FINAL REPORT

of civil aviation safety investigation

CLASSIFICATION	**Accident**
Owner	Romanian Air Club
Operator	Romanian Air Club
Manufacturer	Moravan, n.p., Otrokovice Czech Republic
Aircraft	ZLIN Z 142
Registration country	Romania
Registration	YR-ZCC
Location	Clinceni Aerodrome
Date and time	23.08.2013 / 08:40 LT

NR. A 16-03
Date: 10.06.2016

Telefon: +4.021.222.05.35, Fax: +4.0378.107.106
E-mail: info@cias.gov.ro
notificari@cias.gov.ro
Șoseaua București – Ploiești nr. 40, Sector 1, București - 013695 www.cias.gov.ro

AKNOWLEDGEMENT

This REPORT presents data, analysis, conclusions and recommendations on civil aviation safety, of the Civil Aviation Safety Investigation Commission appointed by the Director General of CIAS.

The flight safety investigation was conducted in accordance with the provisions of the Government Ordinance No. 51/1999 concerning the technical investigation of civil aviation accidents and incidents, approved with amendments and additions by Law No. 794/2001, of the REGULATION (EU) No. 996/2010 of the European Parliament and of the Council from 20 October 2010 on the investigation and prevention of accidents and incidents occurred in civil aviation and repealing of Directive 94/56/EC and the provisions of Annex 13 to the Convention on International Civil Aviation signed at Chicago on 7 December 1944.

The objective of civil aviation safety investigation is preventing the occurrence of accidents and incidents, by effective determination of causes and circumstances that led to this occurrence and establishing the necessary recommendations for civil aviation safety and it HAS NOT THE PURPOSE of finding guilty, individual or collective responsibilities.

As a consequence, the use of this REPORT for other purposes than preventing the occurrence of accidents and incidents might generate misinterpretations.

CONTENT

CLASSIFICATION: Accident

Owner	Romanian Air Club
Operator:	Romanian Air Club
Manufacturer:	Moravan, n.p., Otrokovice, Czech Republic
Aircraft:	ZLIN Z 142
Registration:	YR-ZCC
Date and time:	23.08.2013 / 08:40 LT
Location:	Clinceni Aerodrome – Bucharest Territorial Air Club

On 23.08.2013 the aircraft type ZLIN 142, registered YR-ZCC was planned to perform training flights (runway laps) in the area of Clinceni Aerodrome. The crew was made up of a pilot-instructor and a pilot-student.

After performing four runway laps, during the fifth lap, the pilot-instructor decided to simulate an engine failure. He communicated to the pilot-student through a short briefing what he was about to do and what he should have to follow during the exercise.

When the aircraft was on the long side of the runway, perpendicular to the flight control point, at a height of 220m, the pilot-instructor noticed a loud noise in the front part of the aircraft, in the engine area. He immediately identified a real failure of the engine and decided to perform an emergency landing. He shut-off the engine and put all the electric contacts in off position. Shortly after this, smoke appeared in the aircraft cockpit. The pilot-instructor landed the aircraft in safety conditions on the runway from Clinceni Aerodrome, on direction 060 with front wind of approximately 2-3 m/s.

The main cause of the accident occurrence is the breakage of the no. 6 piston rod as a result of wrong installation of one of the two locking snap rings of the piston bolt during the last major engine repair.

The flight safety investigation was conducted in accordance with the provisions of the Government Ordinance No. 51/1999 concerning the technical investigation of civil aviation accidents and incidents, approved with amendments and additions by Law No. 794/2001, of the REGULATION (EU) No. 996/2010 of the European Parliament and of the Council from 20 October 2010 on the investigation and prevention of accidents and incidents occurred in civil aviation and repealing of Directive 94/56/EC and the provisions of Annex 13 to the Convention on International Civil Aviation signed at Chicago on 7 December 1944.

1.1 History of accident

1. General

The Civil Aviation Safety Investigation and Analysis Center notified the AIR ACCIDENTS INVESTIGATION INSTITUTE – AAII from the Czech Republic, representing the manufacturer country of the aircraft and engine. AAII designated an accredited representative who actively participated in the technical expertise of the aircraft engine made at the headquarters of LOM Praha, the engine manufacturer.

The flight history was rebuilt based on the accident witness statements, but also on the aircraft crew statements.

2. Flight

On 23.08.2013 at Clinceni Aerodrome there were planned for flight three aircraft. The aircraft ZLIN 142 type, registered YR-ZCC was planned to perform training flights (runway laps) in the aerodrome area, the crew was consisting in two persons, a pilot-instructor and a pilot-student respectively.

After carrying out all the pre-flight activity procedures in that day, namely joint briefing with the students, pilots, pilot-instructors and the flight leader, after preparing the flight documentation (mission orders, planning), around 08:00 o'clock the flight opening took place.

The engine was started to warm up, then it started the training flight that consisted of runway laps with double control.

There were performed four runway laps, after which at the fifth the pilot-instructor decided to make a runway lap during which to simulate an engine failure. He communicated to the student through a short briefing what he was about to do and what he should have to follow during the exercise.

Around 08:40 LT the aircraft was on the long side of the runway lap, perpendicular to the flight control point, at a height of 220m. The pilot-instructor reported to the flight leader the intention to perform a simulated engine failure, when he noticed a loud noise in the front part of the aircraft, in the engine area. The pilot-instructor immediately identified a real failure of the engine and decided to perform an emergency landing. He shut-off the engine and put all the electric contacts in off position. Shortly after this smoke appeared in the aircraft cockpit.

The pilot-instructor landed the aircraft in safety conditions on the runway from Clinceni Aerodrome, on direction 060 with front wind of approximately 2-3 m/s.

Aircraft location: 44° 21' 35,06'' N 25° 55' 56,62'' E **Altitude:** 119 m

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor/none	2	-	-

1.3 Damage to aircraft

As a consequence of the accident there occurred the following damages:

- The aircraft engine was seriously damaged: the cylinder rod 6 broken, and the engine block was sectioned by the broken rod.
- The left support of the engine frame broke from the firewall wall.

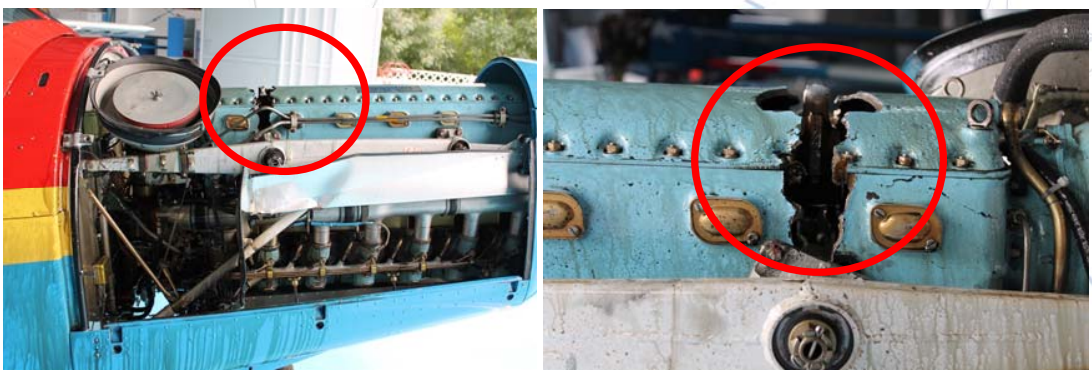

Fig. 1 – Sectioned engine block

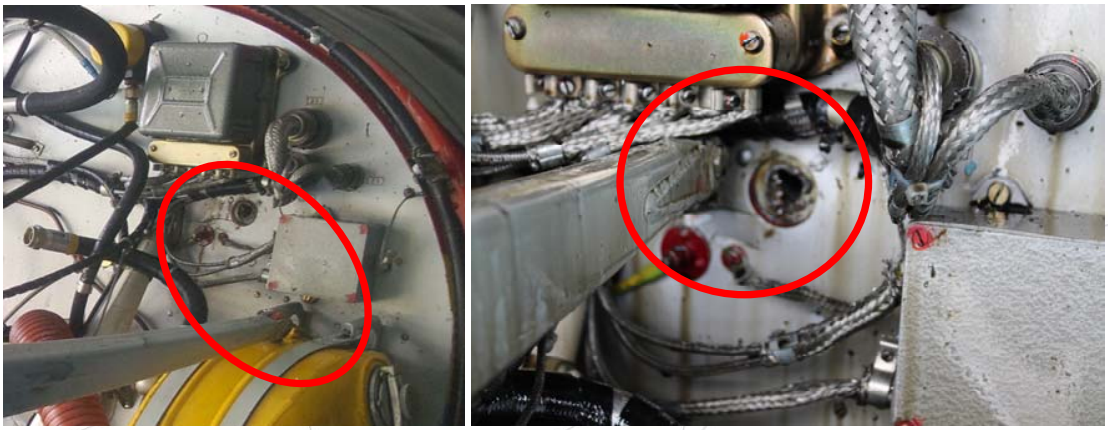

Fig. 2 – Broken engine frame from the firewall wall

1.4 Other damage

The pilot-instructor landed the aircraft in safety conditions. There were no other damages.

1.5 Personnel information

Pilot (Instructor)	Male 29 years old
License	RO.FCL/CPL/002074A
Medical certificate	Valid
Flight experience	660 hours
Work time	-
Rest time	-

The pilot was qualified as instructor and examiner/instructor.

1.6 Aircraft information

Manufacturer and aircraft type	Moravan, n.p., Otrokovice, Czech Republic
Serial number and manufacturing year	0398 / 1985
Registration state and mark	Romania / YR-ZCC
Owner	Romanian Air Club
Keeper (Operator)	Romanian Air Club
Airworthiness certificate	No. 343 – expires on 14.10.2013
Total number of hours - DPS	1982

Engine

Engine type	M337AK
Engine series	881981
Manufacturing date	30 MAR 1988
Last overhaul	09 NOV 2005
Last major repair	29 APR 2011
Number of hours since the last overhaul	588 hours and 23 minutes

The last major engine repair was performed at an authorized maintenance organization No CZ-145-0066. The investigation commission did not manage to identify a complete file of the repair that should have included the firm command of engine repair from the operator to the maintenance organization which made the repair, the non-conformities found during the engine repair by the maintenance organization, the operator's accept of repairing the non-conformities, EASA FORM 1 type certificates or the equivalent for the replaced parts.

After studying the engine documents and the repair file, the commission found the following:

- Volume I of the Engine Journal in Czech language is not available. Only volume II in Czech language and Engine Journal in Romanian language are available;
- The Engine Journal in Romanian language has amendments and corrections;
- The investigation commission did not manage to identify the nature of the failure that made the object of repair;
- From analyzing the available documents elaborated after the repair it was identified a list of replaced parts, and the most important are:
    - 6 pcs cylinders p/n Sc2606 – EASA FORM 1 certificate issued by LOM;
    - 2 pcs cylinders p/n Sh2503 - EASA FORM 1 certificate issued by LOM;
    - 12 pcs compression segments p/n 30-105-20-02 – unidentified origin;
    - 6 pcs lubrication segments – the upper one p/n 40-105-20-02 - EASA FORM 1 certificate issued by LOM;
    - 6 pcs lubrication segments – the bottom one p/n 40-105-20-07 – 5 pieces with EASA FORM 1 certificate issued by LOM; 1 piece of unidentified origin;
    - 2 pcs piston bolts p/n Sc2510 – unidentified origin;
    - 4 pcs locking snap rings p/n Sc2515 – unidentified origin;
    - 1 pc rear part of the cooling air deflector p/n Sh0765 – unidentified origin;
    - 1 pc cylinder cover p/n Sh7687 – unidentified origin;
    - 1 pc cooling air deflector assembly p/n Sh0781 – unidentified origin.

ready to fly and it was issued EASA FORM 1 certificate no. 6/2011. For testing it was mounted on Zlin 142 aircraft, registered OK-LNP, with manufacturing series 0233. The aircraft flew with this engine for its testing almost 11 hours. On 15.06.2011 the engine was demounted from the aircraft.

In the engine logbook in Romanian language, it is not recorded its mounting on YR-ZCC aircraft or on another aircraft, but on 24.02.2012 the operator started to make notes on the engine operation hours.

1.7 Meteorological information

METAR:LRBS 230530Z 07009KT 040V110 CAVOK 21/15 Q1016 NOSIG

1.8 Aids to navigation

N/A, the flight was conducted according to VFR rules.

1.9 Communications

N/A.

1.10 Flight field data

The natural grassy runway of Clinceni Aerodrome is owned by the public state and administered by the Ministry of National Defence, by the U.M. 01971 Bucharest, and according to the protocol signed between the Ministry of Defense and the Romanian Air Club, the latter uses the grassy runway with free title.

1.11 Flight recorders

The aircraft is not equipped with voice or flight parameters recorders.

1.12 Wreckage and impact information

N/A.

1.13 Medical and pathological information

N/A.

1.14 Fire

N/A.

1.15 Survival information

After the emergence of the particular case, the pilot-instructor landed on the grassy runway of the aerodrome in safety conditions. Both, the pilot-instructor but also the pilot-student, did not suffer injuries that require medical attention.

Oil samples were taken from the barrel of 200 liters, from which they used for engine maintenance and they were sent to the laboratory to test the oil quality. At that moment the investigation commission noticed that the oil barrels were stored outdoors in a fenced location.

Fig. 3 – Oil barrels storage

There were also taken oil samples from the engine oil tank and from the engine crankcase.

For the oil taken from the oil barrel used for engine maintenance, the laboratory analyzes showed that they were in accordance with the SAE J-1899 Grade 60 quality standard, required for this engine type.

The analyzes bulletins corresponding to the oil samples taken from the engine oil tank and from the engine crankcase showed a high content of metal particles (Fe 27,584 ppm, Pb 53,997 ppm, Ni 3,678 ppm, Cu 3,853 ppm, Cr 1,316 ppm) and also a high content of ash (0,127 %m).

In order to find exactly the causes that led to the cylinder no. 6 rog breakage the investigation commission decide to send the engine to its manufacturer, LOM Praha, to perform the technical expertise. The engine expertise was made in the presence of a member from the investigation commission and of the accredited representative of AAII.

The box in which the engine was transported was unsealed and opened in the presence of the two representatives of investigation institutions – CIAS and AAII. The engine was properly transported, not suffering further damage.

Fig. 4 – Sealed engine box

there were also the engine fastening holes to the support. Thus, there were made two holes in the engine block, in the area where it was broken, for an easier fastening of the engine support, and then it was mounted on the engine stand (see figure 5).

Fig. 5 – Engine installed for expertise

There were demounted the accessories from the engine, the engine valve covers, the supply pump and the air intake manifold.

It was demounted and verified the cam shaft – no marks of usage were found on the cams or on the shaft.

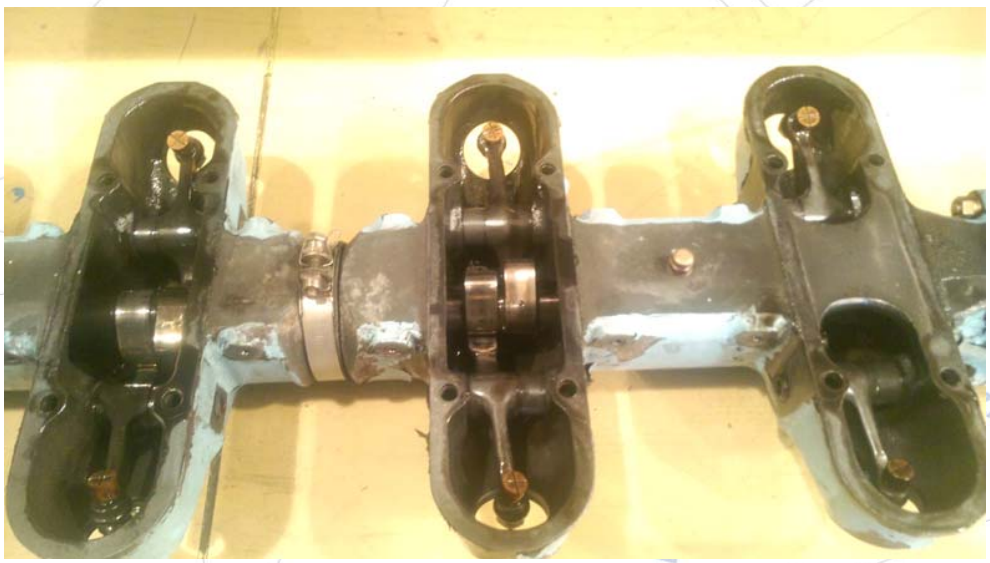

Fig. 6 – Cam shaft

There were demounted the cylinders and the pistons. At piston no. 5 it was found a crack in the piston shoulder area where the piston bolt is fixed.

Fig. 7 – Crack of piston no.5

At cylinder no. 6, the following were found:

- Broken rod, with missing pieces from the central part,
- Broken piston and a missing locking snap ring of the piston bolt. It was subsequently found broken in two pieces, in the engine oil collector,

Fig. 8 – Broken rod/piston no. 6

Fig. 9 – Broken locking snap ring of piston no.6 bolt (left) and the whole locking snap ring of the piston no.6 bolt (right)

- The cylinder is sectioned at its base, and on the inner surface there are friction marks of the piston bolt.

Fig. 10 – Cylinder sectioned at base

Fig.11 – Friction marks of the piston bolt on the cylinder

At the inspection of the piston segments the following were found:

- Piston no. 1 – compression segments are gummed;
- Piston no. 2 – compression and lubricating segments moving freely;
- Piston no. 3 – lubricating segment is gummed;
- Piston no. 4 - compression and lubricating segments moving freely;
- Piston no. 5 – compression segments almost gummed;
- Piston no. 6 – segments are completely gummed, piston is destroyed.

On the lateral sides of the pistons there were carbon deposits.

Fig. 12 – Carbon deposits on the lateral sides of the pistons

The rods from the crankshaft were demounted in order to inspect the bearings and it was noticed that they presented normal usage.

Fig. 13 – Bearings usage

The engine crankshaft was demounted to chech if the lubricating holes were blocked with ash deposits. There were inspected the crankshaft lubricating holes for pistons 1 and 6, there were found ash deposits in the normal limit, and the lubricating holes were free, unblocked, without ash deposits.

Fig.14 – Ash deposits on the crankshaft lubricating holes

While demounting the propeller flange it was noticed that it was incorrectly mounted on the conical surface of the crankshaft. The latch key was improperly installed.

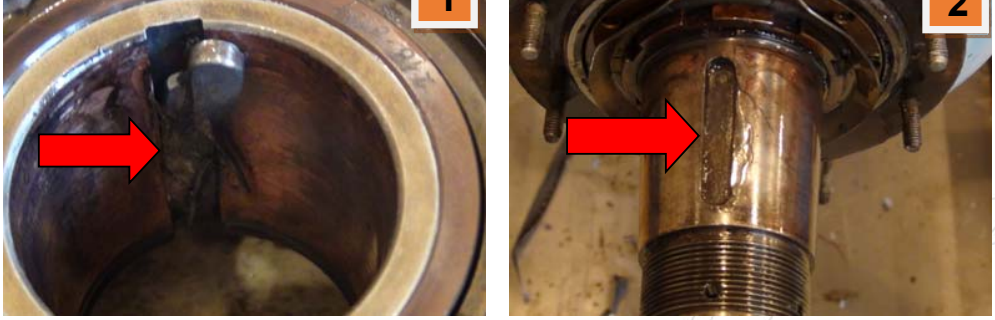

Fig. 15 – Latch key incorrectly mounted between the propeller flange (1) and the crankshaft (2)

Fig. 16 – Example of undeformed latch key

2 ANALYSIS

The segments gumming, but also the results of the engine visual inspection indicate that the engine was operated exciding the upper limit of the temperature recommended by the manufacturer. The segments gumming favors the transition of exhaust gases to engine crankcase, thus contaminating the engine oil. Also, the large amount of ash found in the oil after the lab analysis indicates the same thing.

The high operation temperature of the engine leads to a large expansion of the piston increasing the mechanical loading between the piston, the cylinder and the piston bolt, resulting in the appearance of fatigue cracks of these components.

Besides that, on 12.12.2009 the engine manufacturer LOM Praha issued the Informative Bulletin no. LOM-IB-04b/2009, recommended for all engine versions M132, M332, and M137, especially for version M 337 AK installed on aircraft types ZLIN Z-42, Z-43 and Z-142, the subject being the importance of monitoring their operation temperature. The manufacturer found that the engine operation at temperatures above the maximum recommended limit, could lead to premature damage of pistons, implicitly to reducing the engine operation time and he detailed a set of means for monitoring the engine operation.

the propeller flange when positioning it on the conical surface of the engine crankshaft. Most likely, the installation procedure recommended by the manufacturer was not followed by the maintenance organization of the operator when the engine was installed on YR-ZCC aircraft.

The process that led to the breakage of piston no. 6 rod was triggered by the breakage of one of the two locking snap rings of the piston bolt, the most likely cause being its incorrect installation after the last major engine repair. Thus, when installing the locking snap rings of piston no. 6 bolt, one of the rings was not properly fixed in the slot of the piston shoulder, resulting in an increased longitudinal axial play of the piston bolt.

Fig. 17 – Marks of the incorrect installation of the locking snap ring of piston no.6 bolt

Meanwhile, due to incorrect positioning of the piston bolt and of its increased axial play, fatigue cracks started to appear in the piston material in the area of the two fixing holes of the piston bolt.

The locking snap ring of the piston bolt that was incorrectly installed broke, when the axial play of the fixing bolt increased, this being also the moment when there appeared friction marks on the cylinder between the piston bolt and the cylinder.

Fig. 18 – Friction marks of piston no. 6 bolt on the cylinder

The influence of these negative factors lead in the end to the breakage of piston no.6 shoulder, to the displacement of the piston bolt that along with the increased mechanical forces resulted in rod breakage and cylinder no. 6 sectioning. In the end, the broken rod penetrated and sectioned the engine block.

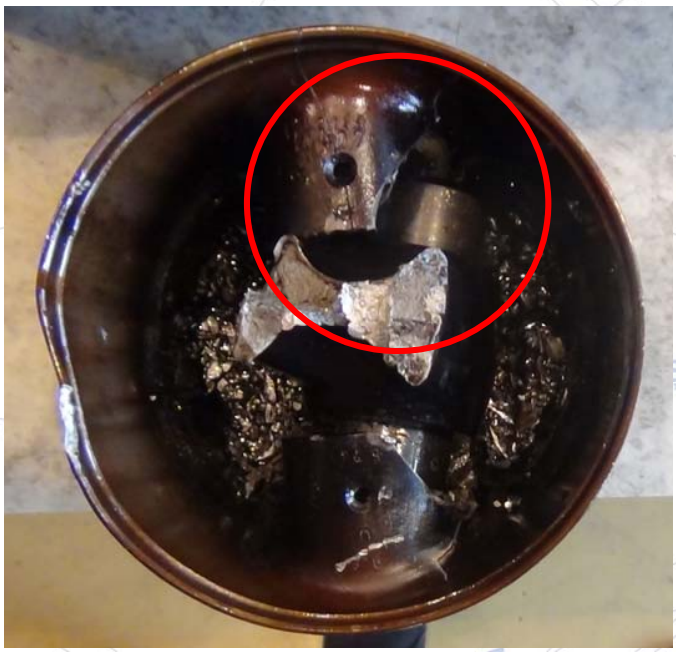

Fig. 19 – Broken shoulder of piston no. 6

On November 12, 2014 engine manufacturer LOM PRAHA issued a Service Letter Nr. 0013/2014 addressed to the certified maintenance organizations, owners and operators of engine type M337/M137 with the topic "Terms of locking snap ring p/n Sc2515 release while engine operation and the safety proposals".

concerned subjects and for the completion of provisions prescribed in the instruction "Operator's manual M337A/AK, M332A/AK, M137A/AZ, M132A/AK aircraft engines" section No.7, Par. 18. „Piston – cylinder parts replacement procedure".

3 CONCLUSIONS

3.1 Findings

The investigation commission made the following findings:

1. The oil sample taken from the barrel used for the engine maintenance corresponds to the quality standard SAE J-1899 Grade 60, which is required for this engine type.
2. When the accident took place, the investigation commission found that the oil barrels were stored outdoors in a fenced location.
3. The analyzes bulletins corresponding to the oil samples taken from the engine oil tank and from the engine crankcase showed a very high content of metal particles, but also a high content of ash.
4. At the inspection of the piston segments, most segments were found gummed or partially gummed.
5. On the lateral sides of the pistons there were carbon deposits.
6. The engine operation was made at a temperature above the limits recommended by the manufacturer.
7. The latch key between the propeller flange and the conical surface of the crankshaft was found deformed.
8. One of The locking snap rings of piston no. 6 bolt was incorrectly mounted during the last major engine repair.
9. Volume I of the engine journal in Czech language is not available.
10. The engine journal in Romanian language presents amendments and corrections.
11. The investigation commission did not manage to identify the nature of failure that made the object of the last major engine repair.
12. After analyzing the available documents issued after the repair, no complete file of the engine repair was identified that might have offered the possibility of having traceability of performed works and of replaced parts as well as their origin.

3.2 Causes of accident occurrence

The main cause of the accident occurrence is the breakage of piston no. 6 rod as a consequence of wrong installation of one of the two locking snap rings of the piston bolt during the last major engine repair.

4 RECOMMENDATIONS

1. It is recommended for the operator the Romanian Air Club to inform the pilots that operates the aircraft type ZLIN 142 about the content of the Informative Bulletin LOM-IB-04b/2009 highlighting the necessity of monitoring the engines operation temperature and the effects of operations at temperatures above the limits recommended by the manufacturer.
2. It is recommended for the maintenance organization of the Romanian Air Club to issue a procedure on how to perform a repair with an external contractor enabling traceability of performed works and of the changed parts as well as their origin.
3. It is recommended for the RCAA to audit the maintenance organization of the Romanian Air Club in order to:
   - verify how the chemical products are stored, especially the oil barrels used for the maintenance of aircraft under the operation of the Romanian Air Club;
   - verify how the planned/unplanned maintenance are made, given the way of using the technical documentation and the appropriate tools.

Note: The documents and analysis objects used for the issuance of the flight safety investigation Report are confidential and are archived at the Civil Aviation Safety Investigation and Analysis Center, according to legal provisions.