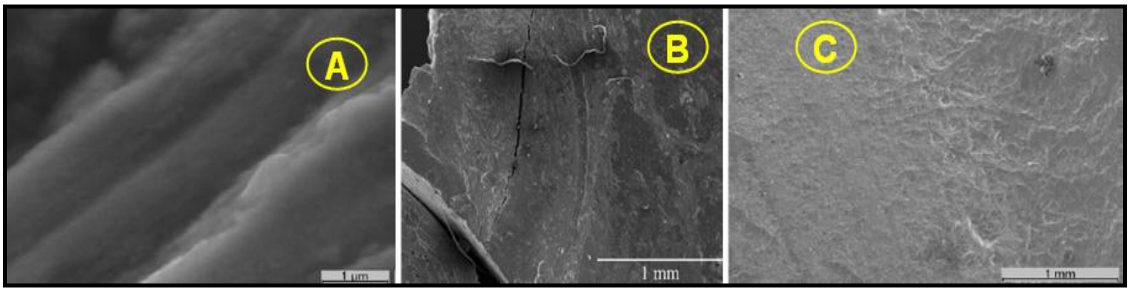
a) "Ratcheting" mark – This mark, looking like a tooth (*picture nr 25-A*), results from the junction of two micro-fissures propagation plans, originating in the maximum stress region along the concordance groove between connecting rod bearing and adjacent crank web, being associated to the extreme mechanical strain developed in that area. This mark coincides with crack initialization zone corresponding with initial stage of fatigue process.



Picture Nr 25

b) Concordance groove – Having evidence of high concentration of stress in concordance groove zone, that point was examined in detail (*picture nr 25-B*), looking for eventual machination defects. The image shows corrugation marks, aligned in parallel to the groove, developing along the entire journal circumference, near the crank web. These marks are compatible with manufacturing process (lathe work) and do not show any sign of defect resulting from this machination process.

c) Crack propagation stage – This image (*picture nr 26-A*) confirms the presence of fatigue furrows, parallel amongst them and perpendicular to the crack pace direction, supporting the existence of cyclic plastic deformation mechanisms, intrinsic to a fatigue process.



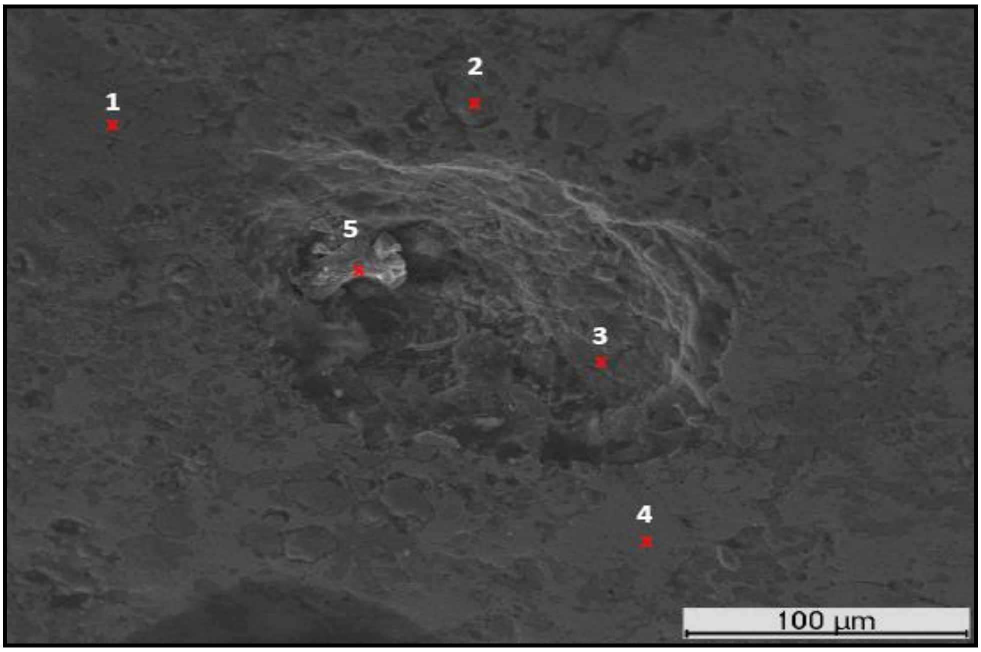
Picture Nr 26

d) Secondary fissure – Here (*picture nr 26-B*) we may see some fissures developing perpendicularly to crack propagation plan, which is a characteristic frequently found on fracture surfaces derived from a fatigue process, when the basic material is not able to accommodate completely the entire plastic deformation process, inherent to a fatigue crack propagation.

e) Transition boundary – On this transition boundary, between fatigue crack propagation zone and final brittle fracture zone (*picture nr 26-C*), it is evident the increase on fracture surface roughness, which represents, clearly, a typical feature of a fatigue cracking.

1.16.2.3 Elementary Chemical Analysis

During fracture surface observations, through different optical microscopes and SEM, namely during ratcheting zone examination, a special mark was detected on fracture surface, near fissure initialization point (highest mechanical stress zone), with a morphological aspect similar to a cavity with an average size of 150µm approximately (*picture nr 27*).



Picture Nr 27

A detailed examination of such mark brought to light some superficial areas with distinct morphologic characteristics.

The crankshaft is manufactured, according with manufacturer information, by a conventional forgery process, which may convey, sometimes, different types of defects inside its stuff. To highlight, specially, the formation of micro-cavities, induced by high mechanical stress during forgery process, usually described as "*bursts*" or "*hot tears*". These defects are fomented by the existence of intrinsic weak point in basic material, like pores, inclusions or segregation zones, catalysed by the high temperature conditions during forgery process.

In order to check for the dissimilarities which could be involved on that defect genesis, a chemical examination of the elements present in different locations around the defect was performed, resorting to an *Energy Dispersive Spectrometer* (EDS) coupled to the SEM, after a mapping of several distinct points, considered as essential for the measurements, has been done (*picture nr 27*). The choice of those points was based on the following assumptions:

1 **-** Zone of evident superficial multiple micro-fissures with a darker colouring;

2 **-** Zone looking like an inclusion, circular shape, being representative of others with similar characteristics and localized close to the defect;

3 **-** Internal defect zone with a regular texture identical to interior area general characteristics;

4 **-** Zone representative of basic material characteristics, without evidence of relevant morphological changes, useful for comparison reference;

5 **-** Internal defect zone showing circumstantial evidence of contamination presence.

Preliminary chemical analysis, got by EDS measurement, was transferred to a table (*table nr 6*) where, to each chemical element corresponds the measurement value in % of mass, got from each one of referred sample zones.

Chemical element	Reference values*	Measurement location				
		1(**)	2(**)	3(**)	4	5
C	0.14 - 0.19	-	-	-	-	51.43
O	-	37.78	36.76	37.26	-	21.49
Na	-	-	-	-	-	0.52
Al	-	-	-	-	-	2.35
Si	0.4	0.60(0.96)	1.02(1.61)	1.71(2.72)	-	3.50
S	-	1.64(2.64)	0.98(1.55)	-	-	2.00
Cl	-	-	1.19(1.88)	1.22(1.94)	-	1.73
K	-	-	-	-	-	1.34
Ca	-	-	-	1.19(1.90)	-	1.42
Cr	1.4 - 1.7	3.89(6.25)	7.03(11.1)	2.83(4.51)	1.77	0.76
Mn	0.4 - 0.6	0.82(1.32)	1.08(1.71)	0.71(1.13)	-	-
Fe	95.8	53.15(85.4)	48.81(77.2)	52.93(84.4)	96.20	13.48
Ni	1.4 - 1.7	2.12(3.41)	1.86(2.94)	2.14(3.41)	2.03	-
Cu	-	-	1.28(2.02)	-	-	-
P	0.035	-	-	-	-	-

* - Standard chemical composition values of 15CrNi6 alloy, crank basic material.
** - Corrected values, considering the absence of oxygen.

Table Nr 6

From table analysis it is possible to say that point 4 values are very close to 15CrNi6 alloy reference values, which confirms this is part of crank manufacturing basic material. The other points, however, show a composition substantially different from reference material standard composition, denouncing the presence of inclusion or segregation zones, occurred during crankshaft manufacturing (forgery) process. This fact, together with micro-cavity presence, suggests the referred defect was originated during part's manufacturing, possibly being one contributory factor, cumulatively with lubrication bore, concordance groove between connecting rod bearing and crank web and other strain concentration factors, for the occurrence of a fatigue process, which caused crankshaft catastrophic failure.

1.16.2.4 Material's Hardness Determination

During crankshaft fracture surface examination process it was detected what seemed to be an exterior protective layer, with a nominal hardness greater than crankshaft basic material hardness. The manufacturer was contacted and he confirmed the application of a superficial treatment (*case hardening*) to connecting rod bearing, in order to minimize the probability of micro-fissures development on the peripheral surface of this component, which is subject to high contact pressures.

These hardness measurements were made on a fractured bearing section, parallel to the fracture surface, after making a cross section cut and an adequate polishing process. The measurement equipment was provided with a "*Vickers*" indenter and a 1kg load was applied.

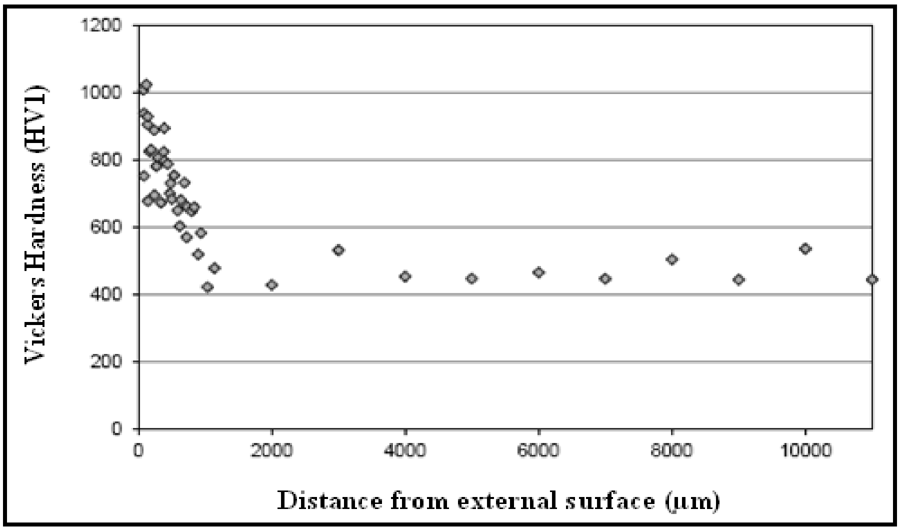


Table Nr 7

The outcome of those measurements (*table nr 7*) are well explanatory of hardness variation from component internal zone (where the 472HV1 value is not exceeded) until its outer surface where it was found a value above 1000HV1. Yet to stress the concentration of hardness higher values in a narrow zone in part's periphery, which confirms the application of referred "*case hardening*" process, by the manufacturer.

1.16.2.5 Conclusion

The crankshaft fracture surface examination carried out confirmed the existence of a fatigue process due a state of cyclic loading, which caused the progress of an initial crack fissure, originated in the interface region between connecting rod nr 3 bearing and adjacent counter-weight crank web. Despite the application of a superficial hardening process to the part and the machination of a concordance groove in interface zone, in order to reduce strain concentration on that area, a "*ratcheting*" process was developed, with the appearance of two micro-fissures localized in the proximity of concordance groove and a lubrication bore.

The presence of a micro defect, looking like a micro-cavity, was discovered in crack initialization zone, which should be originated during manufacturing process. The existence of this manufacturing defect, cumulatively with the concordance groove and the proximity of a lubrication bore, contributed to intensify strain concentration in that crankshaft zone, increasing the probability for fatigue fissures to begin, develop and propagate.

1.16.3 Lubricating Oil

1.16.3.1 Recommended Brands

Engine Owner Manual and Engine Maintenance Manual, issued by engine manufacturer, presents a list of recommended oil brands & specifications to be used for lubrication of Rotax 912 engines, calling attention for Service Information (SI-912-016) reading, which gives additional information on lubrication oil choice and other related maintenance procedures.

On SI-912-016-R3, dated July 13th, 2010, the oil tested and recommended by the manufacturer (BRP-Powertrain) is the same for any kind of fuel used. However, when the engine is mainly operated with AVGAS, the following advice is highlighted:

3.3) Operation with leaded AVGAS fuels

If the engine is mainly operated with leaded AVGAS fuels, the following maintenance operations are necessary in addition by latest after **every 50 operating hours**:

- change of oil filter
- change of engine oil
- oil level checks, etc., according to the most recent Maintenance Manual.

In addition, compliance with the following operating conditions is required:

■ CAUTION: The engine is considered to be operated mainly on leaded AVGAS, when run for more than 30% of engine operating time on leaded AVGAS fuel.

◆ NOTE: When operating primarily on leaded AVGAS fuel, we **recommend** to make a change of engine oil **every 25 operating hours.**

More frequent oil changes will assure timely removal of residues and oil sludge thus avoiding increased wear or operating troubles.

Use the following oils and observe the oil specification indicated:

Motor oils tested and released from BRP-Powertrain (for use with leaded AVGAS)

09464

Marke / brand	Bezeichnung / description	Spezifikation / specification	Viskosität * / viscosity	Code 1) / code 1)
SHELL®	AeroShell Sport Plus 4	API SL	SAE 10 W-40	2

Just in case there is not available, or by operator's option, another brand with similar characteristics may be used, being presented an alternative list of oil brands, not tested by the manufacturer, but recommended by official distributors, based on their personal experience.

Motor oils recommended from the authorized distributors (not tested from BRP-Powertrain) (for use with leaded AVGAS)

◆ NOTE: The following list is based on the experiences and local recommendation from the authorized distributors. Oil brand, with same designation, may vary from one to the other region. Please contact the local distributor for (the recommendation for) its region.

Marke / brand	Bezeichnung / description	Spezifikation / specification	Viskosität * / viscosity	Code[1]/ code[1]
EVVA®	EVVA Mehrbereichsöl C52 / multigrade oil C52	API SJ/CF	SAE 15 W-50	3
MOBIL®	Mobil 1 Clean 7500	API SM/SL	SAE 10 W-30	4
Skydrive®	Skydrive Aerolube 10W40 oil	API SL	SAE 10 W-40	2
SHELL®	Advance VSX 4	API SG	SAE 10 W-40	3
SHELL®	Formula Shell Synthetic Blend	API SL	SAE 10 W-30	4
SHELL®	Formula Shell	API SJ	SAE 10 W-30	5
SHELL®	Formula Shell	API SJ	SAE 20 W-50	5
Valvoline®	DuraBlend Synthetic	API SJ	SAE 10 W-40	4
YACCO®	MVX 500 Synthetic	API SJ	SAE 10 W-40	3

[1] property code 09466

2 Semi-synthetic aviation oils with gear additives. Highly recommended for normal (lower than 120 °C / 248 °F) and occasionally high oil temperature (higher than 120 °C / 248 °F) operation using leaded or unleaded fuels.

3 Semi-synthetic motorcycle oils with gear additives. Highly recommended for normal (lower than 120 °C / 248 °F) and occasionally high oil temperature (higher than 120 °C / 248 °F) operation using leaded or unleaded fuels.

4 Semi-synthetic oil. Recommended for normal (lower than 120 °C / 248 °F) and occasionally high oil temperature (higher than 120 °C / 248 °F) operation using leaded or unleaded fuels.

5 Petroleum based oil. Recommended for use only when oil temperatures remain below 120 °C (248 °F) and when using leaded fuels.

* The viscosity column is only a guideline. Substituting other than that shown is acceptable providing all temperature limitations are respected.

Example: Formula Shell Synthetic Blend SAE 5W-30 is a substitute for 10W-30. The guidelines given here must, however, be obeyed in all cases, using only those oils with which there have already been good operating experiences on ROTAX® engine types 912 and 914 (series).

◆ NOTE: The coefficient of viscosity indicates the tendency of oil to flow but it is not necessarily a quality code. Country specific deviations of the viscosity are possible.

Although a diversified selection of oil brands is presented, the manufacturer doesn't impose its use, but recommends the usage of lubricating oils with classification API[3] "**SG**" or higher only, and, preferably, multi-grade oils. On the other hand, previous experience proved that certain oils didn't have required characteristics and may cause damage to this kind of engine, being considered inappropriate for Rotax 912 engines.

3.4) Motor oils not suitable for engine types 912 / 914 Series

Experience has shown that only some oils are suitable for use in ROTAX® engine types 912/914 and careful selection is advised following the recommendations in this Service Instruction.

BRP-Powertrain is aware of formulation changes to some oils previously recommended for use in this Service Instruction. As a result, BRP-Powertrain no longer recommends the following oils and these should not be used anymore.

Marke / brand	Bezeichnung / description	Spezifikation / specification
Castrol®	Castrol Power 1	API SJ
Castrol®	GPS	API SG / CD
MOTUL®	5100 Synthetic Blend	API SJ

[3] - American Petroleum Institute

1.16.3.2 Used Brand

The engine was serviced regularly with "*CEPSA Moto 4T Ruta 66 Sintético 10W-50*" lubrication oil. As this brand was not included on the list referred in 1.16.3.1, CEPSA web page was checked and found the following information, regarding that brand:

CEPSA MOTO 4T RUTA 66 SINT 10W50

Description

A 100% synthetic supermulti-grade lubricant for four-stroke, multi-cylinder and multi-valve motorbikes and motorcycles for sporting events and in joint lubrication of the engine, primary transmission and wet clutch.

Applications

- For very severe conditions at high and low temperatures.
- All types of motorbikes with high cylinder capacity and features (superbikes) with electronic injection, driven at high speeds for prolonged periods or for sporting events (>10.000 rpm).
- Especially for lengthening drainage periods in maintenance.
- Especially recommended when, in joint lubrication, the film needs to be particularly "tenacious" due to the efforts of gear "cutting" or shearing.

Performance

- *Superior lubricity – Its synthetic bases and high viscosity index provide superior lubricity at any temperature, especially on starting up at low temperatures.*
- *Superior deposit control – Its special detergent and dispersant formula, boosted by latest generation antioxidants, prevents the formation of deposits in pistons and valves and significantly lengthens the life of the oil.*
- *Superior anti-wear capacity – Its anti-wear additives provide a protective film against high shock loads and boundary lubrication in the valve train, reducer gearbox and clutch.*
- *The JASO MA2 standard indicates higher and improved levels of both static and dynamic friction than the JASO MA1 standard and this makes it possible to take more effective advantage of all the power of the engine right from the start.*

Specifications

M034CEP001 MA2 JASO T903:2006	· API SL	· JASO T-903:2006 MA2 – M034CEP001

Typical Characteristics

CHARACTERISTICS	ASTM STANDARD	CEPSA MOTO 4T RUTA 66 SINTETICO
SAE Grade	---	**10W50**
Density, at 15ºC, Kg/l	D-4052	0.8597
Flash point ºC	D-92	208
Pour point ºC	D-97	-36
cSt Viscosity at 100ºC	D-445	16.96
cSt Viscosity at 40ºC	D-445	108.3
Viscosity index	D-2270	171
CCS viscosity at -25ºC, cP	D5293	4790
Kinetic viscosity after the shear test, cSt at 100ºC	D-6278	16.32

1.16.3.3 Conclusion

Even if it is not referred on manufacturer documents, "*CEPSA Moto 4T Ruta 66 Sintético 10W-50*" typical characteristics seem to be not significantly different from manufacturer recommended brand specifications and so, it should satisfy the requirements to be considered suitable for use with this engine, without causing danger to any particular part.

As referred on 1.6.3.3 (table nr 5), since the aircraft entered service with the actual operator, maintenance inspections were carried at very variable intervals and, apparently, the recommendation to change oil every 25 hours of operation, considering it was operating mainly with high lead content fuel (AVGAS 100LL), was never fulfilled.

In such conditions, more than the use of a manufacturer's not recommended lubrication oil, the larger operating periods without oil change, would be responsible for lead oxide deposit formation in the crankcase, which contributed to a premature wear of engine moving parts and for oil filter clogging, allowing metallic particles to enter lubrication flow and increase bearings wear.

1.17 Organizational & Management

The operator is a Flying Club, without profit concern and dedicated to affiliates only. One of its activities is non professional pilot training and ultralight aircraft pilots training, for which two separate departments were set up, one for Private Pilot licensing (PT/RF/13) and the other for Ultralight Pilot licensing (UL/TO/17), duly certified (the first) and approved (the second) by Civil Aviation National Authority (INAC).

The process to obtain the approval for an Ultralight Pilot Training Organization doesn't include the requirement for a certified maintenance support organization or the signing of a protocol for aircraft maintenance with any certified maintenance facility. Only requirements stated on INAC Regulation Nº 164/2006 (art. 40º to 53º), with changes introduced by INAC Regulation Nº 510/08, are to be observed.

1.18 Additional Information

Pilot's Ultralight Pilot Licence (PU 1233) has been issued by INAC, on the basis of his Commercial Pilot License (CPL(A) 3649). His flight experience was acquired on GA aircrafts, mainly Cessna 152 and 172, where he received his training and later on started to act as Flight Instructor Pilot. Engine failure procedures on these aircrafts are not significantly different from those on ultralight aircrafts. Their performances are different but not contrary. At the most, gliding performance would be better for ultralight aircrafts, considering its characteristics of mass and lift/drag coefficient.

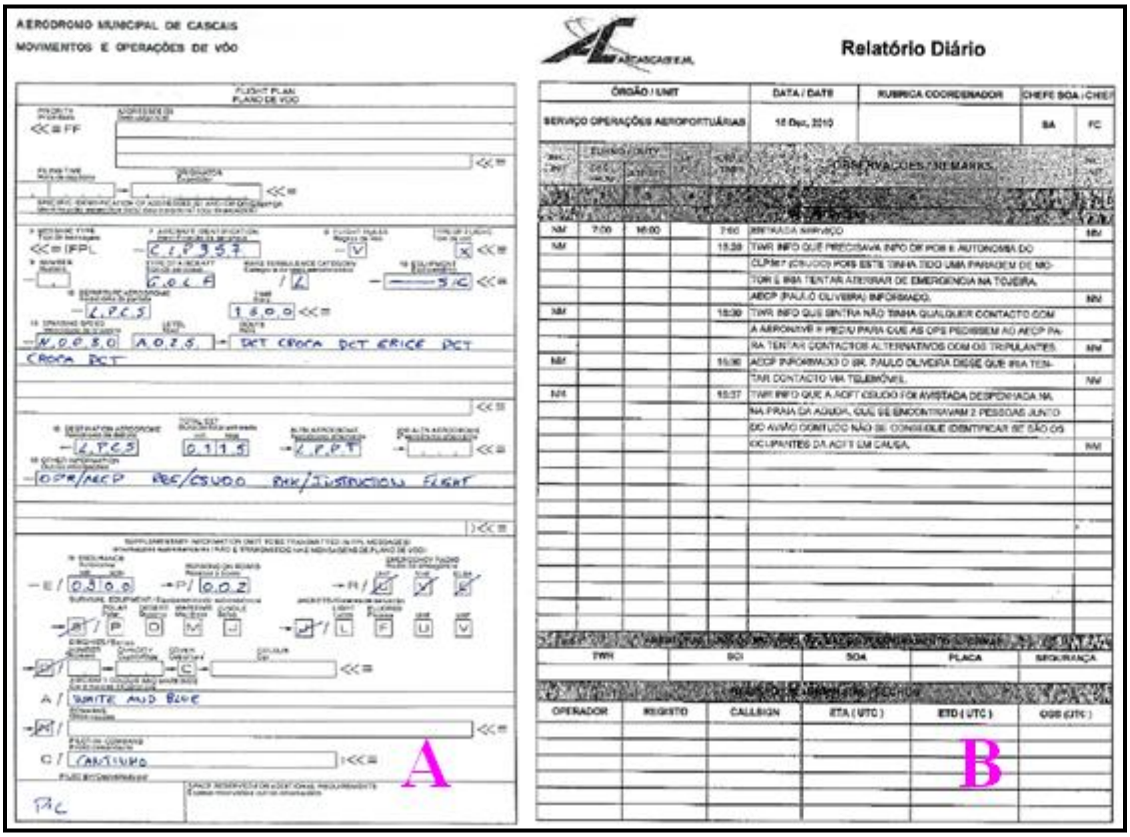
1.19 Useful or Effective Investigation Techniques

No special investigation techniques were used, besides those referred along the "test & research" information section, when optical microscope, scanning electron microscope, energy dispersive spectrometer and Vickers indenter had been used.

2. ANALYSIS

2.1 Flight Preparation

No special flight preparation actions have been performed and successive investigators had only access to a ICAO flight plan form, which was supposed to be presented to Aerodrome Operational Service (AOS) but was not signed by the PIC or any representative, neither stamped and signed by receiving Dispatcher (*picture nr 28-A*).


AERODROMO MUNICIPAL DE CASCAIS
MOVIMENTOS E OPERAÇÕES DE VÔO
FLIGHT PLAN / PLANO DE VOO

Relatório Diário

ÓRGÃO / UNIT	DATA / DATE	RUBRICA COORDENADOR	CHEFE SOA	CHEF
SERVIÇO OPERAÇÕES AEROPORTUÁRIAS	18 Dez, 2010		BA	FC

OBSERVAÇÕES / REMARKS

INIC	DUTY			TIME	OBSERVAÇÕES / REMARKS	INIC
NM	7:00	16:00		7:00	ENTRADA SERVIÇO	NM
NM				15:28	TWR INFO QUE PRECISAVA INFO DE POB E AUTONOMIA DO CLP... (CSUDO) POIS ESTE TINHA TIDO UMA PARAGEM DE MOTOR E IRIA TENTAR ATERRAR DE EMERGENCIA NA TOJEIRA. AECP (PAULO OLIVEIRA) INFORMADO.	NM
NM				15:30	TWR INFO QUE SINTRA NÃO TINHA QUALQUER CONTACTO COM A AERONAVE E PEDIU PARA QUE AS OPS PEDISSEM AO AECP PARA TENTAR CONTACTOS ALTERNATIVOS COM OS TRIPULANTES.	NM
NM				15:36	AECP INFORMADO O SR. PAULO OLIVEIRA DISSE QUE IRIA TENTAR CONTACTO VIA TELEMÓVEL.	NM
NM				15:37	TWR INFO QUE A ACFT CSUDO FOI AVISTADA DESPENHADA NA PRAIA DA AGUDA, QUE SE ENCONTRAVAM 2 PESSOAS JUNTO DO AVIÃO CONTUDO NÃO SE CONSEGUE IDENTIFICAR SE SÃO OS OCUPANTES DA ACFT EM CAUSA.	NM

Picture Nr 28

In addition, AOS Daily Report (*picture nr 28-B*) refers that the tower controller asked about the number of people on board and aircraft endurance and this request was forwarded to the operator, signalling that Flight Dispatch and Control Tower did not receive the Flight Plan on due time (before departure).

There was no more information available regarding the usual pre-flight meteorological and aeronautical information briefing or detailed aircraft status check.

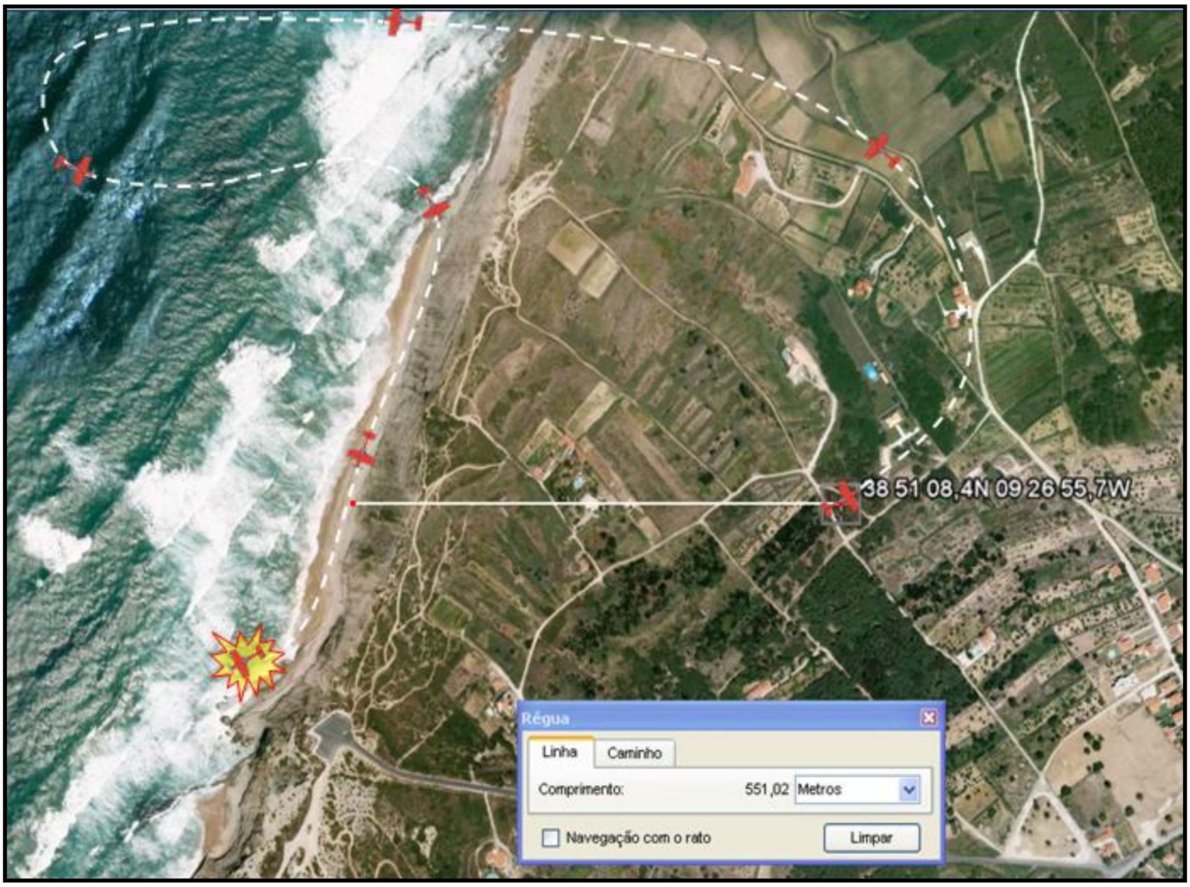
2.2 Flight Progress

2.2.1 Pilot Performance

Airborne at 15:11, the pilot proceeded to Roca Cape, where he reported at 15:17, maintaining 1000ft altitude, when he was transferred to Sintra Air Force Base Approach Control (APP STR). From here he flew on heading 032º, destination Tojeira airfield, being cleared to climb to 1500ft, on Sintra QNH 1023hPs, attaining that altitude at 15:21, on coordinates 38 51 10 N 009 26 58 W, about 3800m Southwest of Tojeira airfield.

One minute later (15:22), heading 083º, the pilot entered APP STR frequency again and declared "***May Day … May Day … May Day … Sintra Approach … CLP 357***". Asked if he was in "***Operations Normal***", he declared "***Negative***" informing the engine had stopped. Asked if it was possible to reach Tojeira airfield and his precise position, he informed it was impossible to reach Tojeira and to stand by for his precise position. From now on he didn't call APP STR or any other station and didn't answer any call.

From aircraft last radar position, recorded at 15:21:00 (38 51 08.4 N / 009 26 55.7 W), until it became immobilized in the sea, a probable trail was drawn (*picture nr 29*), based on pilot report and other local testimonies narration of the events.



Picture Nr 29

Facing the engine failure, the pilot headed towards the sea, turning by his left, keeping the aircraft clean and leaving ATC contact, probably due a main power cut, which could also explain the loss of transponder signal by radar controller (on cockpit inspection, main switch key and ignition switches were found in "OFF" position).

Being too high for a direct approach to the beach, the pilot deviated from shore line, into the sea, coming back with the aircraft still clean, perpendicular to the cliffs. He made a right turn, at high speed, in order to align the aircraft with the coast line, and forced the aircraft into the ground. Aircraft excessive speed was well patent, on last approach segment, when it managed to touch down after covering 250m distance only and, even so, it couldn't keep on the ground, it jumped and flew for another 250m. The excess speed and the fact the flaps being retracted offered much less drag, associated with tail wind effect, caused the speed to take more time to dissipate, increasing landing distance. When it touched down for the second time, the aircraft was too close to the rocks, which forced the pilot to deviate towards the sea where it dashed against the water and, due its inertia, flipped over and rested upside-down.

2.2.2 In-flight Engine Failure

Engine failure in flight, even for a single engine aircraft, is not necessarily synonymous of ***accident***. More refined than on general aviation, ultralight aircraft's gliding characteristics, associated to a lighter mass and lower stall speed, allow the pilot to make a wise evaluation of surrounding area, to select a suitable field and manoeuvre in order to perform an emergency landing, without causing substantial damage to the aircraft, as long as recommended procedures are followed and a good altitude and speed management put the aircraft in the correct pattern for the selected landing place. Regular training of this manoeuvre enables the pilot to acquire a high degree of proficiency and grant aircraft landing on any selected place.

When the engine stopped, surrounding area was full of reasonably flat and unhindered grounds, except a small zone, south of aircraft position (*picture nr 30*). Moreover, that region was well known for the pilot, as he used to fly there regularly.

Picture Nr 30

Looking in detail to covered track (*picture nr 29*), it's reasonable to believe it was possible for the aircraft to reach Tojeira airfield, gliding, if the pilot had opted for that solution. Anyhow there would be always a suitable field for an emergency landing, on shore, without the cliff imposed constraints to aeroplane manoeuvre and avoiding the risk of ending in the water, subjected to all consequences of lack of assistance, giving the accessibility limitations to the beach.

Tecnam P-96 Golf grants an exceptional performance with a 15º flap selection, with a low stall speed and a high lift capability, essential for manoeuvring in narrow spaces and to reach the selected landing site in circumstances to perform a safety landing, selecting full flaps whenever the field becomes granted.

The pilot made no use of flaps during the entire manoeuvre. His limited flying experience, almost acquired in general aviation aircrafts, with only four hours in this type of aeroplane, most probably having never practiced this kind of emergency on this aircraft and a superficial knowledge on aircraft features and performance, contributed for him not to profit from aircraft characteristics to obtain the best results.

3. CONCLUSIONS

3.1 Findings

From previous chapters information it's possible to retrieve the following conclusions:

1st The ultralight aircraft Tecnam P-96 Golf, s/n 285, Portuguese registration CS-UOO, took-off from Cascais Municipal Aerodrome (LPCS) at 15:11, on the 15-12-2010, for a local pleasure flight;

2nd By 15:22, the pilot reported in-flight engine failure and proceeded for an emergency landing on Aguda beach, Fontanelas, Sintra;

3rd Landing manoeuvre was not successful and the aircraft ended in the sea, upside-down;

4th The pilot suffered serious injuries and the passenger died in the accident;

5th The aircrafts was destroyed;

6th Meteorological conditions were proper for the flight and it was not a contributing factor for the accident;

7th The pilot held a valid pilot license and was qualified to fly that aircraft and operate that kind of flight;

8th Pilot's flying experience was limited, having flown 4:10 on type only, of which 2:00 under supervision;

9th Pilot's lack of training on simulated engine out landings and his limited flying experience, didn't assured an assertive management in order to grant a successful landing, without serious injuries to the occupants and avoiding substantial damage to the aircraft;

10th The aircraft had a valid Flight Certificate and last scheduled maintenance inspection had been performed 20 days before the accident, having flown 09:30 since;

11th In the course of this inspection, a check looking for the presence of metallic particles in lubrication oil, inspecting magnetic probe or oil filter, was not carried out, or was not reported on engine log;

12th Lubrication oil used by the operator was not referred on manufacturer recommended brand's list, but its characteristics were similar and can not be assured it contributed to the accident;

13th During last scheduled inspection engine carburettors had been tuned, because they were not synchronized and electric and ignition cables were repaired;

14th Engine oil changing intervals used to be not on schedule and didn't follow manufacturer recommendation for a more frequent oil change due utilization of high lead content fuel, as it happened with this engine;

15th A preliminary engine inspection detected the presence of metallic particles in crankcase, in propeller reduction gearbox and embedded in lubrication oil, with large deposit in oil filter;

16th Inside crankcase a large quantity of lead oxide slush was visible, deriving from the use of high lead content fuel (AVGAS 100LL gasoline);

17th Cylinder #4 connecting rod was stuck and its journal was found destroyed;

18th Crankshaft was totally fractured between cylinder #3 connecting rod bearing and adjacent counterweight crank web;

19th Microscopic examination of crankshaft fracture surface revealed a fatigue fracture process, initiated on concordance groove zone, between connecting rod bearing and adjacent crank web, with the coming of two micro-fissures, which developed in ratcheting and propagated along beach marks, due cyclic loadings, for 2/3 of the surface, until a brittle fracture occurred, causing catastrophic fracture of crankshaft;

20th Close to the initialization point of fracture fissures was localized a lubrication bore and a micro point that, observed through a scanning electron microscope (SEM), looked like a material defect;

21st Detailed examination of such defect, using an *Energy Dispersive Spectrometer* (EDS) coupled to the SEM and by chemical and hardness analysis of surrounding material, confirmed the presence of inclusions and segregation zones originating on crankshaft manufacturing process;

22nd This manufacture defect, associated to the presence of one lubrication bore and the concordance groove, all in one zone of high strain concentration, should have contributed for the fissures appearance and fatigue crack propagation process.

3.2 Causes of the Accident

3.2.1 Primary Cause

The accident was due to the unsuccessful pilot attempt to deal with in-flight engine failure, when trying to make an emergency landing on the beach, selecting an area with difficult access and with physical characteristics that will limit all correcting actions to any deviation from initially planed landing manoeuvre.

3.2.2 Contributory Factors

The following factors contributed to the accident:

1st In-flight total engine failure, due technical problems, leading to a catastrophic crankshaft failure, associated with:

a) Inappropriate engine maintenance programme, for actual operating conditions, not allowing lead oxide deposits, due high lead content fuel routinely utilization, timely cleaning, which facilitated connecting rod bearings and other engine bearings premature wear and the introduction of metallic particles in lubrication oil flow;

b) Continued engine operation with desynchronized carburettors and defective ignition cables, which increased engine vibrations and favoured the development of high strain concentration, potentiating the beginning of fissures and its development and propagation, initializing a fatigue fracture process;

c) The presence of a lubrication bore, the machination of a concordance groove in the segregation zone between connecting rod bearing and adjacent counterweight crank web plus the presence of a manufacture defect in surrounding area, led to a reduction on material resistance to strain concentration on that zone and facilitated the fissures appearance, which led to crankshaft catastrophic failure;

2nd Pilot limited flying experience, especially on this type of aircraft, which contributed for an inadequate evaluation of the situation, with a questionable decision and an inefficient accomplishment of required measures to bring the aircraft to a successful end.

4. SAFETY RECOMMENDATIONS

No safety recommendations were issued.

Lisbon, May the 28th, 2013

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