Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

Air Accident Investigation Unit (Belgium)
City Atrium
Rue du Progrès 56
1210 Brussels

Safety Investigation Report

ACCIDENT
YAKOVLEV 52
AT COUVIN
ON 14 FEBRUARY 2017

Ref.:
AAIU-2017-AII-02

Issue date:
27 June 2018

Status:
Final

TABLE OF CONTENTS

FOREWORD

This report is a technical document that reflects the views of the investigation team on the circumstances that led to the accident.

In accordance with Annex 13 of the Convention on International Civil Aviation and EU Regulation 996/2010, it is not the purpose of aircraft accident investigation to apportion blame or liability. The sole objective of the investigation and the Final Report is to determine the causes and to define recommendations in order to prevent future accidents and incidents.

In particular, Article 17-3 of EU regulation 996/2010 stipulates that the safety recommendations made in this report do not constitute any suspicion of guilt or responsibility in the accident.

The investigation was conducted by the AAIU(Be) with the support of the Air Accident Investigation Branch of UK, the Transportation Safety Bureau of Hungary, the Civil Aviation Safety Investigation and Analysis Center (CIAS) of Romania, the Aviation Safety Directorate (ASD) of the Belgian Defence and the laboratory of the Royal Military Academy of Belgium.

The report was compiled by Henri Metillon and was published under the authority of the Chief Investigator L. Blendeman.

SYMBOLS AND ABBREVIATIONS

’	Minute
°C	Degrees centigrade
AAIU(Be)	Air Accident Investigation Unit (Belgium)
AAN	Airworthiness Approval Note
AccRep	Accredited Representative of a State Investigation Unit
AGL	Above Ground Level
AMSL	Above Mean Sea Level
ARC	Airworthiness Review Certificate
ATC	Air Traffic Control
ATPL	Airline Transport Pilot Licence
BCAA	Belgian Civil Aviation Authority
CAVOK	Ceiling and Visibility OK
CG	Centre of Gravity
DOSAAF	Volunteer Society for Cooperation with the Army, Aviation and Navy
E	East
EASA	European Aviation Safety Agency
EBCF	Airfield of Cerfontaine
EU	European Union
FH	Flight hour(s)
ft	Foot (Feet)
GA	General Aviation
lbs	Pounds
LH	Left hand
m	Metre(s)
Hz	Hertz
MSN	Manufacture’s serial number
MTOW	Maximum Take-off Weight
N	North
NM	Nautical mile
O/H	Overhaul
PIC	Pilot in Command
PFM	Pilot’s Flight Manual
QNH	Pressure setting to indicate elevation above mean sea level
RH	Right hand
RMA	Royal Military School of Belgium
RPM	Revolutions per Minute
RWY	Runway
SCF-PP	System or Component Failure – PowerPlant
SEP	Single Engine Piston rating
SN	Serial Number
UTC	Universal Time Coordinated[1]
VFR	Visual Flight Rules

1 About the time: For the purpose of this report, time will be indicated in UTC, unless otherwise specified.

TERMINOLOGY USED IN THIS REPORT

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence.

Cause: any act, omission (individual), behaviour or condition (system) that produces an effect; eliminating a cause will eliminate the effect.

> **Direct cause:** the most obvious reason (acts or omissions, so mostly individuals) why an adverse event happens
>
> **Indirect cause:** a less obvious reason (acts, omissions, conditions) for an adverse event happening. The hazard has not been adequately considered via a suitable and sufficient risk assessment

Contributing safety factor: a condition that influences the effect by increasing its likelihood, accelerating the effect in time, affecting severity of the consequences, etc.; eliminating a contributing factor(s) won't eliminate the effect.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to be communicated in an investigation report in the interest of improved transport safety.

Safety issue: a safety factor that
(a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and
(b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency on its own initiative in response to a safety issue.

Safety recommendation: a proposal by the accident investigation authority in response to a safety issue and based on information derived from the investigation, made with the intention of preventing accidents or incidents. When AAIU(Be) issues a safety recommendation to a person, organisation, agency or Regulatory Authority, the person, organisation, agency or Regulatory Authority concerned must provide a written response within 90 days. That response must indicate whether the recommendation is accepted, or must state any reasons for not accepting part or all of the recommendation, and must detail any proposed safety action to bring the recommendation into effect.

Safety message: an awareness which brings to attention the existence of a safety factor and the lessons learned. AAIU(Be) can distribute a safety message to a community (of pilots, instructors, examiners, ATC officers), an organisation or an industry sector for it to consider a safety factor and take action where it believes it appropriate. There is no requirement for a formal response to a safety message, although AAIU(Be) will publish any response it receives.

AAIU-2017-AII-02

SYNOPSIS

Date and time:	14 February 2017 – 10:30 UTC
Aircraft:	Yakovlev YAK-52, SN: 833707
Accident location:	At about 12 km south of the airfield of Cerfontaine and 6 km west of the city of Couvin. 50°02'46.01''N – 4°24'39.36''E
Aircraft owner:	Private
Type of flight:	General aviation – Local flight
Phase of flight:	En route
Persons on board:	1 (the pilot-owner)
Injuries:	The pilot was seriously injured

Abstract:

After a short flight starting from the airfield of Cerfontaine (EBCF), the engine suddenly began to sputter and lost power. The pilot determined he could not fly back to the airfield and decided to land the plane where he could. Just before landing, the aeroplane hit the top of a tree, pitch nosed down and violently hit the ground.

Occurrence type: powerplant failure or malfunction (SCF-PP[2])

Direct cause:

The collision of the aeroplane with the top of a tree when performing a forced landing caused by a significant loss of engine power.

Indirect cause:

- The engine loss of power was most probably caused by the internal corrosion of the carburettor which partially blocked the fuel flow at the pressure regulator valve. The corrosion of the magnesium alloy casing of the carburettor was likely caused by water contamination.
- The limited height above ground level when the engine loss power occurred and the limited maximum lift to drag ratio did not leave the pilot much time to prepare the landing.

Contributing factors:

- The schedule used for the last maintenance dated June 2016 did not require the cleaning of the fine fuel filter.

2 SCF-PP means "Failure or malfunction of an aircraft system or component related to the powerplant (System Component Failure - PowerPlant)". This abbreviation is in accordance with ICAO Accident/Incident Data Reporting (ADREP) system which is based on the ADREP taxonomy. The ADREP taxonomy is a set of definitions and descriptions used during the gathering and reporting of accident/incident data to ICAO.

- Unlike the fuel coarse filter, there is no drain provision at the fine fuel filter and this filter is black coloured while the vast majority of the fuel system components are painted in yellow. This might have confused the mechanics who involuntarily disregarded the inspection of this filter.
- Although the compensation tank is equipped with a drain valve, no requirement was found regarding a periodical activation of this drain in any of the maintenance schedule pertinent to this aeroplane.
- Possible water condensation could have developed inside the compensation tank during the 11 months of grounding of the aeroplane close to the North sea coast where a high level of moisture is often found in the air.
- Releasing to service of an aeroplane where breakdown symptoms have disappeared for an unknown reason.
- In February, there were no leaves on the trees making them hardly discernible.

1. FACTUAL INFORMATION.

1.1 History of flight.

Prior to the flight

The owner stated that unexplained engine power reductions and RPM fluctuations were encountered during several flights performed since the end of 2016. He further characterized these engine problems as similar to "propeller hunting" symptoms[3]. These problems appeared only when the engine RPM was above 82%. On 2 January 2017, a troubleshooting was initiated by a mechanic from the Belgian maintenance company 'Fast Aero' assisted by the owner. The oil and fuel filters were removed and cleaned, the engine oil was changed and a ground run was carried out. On 16 January 2017, the engine stopped operating during the ground acceleration for take-off. Looking for a solution, the owner requested the advice of the company 'Richard Goode Aerobatics' (UK) that acted as an intermediary for the engine overhaul performed in June 2016. It was suggested that the engine power fluctuations could be caused by a too low oil temperature causing the oil to be too thick and leading to a poor operation of the propeller governor. Thereafter, 5 or 6 flights were performed during which propeller RPM fluctuation problems still occurred occasionally at high engine power although the pilot stated that the oil was always brought to the correct temperature before starting the engine by heating the aeroplane in the hangar. The day before the accident the mechanic came back to EBCF airfield to continue the troubleshooting. The replacement of the governor did not lead to any improvement, the engine even stopped during the ground run when running at high rpm and power setting. The mechanic standing outside witnessed wild fluctuation of the propeller with the blade pitch varying fast. The original governor was reinstalled, the fuel filters were removed and checked and several flexible fuel pipes located at the front of the firewall were checked for obstruction. The works lasted one full day and although no evidence of anomaly was found, the ground run carried out at the end of the day was satisfactory. It was therefore decided to perform a limited test during the flight the following day.

Flight

After a thorough pre-flight inspection and engine ground run, the pilot took off and flew around the airfield for 10 minutes without noticing any problem.
All engine parameters were normal, the pilot flew southwards for about 10 minutes until crossing the main road between the cities of Couvin and Chimay.
The pilot stated that, while requesting a new ATC authorization to climb, he performed a few steep turns and gentle aerobatics manoeuvres in order to verify he was adequately strapped and no loose objects were present.
Shortly afterwards, the engine began to sputter and lost power. Witnesses standing in the vicinity stated they heard noise fluctuations, the engine alternatively loosing and regaining power. The pilot stated that wild fluctuation of power was occurring at constant engine throttle (80 cmHg manifold air pressure (MAP)) and propeller position (82 % Max RPM), all the way down to the landing. The main concern of the pilot was maintaining control of the aeroplane because of the speed decreasing rapidly. The pilot performed a quick magneto selection test and checked the position of the fuel primer control, without result. Seeing that it was impossible to fly back to the airfield, the pilot stated he selected a field to perform a forced landing and decided to extend the landing gear. The aeroplane probably started the landing

3 Hunting propeller, i.e. uncommanded RPM excursions above and/or below the selected RPM

at about 600 ft above ground level (last steady height before the aeroplane disappeared from the radar screen, indicating a descent below the radar coverage). Afterwards, the pilot stated that with an engine delivering low power, the rate of descent of a YAK 52 is very high and the top priority was to maintain a minimum airspeed of 150 km/h to avoid stalling. Close to the ground, the pilot realized he could not land on the selected field, interrupted the turn, levelled the wings and flew straight ahead, extending the flaps. The pilot did not see a row of trees perpendicular to its final path. The aeroplane hit the top of a 10-metre tree, pitched down with a significant down angle before violently hitting the ground, coming to a stop after a rebound. The pilot was seriously injured.

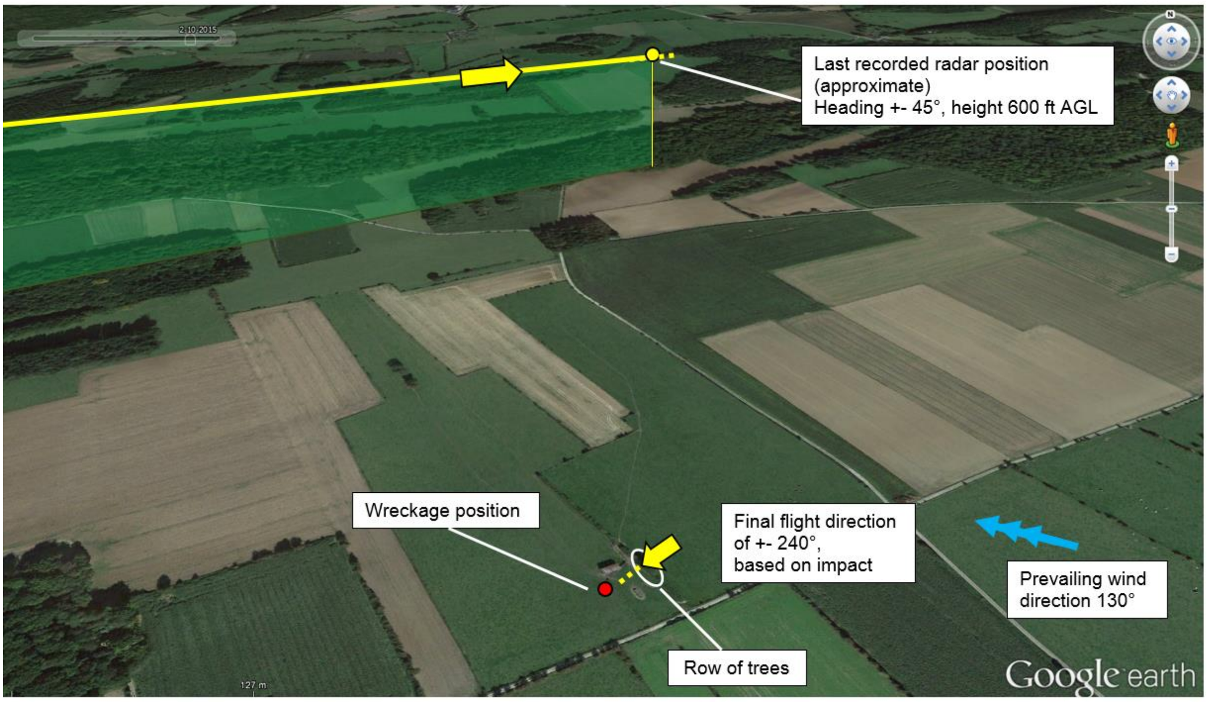


Figure 1 : part of the last recorded flight path and path at impact

The duration of the event was very short. The period of time from the decision to land until the crash was estimated by the pilot to less than 20 seconds. The direct distance between the last recorded radar position and the impact position was approximately 0,5 NM.

1.2 Injuries to persons.

Injuries	Crew	Passenger	Others	Total
Fatal				
Serious	1			1
Minor				
None				
Total	1			1

1.3 Damage to aircraft.

Significant damage, beyond repair

1.4 Other damage.

Small contamination of the soil with engine oil and fuel.

1.5 Personnel information.

Pilot:

Sex:	Male
Age:	55 years old
Nationality:	Belgian
License:	EASA PART-FCL Airline Transport Pilot Licence for aeroplanes (ATPL(A)). Flight crew licence first issued on 7 April 2010 by the UK CAA[4].
Ratings:	Class rating: SEP (land) valid until 30 April 2017 Aerobatic and night rating Instrument rating valid until 31January 2017 Type rating: B747-400 LV (Low Visibility) valid until 31 January 2017 Flight Instructor – FI(A) rating valid until 31 July 2018. Aerobatic Instructor - FCL.905.FI (f) A Language Proficiency: English level 6
Medical certificate:	Valid until 01 March 2017
Flight experience:	About 17000 FH. Recent experience flying Yak-52: about 40FH during the last 8 months (= since the engine overhaul). Very experienced Yak-52 pilot with more than 1000 hours flying aircraft equipped with M-14P(F) engines (Yak-52, Yak-50, Yak-18T, Sukhoi-29 and Nanchang CJ-6) all over the world. Previous type ratings: Convair CV-580, Boeing 727 Former Belgian air force pilot (Marchetti SF-260M, Alpha-Jet 1B, C-130 Hercules).

4 Validity for non-EASA Aircraft (such as the Yak-52) – In accordance with and subject to the provisions of the United Kingdom Air Navigation Order this licence is valid for aircraft registered in the United Kingdom for which the flight crew member is not required to hold a Part-FCL licence.

1.6 Aircraft information.

1.6.1 General description

The Yakovlev Yak-52 is an all metal two-seat, tandem single-engine low-wing monoplane, originally designed and manufactured as a military basic training aeroplane in the Eastern bloc. Yak-52 aeroplanes are often used for aerobatic flying and training.

The design company of the Yak-52 was O.K.B. – YAKOVLEV Institute – RUSSIA, which also developed the technical documentation (technical description, flight manuals, maintenance manuals and service bulletins) for this aeroplane.
The never-exceed speed (V_{NE}) is 420 km/h (227 kt) and its design manoeuvring speed (V_A) is 360 km/h (194 kt). Maximum lift-to-drag ratio is 7 with retracted landing gear and 5,5 with extended. The best glide speed is 160Km/h in all configurations. However the best gliding range is achieved with the undercarriage and flaps retracted.

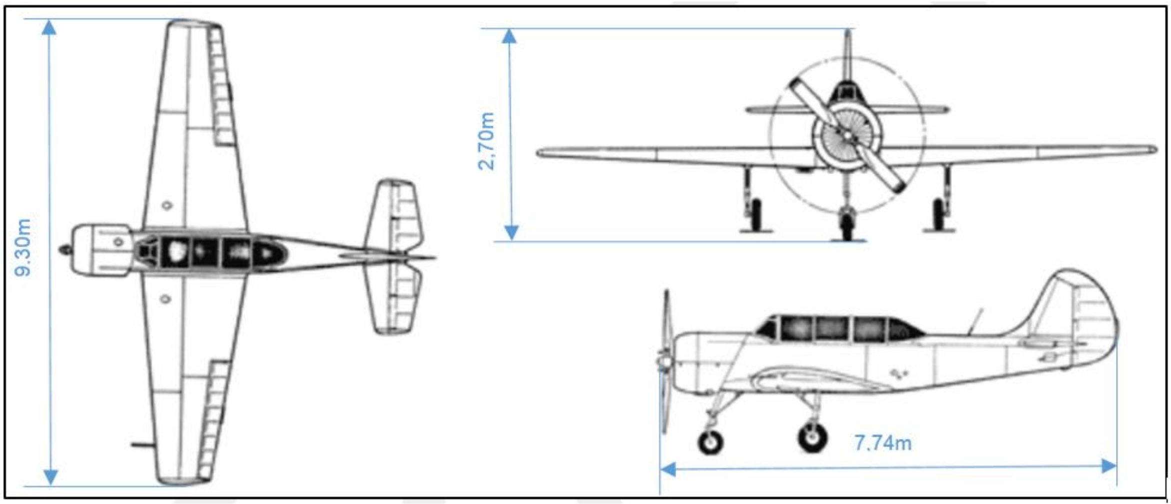


Figure 2 : dimensions

The aeroplane is equipped with a 9-cylinder radial engine Ivchenko Vedeneyev M14-PF 360 HP and a Vperyod B530TA-D35 propeller.

1.16.2 The accident aeroplane

The accident aeroplane was produced in Romania in 1983 for the former USSR by the company "Intreprinderea de Avioane Bacau" (New name of this company: SC Aerostar SA). Reportedly, it had been first operated by DOSAAF-Russia, and was marketed thereafter.

Airframe:

Year of built:	1983
Total flight time:	1499FH
Manufacturer:	Intreprinderea de Avioane Bacau, Romania
Serial number:	833707
First operator:	DOSAAF, a paramilitary sport organisation in the former USSR
Empty weight:	1017 kg (without engine oil)
MTOW:	1315 kg
Registration:	Certificate of registration issued by UK CAA on 13 April 2005

Airworthiness:	UK ‘Permit to fly – Certificate of validity’ last issued by Arion Aviation Ltd (UK) on 17 June 2016 and valid until 19 June 2017. A Belgian ‘Temporary Permission to Fly over Belgian territory‘ was valid from 01 June 2016 until 31 May 2017.

<u>Engine:</u>

Manufacturer:	Ivchenko Vedeneyev
Serial number:	031002
Type:	M14-PF
Total flight hours:	403:23FH - 40FH since major overhaul performed on 2 June 2016

<u>Propeller:</u>

Manufacturer:	Vperyod
Serial number:	B530TA-B35
Hub Type:	1000127
Total flight hours:	40FH since major overhaul

History

The aeroplane was purchased in 2005 by the current Belgian pilot/owner. At that time, the aeroplane was already registered in the United Kingdom as an Annex II aeroplane operating on a National Permit to Fly since a few years. After its purchase, it remained registered in the UK and kept flying under a UK Permit to Fly.

On 23 April 2009, the engine was replaced by an overhauled unit type M14P-400 with serial number KJA031002. At that time this engine had a total time of 245:20 since new. It has to be noted that this engine was more powerful than the previous one (400 HP instead of 360 HP).

On 5 June 2011, a review of the maintenance records was carried out by « Aero Aeronautical Service Ltd. » in accordance with CAA Airworthiness Approval Note (AAN) 29189, concluding that the airframe life of the aeroplane was extended until 22 May 2021 or 2007 flying hours or 4608 landings, subject to conditions.

In July 2015, the aeroplane was grounded at the Koksijde air base (EBFN) due to an engine problem caused by a broken exhaust valve causing additional cylinder(s) damage. The owner decided to send the engine to a specialized company ‘Aerometal Kft’ (Hungary) to carry out the overhaul. At the same time, it was also decided to overhaul the propeller. The company ‘Richard Goode Aerobatics’ (UK) acted as an intermediary between the owner and ‘Aerometal Kft’ for the engine overhaul.

On 4 June 2016, the overhauled engine and propeller were reinstalled on the airframe by the Belgian maintenance company ‘Fast Aero’. At the same time, the maintenance company performed a 100-hour inspection according to the inspection schedule provided by ‘Arion Aviation’. These maintenance operations were performed under the supervision of the latter sending an inspector on site for the annual review of the aeroplane at the end of the engine reinstallation.

After the annual review, the aeroplane was issued with a Permit Maintenance Release by ‘Arion Aviation’ who also issued a new Certificate of Validity which was valid until 19 June 2017. The annual Certificate of Validity supports the non-expiring National Permit to Fly in accordance with the requirements described in Chapter A3-7 of British Civil Airworthiness Requirements (BCAR) Section A, CAP553.

When the accident occurred, the aeroplane had flown about 40 hours since the last engine overhaul and since the last 100-hour inspection.

Propeller control system description

The propeller is controlled by a governor, also called Constant Speed Unit (CSU), that uses oil under pressure to adjust the propeller pitch and maintain a selected rotation speed. The oil pressure is fed to the propeller hub through internal oil passages in the propeller shaft of the engine. The propeller blades are shifted to a smaller pitch by the pressure of the oil fed by the governor to the propeller hub. Shifting to a higher pitch is performed by counterweights installed on the propeller blades; in this case the oil returns from the propeller hub to the engine gearbox case.
In a Yak-52, unlike most single-engine aeroplanes, a governor delivering a too low oil pressure or an internal oil leak between the governor and the propeller hub, or a too viscous oil will tend to set the blade pitch to coarse causing the engine RPM to drop.

Fuel system description

The aircraft is equipped with 2 inboard wing tanks and with 2 optional outboard wing tanks, not represented on the figure. Long-range optional fuel tanks were fitted in 2002 in accordance with modification Yak/36. This modification consists of two auxiliary 'wet wing' fuel tanks within the existing wing structure. These are connected to the main fuel tanks and increase the fuel capacity from 120 litres to 288 litres. The modification is approved in the UK under Airworthiness Approval Note (AAN) No. 28121.

The pilot stated that he almost didn’t use the auxiliary fuel tanks and in particular that they were not used recently.

A collector tank, installed under the rear pilot floor, is gravity fed by the wing tanks through non-return valves. A flexible line is installed inside the collector tank to ensure proper fuel pumping when flying inverted.

The fuel is drawn from the collector tank by the engine-driven fuel pump through a shut-off valve and the coarse filter. Fuel under pressure is then supplied to a compensation tank which is fixed on the right side of the firewall. This compensation tank is provided with in- and outlet connections, a drain valve and a connection located on the top and equipped with a restrictor allowing a limited part of the fuel flow to return to the collector tank.

A fuel fine filter incorporating a relief valve is directly connected to the outlet of the compensation tank. This filter (Type: 8D2.966.064) is intended to filter off mechanical impurities over 36 to 40 µm in size. It is not equipped with a drain valve to evacuate possible water contamination. Unlike the vast majority of the fuel system components and lines that are painted yellow, this fine filter is painted black.

After the fine filter, the fuel is directed to the pressure carburettor inlet. Finally, a screen filter is installed inside the carburettor next to the fuel inlet. The carburettor is a pressure carburettor (floatless carburettor) equipped with a pressure regulator, a metering valve and incorporating different automatic adjustments. It is provided with drains plugs at lowest points to remove possible water or sediment contamination which may enter into the carburettor.

Additionally, several fuel quick drains are installed at different locations of the airframe:

- At the bottom of each wing tank,
- Under the fuselage, on the fuel line before the collector tank,
- At the coarse fuel filter,
- At the compensation tank.

A dual function manual primer is positioned on the upper right-hand side of the front cockpit panel and has three positions (left, right and upright)

- Left pressurizes the fuel system,
- Right primes fuel into the engine cylinders,
- Upright is the Neutral position which is the normal flight position (the knob must be locked in this neutral vertical position).

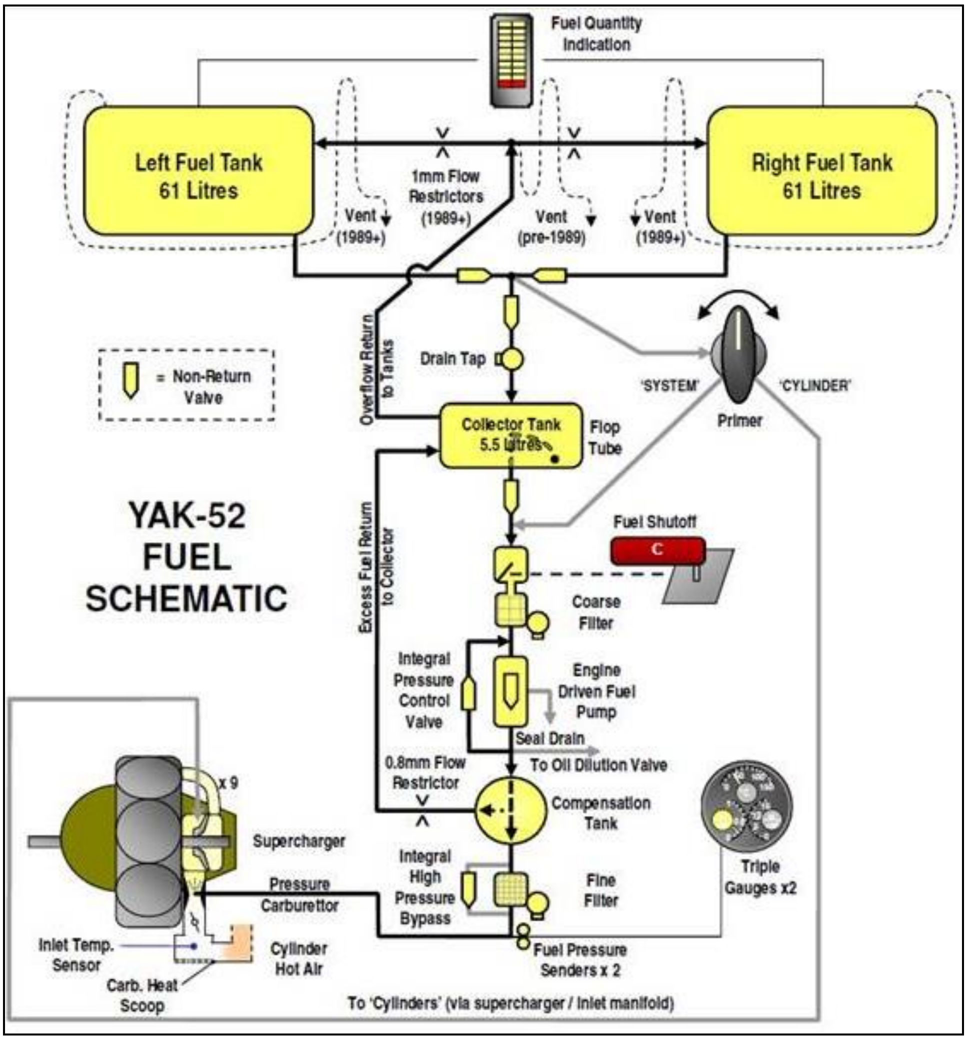
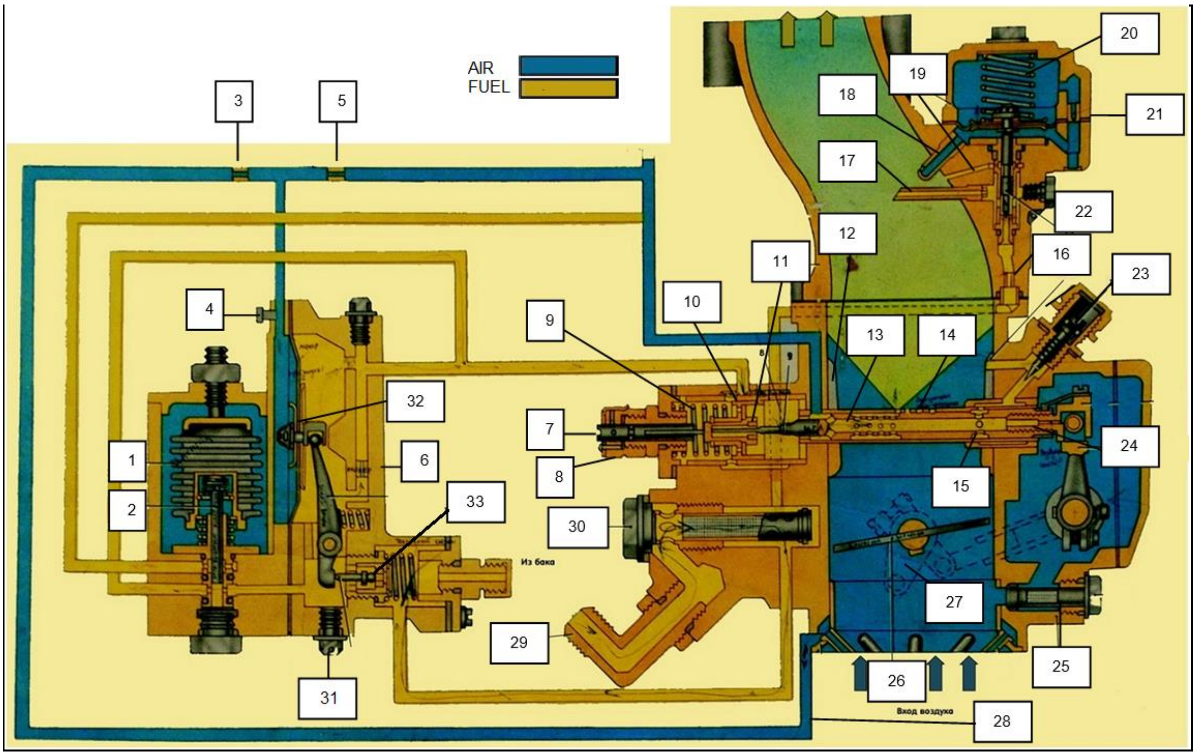


Figure 3: Basic diagram of the fuel system (auxiliary wing tanks not represented) (© Robert A. Rowe)

Pressure carburettor description

As can be seen in the drawing below, the carburettor is vertically installed on the engine with an upstream airflow. A 90° elbow (29) is screwed in the fuel inlet bore and a screen filter (30) is screwed in another bore located just above the fuel inlet.



1: Altitude control aneroid capsule, 2: Altitude control needle, 3: Inlet air jet, 4: Air pressure measuring point, 5: Suction jet, 6: Fuel jet, 7: Metering needle adjustment screw, 8: Adjustment screw limiter, 9: Spring, 10: Piston, 11: Valve, 12: Venturi, 13: Metering needle, 14: Nozzle, 15: Orifice in idle passage, 16: Fuel jet, 17: Acceleration pump pipe, 18: Air intake pipe, 19: Drain passage, 20: Spring, 21: Air jet, 22: Acceleration pump needle valve with diaphragm, 23: Idle adjustment screw, 24: Idle air jet, 25: Air filter, 26: Throttle, 27: Throttle actuation lever, 28: Ram air pressure pipe, 29: Fuel inlet connection, 30: Fuel filter, 31: Drain plug, 32: Diaphragm assembly, 33: Pressure regulator valve

Figure 4: Pressure carburettor

Flight manual

The flight manual is not approved and is called 'Pilot's notes', based on a translation of the original Pilots Notes for the aeroplane as modified (Ref: Aerobuild Yakovlev Yak 52 Flight Manual AB/FA/52-3) which are considered acceptable by the UK CAA.

The procedure for the forced landing is as follows:

> In the event of an engine failure during a flight and where it is not possible to re-start a forced landing will need to be carried out. Follow the procedure below:
>
> - If possible trade speed for height
> - Start descent, set airspeed 160 km/h
> - Ensure the landing gear is UP
> - Select an emergency landing area, verify and correct approach
> - If time permits call MAYDAY
> - Close the fuel stop-valve (fully back)
> - Brief Passenger
> - Switch off magneto, Master Switch (Battery), Generator and Ignition
> - Open the canopy
> - Tighten harnesses

Figure 5 : extract of "The definitive pilots operating Handbook[5] for the Yakovlev YAK 52" revision 1.4. November 2003

About the glide:

> The best glide speed is 160Km/h in all configurations. However the best gliding range is achieved with the undercarriage and flaps retracted.
>
> Gliding turns should be made at 160Km/h and at an angle of 45°. For a 360° turn this will produce a height loss of approximately 750 feet.
>
> Wind strength will alter the glide range and a headwind of 10kts will shorten the available distance by 10%.
>
> The following chart shows the approximate gliding distances assuming Nil Wind, No turns, Flaps and Gear Up.

1000 Ft	1.0nm
2000Ft	2.0nm
3000Ft	3.5nm
4000Ft	4.5nm
5000Ft	5.5nm

Figure 6 : extract of "The definitive pilots operating Handbook for the Yakovlev YAK 52" revision 1.4. November 2003

5 This document is an attempt to finally produce a definitive operating handbook for the Yak 52.

1.7 Meteorological conditions.

Based on the METARs from EBCI Charleroi airport and EBFS Florennes air base, the meteorological conditions were adequate for flying in VMC.
The following approximate data prevailed:
Wind direction 130°, windspeed 7 kt, visibility more than 10 km, temperature 7° C, dew point -01°C and QNH 1027 hPa.

1.8 Aids to navigation.

Not applicable.

1.9 Communication.

The military air base of Florennes being active on that day, the pilot was required to fly below 2000' QNH (under 1000' height above ground level). Thereafter, the pilot requested a climb from military ATC and was told to proceed southwards and to wait a few minutes because of crossing military traffic (F-16s).

1.10 Aerodrome information.

Not applicable, as the accident occurred at 12km south of the EBCF airfield (where the elevation of the terrain is about 780 ft (238 m)).

1.11 Flight recorders.

Not applicable

1.12 Wreckage and impact information.

On the crash site initial wreckage examination

Although several pieces were scattered around the main wreckage, all parts of the aeroplane were found at the accident site. The top of a tree showed few broken branches (about 30 mm diameter) that were found on the ground, in the direction of the flight at a distance of 8 to 12 metres from the tree. The flight direction was determined to be about 240° and the wreckage direction was 230°. The height of the tree was estimated to be 9,5 metres and the distance from the tree to the impact was measured at 19,2 metres, deducting that the nose down flight path angle from the top of the tree to the place the aeroplane impacted the ground was about 26°. Examination of the wreckage shows that the landing gear was in extended position and the flaps were fully lowered. The pilot was wearing the safety harness that properly withstood the impact forces.

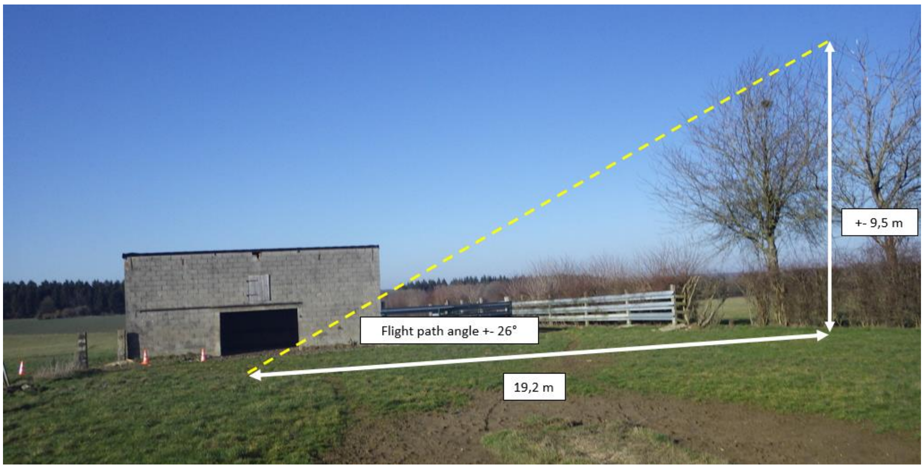


Figure 7: Approximate last flight path angle

Figure 8: Final rest of the wreckage

Both wooden propeller blades disintegrated on impact with the ground and their remains were found at different places. The blade roots were still connected to the propeller hub. The front underside of the engine impacted the ground. The engine separated from the fuselage with the crankshaft pointing towards the R/H with respect to the direction of the fuselage. Despite this, some engine control cables and fluid lines were still connected to the airframe. At impact, the nose landing gear partially detached rearwards and impacted the underside of the fuselage. The front underside of the fuselage structure moved upwards towards the inside of the cabin to such an extent that there was very little space available for the pilot's legs. The pilot's foot rests are displaced at the same level as the seat base. The left wing aileron and a part of the trailing edge of the wing were severed and rested near the pole of a fence located between the initial impact location and the wreckage.

Wreckage detailed inspection

The wreckage examination started out with an external examination of the engine and with the removal of all spark plugs. No obvious external anomaly was found and all spark plugs were found in good condition leading the investigators to determine that no mechanical internal failure had occurred in the combustion chamber of a cylinder (valve failure …).

The above, added to the symptoms reported by the pilot and the mechanic, led the investigators to perform a thorough inspection of the entire fuel system, beginning from the wing fuel tanks and examining the different components of the fuel system up to a deep examination of the carburettor. The wing fuel tanks were found intact and no fuel leak was noticed at the inboard fuel tanks that contained approximately 50 litres of 100 LL blue coloured fuel (about 25 litres in each tank). The fuel tanks were emptied and visual inspection of the fuel samplings and inside each tank did not find any contamination trace. The outboard tanks of both wings were not examined because their caps were locked and the pilot stated that they were empty and not used for a long time. The collector tank was removed and its accessories were disassembled, showing no anomaly. The flexible fuel line inside the tank was inspected and found in good condition. No contamination was found inside the tank.

The fuel shut off valve and the coarse filter, both yellow painted, were found still attached on the remains of the fire wall but they had moved from their original location on the left side of the firewall to the right side. The fuel line connecting the collector tank to the inlet of the fuel shut off valve was severed at the elbow of the shut off valve. The inside of the elbow was found filled with a plug made of black debris that were analysed by the Royal Military School laboratory (RMA) and determined as being a mixture of plastic polyethylene, plastic polypropylene and plastic polycarbonate particles. The origin of these particles looked strange because no similar contamination was found somewhere upstream in the fuel circuit. In particular, the collector tank that is the closer upstream component was thoroughly examined and was determined to be perfectly clean. Finally, a close examination of the ruptured line found that the contamination was greasy and the same kind of contaminant was found not only inside the line but also outside. This could conclude that this contamination occurred during or after the impact.

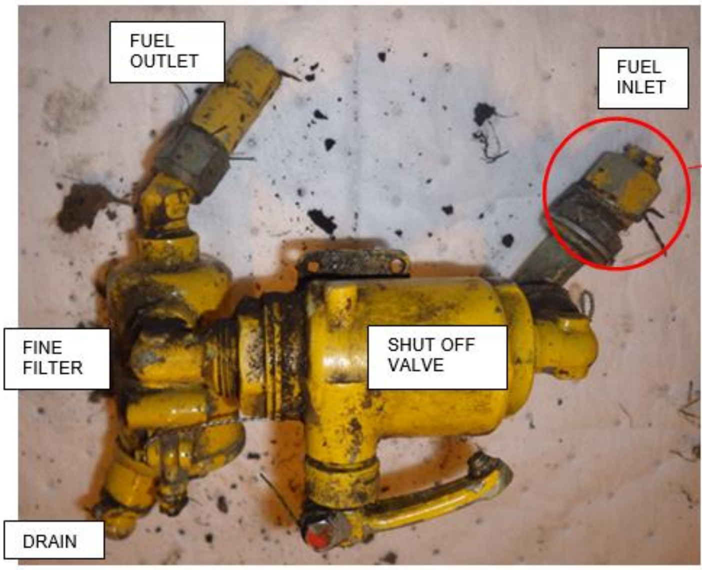


Figure 9: Shut off valve and fine filter fitted together

Figure 10: Fuel inlet elbow of the fuel shut off valve

The outlet flexible line of the coarse filter was found severed close to its end fitting and was obviously contaminated by brown soil and particles of grass, demonstrating that the contamination occurred during the accident or after, possibly when moving the wreckage for its transportation. The cover of the coarse fuel filter was removed for internal inspection. The filter casing and the filter element were found in good condition and without visible contamination, with the filter element properly installed. There was no more fuel and no trace of water inside the casing. The shut off valve assembly was disassembled showing that the connection between the axle and the valve itself was distorted and broken (static failure). The bolt assembling the control to the axle lever was also sheared, indicating it occurred during the accident. The inside of the shut off valve was contaminated by small black particles as seen on Figure 11. Black adhering dirt was also found around the seat of the valve (Figure 12). These contamination products are physically different than the plug of dirt found on the fuel line elbow of the shut off valve.

Figure 11: Particles found inside the shut off valve

Figure 12: Contamination along the shut off valve seat

Figure 13: Magnification of the shut off valve seat contaminants

The thread and the cone at the connection between the coarse filter and the shut off valve were found contaminated with a brown product supposed to be a sealant paste. Normally, no sealant is necessary as the tightness should be obtained by "cone on cone" contacts.

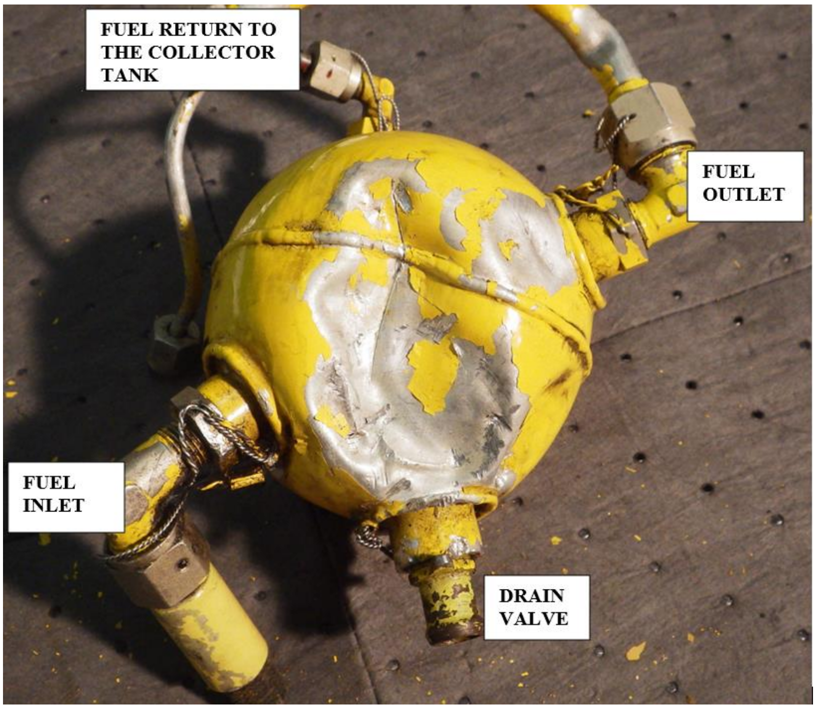


Figure 14: Compensation tank before removal of its connections

The compensation tank still contained a small quantity of liquid that could only be extracted after the removal of the drain valve assembly and shaking the tank. The recovered liquid was identified as being dirty water (about 2,5 centilitres) without any trace of fuel. The inner surface of the drain valve which is in contact with the inside of the compensation tank was found rusted, however there was no contamination particles found inside the compensation tank.

Figure 15: Dirty water from the compensation tank.

Figure 16: Drain valve of the compensation tank

The flexible line at the outlet of the fine filter was disassembled showing that the connection was sealed by an aluminium washer and the addition of a normally not required brown coloured sealant. However, no trace of fuel leak was noticed around this connection which operates under pressure.

Figure 17: Fine fuel filter after the outlet fuel line removal.

The cover of the fine filter was unscrewed, showing evidence of dirt in the cover and on the underside of the filter element. Additionally, the inner side of the cover showed white products being traces of aluminium corrosion.

Figure 25: Contaminants inside of the fine filter cover

Figure 26: Fine filter underside, as seen just after removal of the cover

The filter element made of a metallic very fine mesh fan folded, was found contaminated. The biggest contaminants were of various colour and were visible to the naked eye.
Moreover, close examination of the filter element using a digital microscope determined that the fine mesh was also contaminated with small particles, mostly yellow coloured looking like the paint used to paint most components of the fuel system, partially clogging the narrow interstices of the mesh.

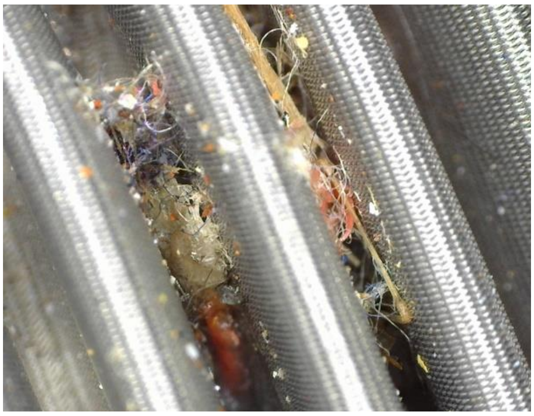


Figure 18: Contamination visible to the naked eye.

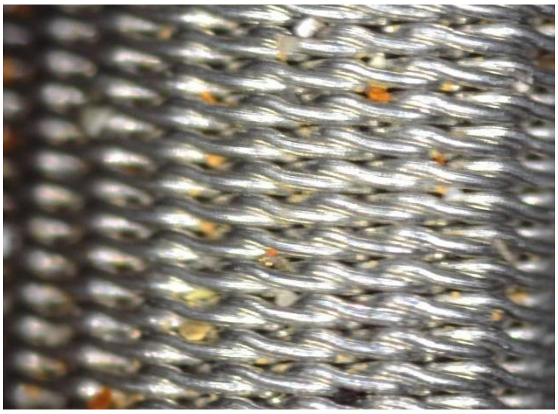


Figure 19: Fine mesh contamination by yellow small particles

Figure 20: Inside of the fine fuel filter body

Figure 21: Fine fuel filter relief valve

After removal of the filter element, the inner side of the fine fuel filter housing was found covered with dirty water droplets. Water was also noticed on the relief valve. After disassembly it became obvious that the entire valve was contaminated with water.

The dual function manual primer was found in locked/neutral position. After removal, the primer was tested for leaks in order to determine the presence of a possible internal leak. Such a leak could have allowed air pressure originating from the engine manifold to enter the fuel system, finally causing the feeding of the carburettor with a mixture of fuel and air. All the tests indicated that the pump was in good condition without internal leak.

Inspection of the carburettor

The fuel inlet elbow screwed in a threaded bore of the carburettor was removed. This elbow was hard to unscrew along its complete thread length suggesting that at least one thread was damaged. Examination of the male and female threads concluded that the male thread of the steel elbow was in good condition but the thread in the bore of the carburettor was found badly damaged. Actually, the female thread inside the fuel inlet bore was dramatically corroded.

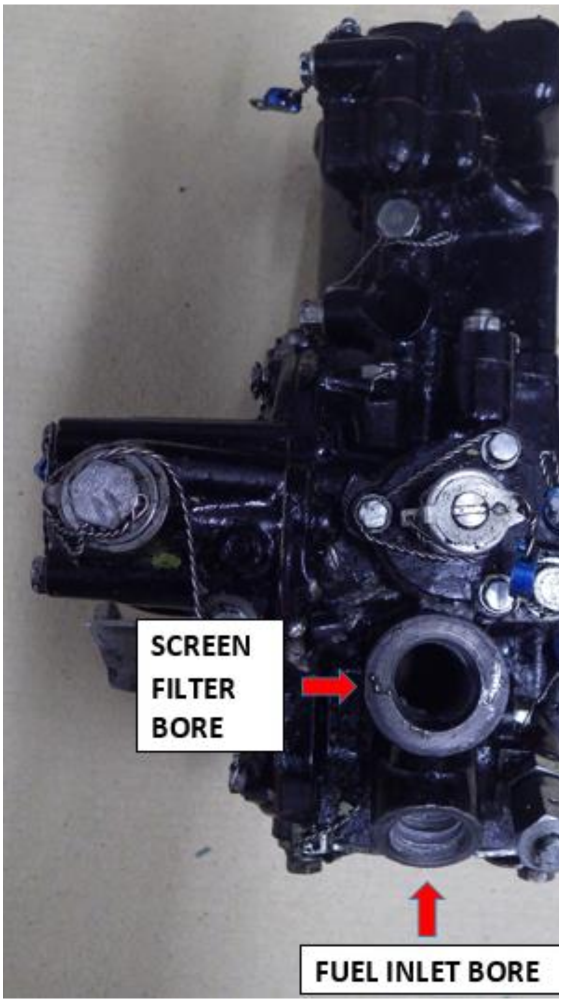


Figure 22: carburettor vertically positioned, as installed on the engine.

Figure 23: fuel inlet bore just after removal of the elbow fitting

This finding at the carburettor inlet bore prompted the removal and the entire disassembly of the carburettor for a detailed internal examination. The fuel screen filter located in the carburettor casing close to the carburettor fuel inlet bore was easily unscrewed and the threads were found in good condition. But the holder of the screen filter showed an accumulation of a grey product at the end of the thread, at a location in contact with the fuel. Nevertheless, no contamination was found inside the filter mesh.

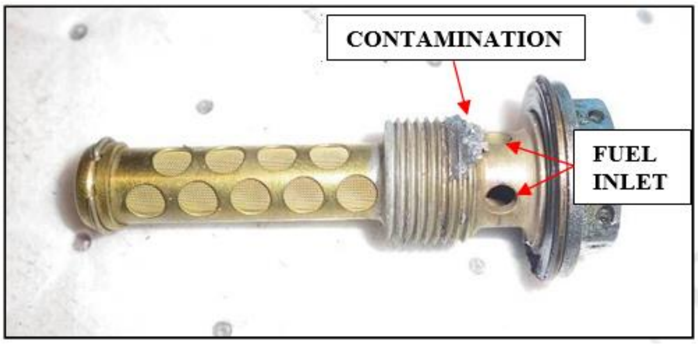


Figure 24: carburettor filter

After removal of the cover of the pressure regulator bore, the fuel chamber feeding the pressure regulator valve was found severely contaminated by white crumbly products later identified as corrosion by-products.

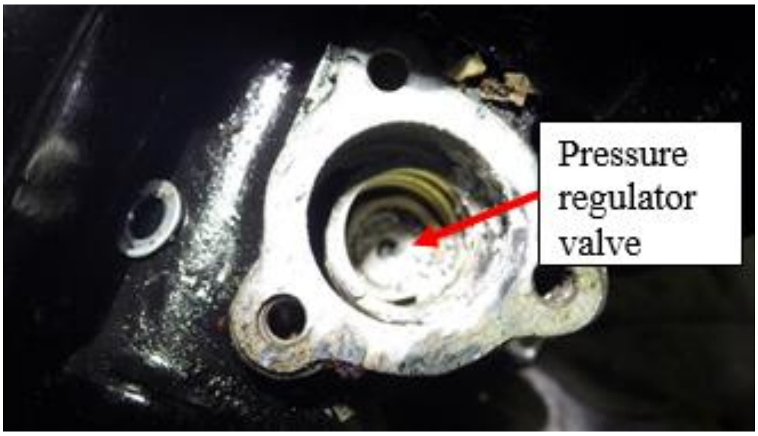


Figure 25: Fuel pressure regulator valve at the bottom of a fuel feeding chamber

The amount of contaminant was so significant that the spring located inside the fuel feeding chamber was trapped by the contaminant. However this spring plays no fuel-metering role and serves only as a safety feature to secure the valve holder.

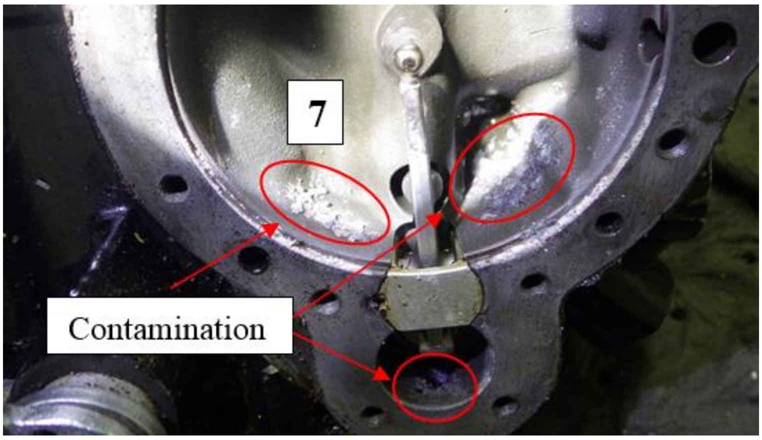


Figure 26: casing of the regulator valve membrane and lever showing contamination

After removal of the membrane, white friable contaminants were found in the lower part of the membrane holder and at the outlet of the pressure regulator valve. The lower part of the fuel inlet chamber of the metering valve was found contaminated, however the metering valve orifices were found unobstructed.

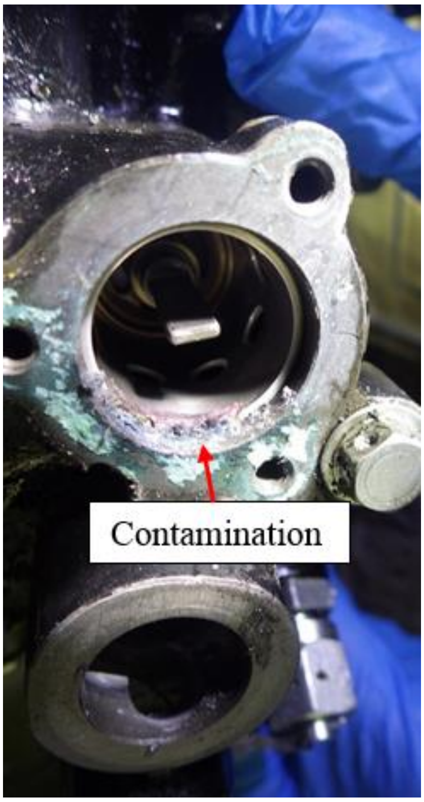


Figure 27: Upper bore: metering valve chamber.

The inspection of the carburettor concluded that 2 locations inside the carburettor were found significantly corroded and contaminated by corrosion residue and other locations were contaminated by corrosion product deposits.
Apart from that, no other anomaly was detected and the general condition of the mechanical sub-assemblies of the carburettor was determined to be consistent with a recently overhauled carburettor.

Assessment of the technical file regarding the overhaul of the carburettor.

An assessment of the carburettor overhaul was performed by a safety investigator from Hungary who acted as accredited representative (AccRep) to support the investigation. The AccRep went in the overhaul company, interviewed the staff and examined the technical file (reference number 031002[6]) of the carburettor overhaul. This document consisting of 5 pages, sets out in detail the carburettor overhaul performed between 21 September 2015 and 16 February 2016. This report shows no anomaly in the work methods.
At the end of the engine overhaul process, the works were certified by “Aerometal Kft” and resulted in the issue, on 2 June 2016, of an EASA Form One for the engine overhaul (Tracking number 2016/116 – Work order A-1591). The engine accessories (magnetos, fuel pump, carburettor…) which are integral parts of the engine overhaul were covered by the same EASA Form One.

6 An extract of this technical file is enclosed at the end of this report.

Engine inspection at Aerometal.

The engine was later returned to the “Aerometal Maintenance Organization” in Hungary for disassembly and parts storage.

The propeller control system was inspected by the Hungarian safety investigation authority SIA at the request of AAIU(Be).

A visual inspection of the oil passages and seals from the governor to the propeller was performed in addition to a general inspection to detect possible mechanical failure in relationship with the propeller control system. No sign of anomaly susceptible to cause a possible internal oil leak, obstruction, mechanical wear or mechanical failure was detected.

1.13 Medical and pathological information.

The pilot was seriously injured at one leg and suffered from chest compression and a back injury but remained conscious.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

The aeroplane was equipped with full aerobatics “Hooker Harness”. The pilot stated that he always ensured that the safety harnesses and the parachutes were protected against moisture and ultraviolet rays to maintain them in good condition.

Figure 28: Safety harness

The pilot survived the impact amongst others thanks to his full aerobatic safety harness system that was in good condition and was carefully fastened.

1.16 Tests and research.

Most fuel system components found contaminated were given to the Royal Military School - RMA laboratory to identify the different types of contamination and as far as possible to determine their origin and/or cause. RMA did an extensive examination of the contaminants and released a detailed report which is enclosed at the end of this report. In summary:

- RMA found that the black plug of dirt at the inlet elbow of the shut off valve was made of plastic polyethylene, plastic polypropylene and plastic polycarbonate particles. The initial assumption that the plug was made of a mixture of soil and engine oil was wrong.
- The particles found inside the shut off valve were made of plastic polycarbonate.
- Beside the contamination by dirt, the inside of the Al alloy casing of the fine filter was corroded.
- The thread of the fuel inlet bore of the carburettor was significantly corroded as well as the feeding chamber of the fuel regulator valve (Mg-Al corrosion). The initial assumption that the thread of the fuel inlet bore had been filled with a 2 component-paste was wrong, the grey friable material was actually the corrosion product of Mg-Al alloy.
- The other contaminant products found inside the carburettor were Mg-Al alloy corrosion deposits originating from the 2 badly corroded areas of the carburettor casing, at the fuel inlet bore and at the pressure regulator valve chamber.

1.17 Organisational and management information.

1.17.1 UK Permit to Fly

A UK National Permit to Fly may be issued by the UK CAA to aircraft that do not meet the International Civil Aviation Organisation (ICAO) certification standards required for the issue of a Certificate of Airworthiness (C of A) subject to satisfying certain requirements. It is granted in accordance with British Civil Airworthiness Requirements BCAR A3-7. Aircraft in this category are generally ex-military, amateur built, microlight, gyroplanes or aircraft without a valid Type Certificate.

When specified on the initial Permit to Fly, the aircraft maintenance programme and any subsequent amendments will be approved by the UK CAA.
When approval of the maintenance programme is not required, which was the case with this aeroplane, the owner/operator is responsible for ensuring that the aircraft is maintained to an airworthy standard.

The base for the issue of the Permit to Fly was Airworthiness Approval Note[7] “AAN” NO: 28459 issued by the UK CAA on 21 February 2003. Amongst others it incorporates a list of required manuals:

7 The Airworthiness Approval Note is a document which records the approval that the particular certificate or permit may be issued (or reinstated following modification). In so doing the AAN provides a record of (either directly or by reference to controlled documents) the build definition of the aircraft or modification, the standards that have been applied, the justification of compliance with those requirements, any restrictions or limitations affecting the approval, and a statement of approval.

5.5 Required Manuals And Other Documents Including Mandatory Placards

a. Flight Manual - The applicant has prepared a set of Pilot's notes based on a translation of the original Pilots Notes for the aeroplane as modified (Ref: Aerobuild Yakovlev Yak 52 Flight Manual AB/FA/52-3) which are considered acceptable.

Later issues accepted by CAA are also considered appropriate provided the limitations as defined in this section of the AAN are not changed.

b. Placards - see section 6 below

c. Electrical Load Analysis - An electrical load analysis in accordance with Airworthiness Notice No 88 shall be carried out – results are shown in 5.2 above.

d. Maintenance Manual - The applicant has elected to use the maintenance manual/schedule as recommended by the aircraft manufacturer. This schedule is defined as Aerobuild Yak 52 Maintenance Schedule ref: YAK 52 at issue 1 dated 3rd December 1993. This schedule must include the list of lifed items as specified in Section 4 of this AAN.

e. Maintenance Schedule - see (d) above

Figure 29 : Extract of Airworthiness Approval Note NO: 28459 dated 21 February 2003

It states that the maintenance schedule elected by the applicant for the maintenance of the accident aeroplane is defined as “Aerobuild Yak 52 Maintenance Schedule ref: Yak 52 at issue 1 dated 3 December 1993”.

An aircraft with a Permit to Fly must not fly unless it has a valid Certificate of Validity, which is valid for one year. Where an aircraft has previously held a Certificate of Validity, a new Certificate may be issued by the UK CAA, by an organisation approved in accordance with BCAR A8-25 (CAMO) or A8-26 (Organisations Supporting Recreational Aviation) for any aircraft within its scope or by an organisation approved in accordance with BCAR A8-15 (Maintenance Organisations – Group M3) for an aeroplane or a rotorcraft with a maximum allowed total weight of 2730 kg or less.

The last Certificate of Validity of the accident aeroplane was issued by Arion Aviation Ltd., which works under an BCAR A8-25 (CAMO) approval.

1.17.2 Permission to Fly over Belgian territory

At the time of the accident, there was no legislation and thus no possibility to register ex-military, historical, or not ‘type-certified’ aircraft on the Belgian register. Aircraft that don’t possess a standard Certificate of Airworthiness as per ICAO Annex 8 but are registered in another state can be granted a Permission to Fly over Belgian territory by the BCAA, if it considered that that state holds an equivalent safety level.

The permission of the aircraft involved was granted based on the UK Permit to Fly and was valid from 1 June 2016 until 31 May 2017. This permission restricts the operation of the aircraft during a total of 30 calendar days, not necessarily consecutive, during this calendar year.

Some operating limitations and conditions:

- All flights shall be operated in accordance with the Aircraft Flight Manual.
- All flights shall be operated in accordance with the operating limitations and conditions of the foreign 'Permit to Fly' and its associated annexes.
- The Belgian flight rules have to be respected.
- Any form of commercial flight is forbidden.

1.17.3 Maintenance Organisations

Over time, different maintenance organisations maintained the aeroplane using other maintenance schedules. The examination of the maintenance records shows that 4 different maintenance schedules were used between 2003 and 2016. It has to be noted that their identification in the maintenance records is not always clear:

- Between 2003 and 2011: Maintenance schedule ref YAK 52 Issue 1, used by the Company YAK UK. This schedule is the one defined in the AAN NO: 28459.
- In 2012 and 2013: Maintenance schedule ref YAK 52 Issue 2 rev3, used by the Company YAK UK. Note: This schedule is likely an evolution of the one defined in the AAN NO: 28459.
- In 2014: Maintenance schedule ref HASL YAKPSS, used by the company HORIZON Aeroplane Service Ltd.
- In 2016: Maintenance schedule (without reference) used by Arion Aviation Ltd. and by Fast Aero (Belgium). This maintenance schedule is also available on the internet.

The investigation could establish that:

- The maintenance schedule ref YAK 52 Issue 1, defined in the AAN NO: 28459 adequately requires the removal and the ultrasonic cleaning of the fuel fine filter (every 50 FH, 100 FH, 200 FH and each year).
- The Maintenance schedule ref HASL YAKPSS, used by the company HORIZON Aeroplane Service Ltd also adequately requires the removal and the ultrasonic cleaning of the fuel fine filter every 50 FH, 100 FH and each year).
- The schedule used by Fast Aero and Arion Aviation Limited does not require the removal and the ultrasonic cleaning of the fuel fine filter. Actually, it contains a typing error asking the oil fine filter cleaning instead of fuel fine filter cleaning.
- None of the above maintenance schedules requires the draining of the compensation tank.

Extracts Of Yak UK Maintenance Schedule

2.3. Replace the filtering element of the fine fuel filter as follows:

- remove locking wire and unscrew the filter cover;
- remove the filtering element;
- install the new filtering element from the spares kit;
- replace packings using the new ones from the spares kit;
- tighten and lockwire the filter cover;
- clean the removed filter element using the ultrasound equipment in accordance with the Instruction No 63.

Figure 30: Maintenance schedule ref YAK 52 Issue 1 (TBCW every 50 FH, 100 FH and 200 FH)

Extracts Of Horizon Maintenance Schedule

39	Change fine fuel filter element. a. Remove wire locking and unscrew filter lid. b. Remove filter element. c. Clean filter with ultrasonic cleaning bath. d. Change filter seals for new ones from kit. e. Refit filter lid and wire lock.

Figure 31: Maintenance schedule ref HASL YAKPSS (TBCW every 50 FH and 150 FH)

Extracts Of Arion And Fast Aero Maintenance Schedule

2.3. Change the filter element of the oil fine cleaning filter, for this purpose:

- remove the locking and unscrew the cover of the filter;
- remove the filter element;
- mount the new filter element from the new single set;
- change the seal rings into new from the spare set;
- screw and tighten the cover of the filter;
- clean the taken off filter element in the ultrasonic instrument according to the instruction No.63.

Figure 32: Maintenance schedule (TBCW every 50 FH, 100 FH and 200 FH)

2. ANALYSIS

2.1 The last phase of the flight

The wreckage examination determined that the aeroplane was found complete at the crash site and that no sign of pre-impact structural failure of the airframe was present. This is consistent with the pilot's statement that the aeroplane remained controllable until the impact with the ground. The pilot stated that he had very little time (about 20 seconds) between the loss of power and the crash. However, witnesses stated that they saw the aeroplane making few circles, considering the circles as being a preparation for a precautionary landing.

Last point on radar was +- 0,5 NM from the crash site at a height of 600 ft AGL. It was flying at this displayed radar height (which has a resolution of 100 ft with an error of +- 50 ft) for 28 seconds. This means that the aircraft could have been between level flight and a descent of maximum 200 ft/min, which indicates that the engine had still enough power as the maximum glide ratio with complete engine failure is 7. For an indicated airspeed of 150 km/h in zero wind conditions the rate of descent is 1200 ft/min in straight flight. In a turn with a bank of 45° it is even 8 m/s or 1600 ft/min. It is likely that the aeroplane disappeared from the radar screen when the engine problems started. In that case the pilot had only half a minute left to cover a ground distance of 0,67 NM. This corresponds to the direct distance of 0,5 NM between the last point on the radar and the crash site and the pilot's statement regarding the little time available from the loss of power to the crash landing.

The circles described by the witnesses were likely the few turns and/or gentle aerobatics manoeuvres performed before the engine problems showed up. The pilot did not have much time to properly prepare for the landing. Just before the last turn he realized that he was too low and gave up the landing in the intended field. His first priority was to maintain a sufficient airspeed to avoid stalling. He therefore decided to fly straight ahead at the last moment, which can explain why he didn't see the line of trees. Additionally, it was February and there were no leaves on the trees making them hardly discernible. After the accident, the propeller blades were found still connected to the propeller hub at the root. They did not separate from the hub but they largely disintegrated on impact with the ground, showing that the engine was still running at some power at impact.

2.2 Troubleshooting made the day before the accident

The initial symptoms of the engine problems were reported by the pilots as "hunting propeller". Since the Yak-52 uses engine oil pressure controlled by the governor to set the propeller speed, such phenomenon can originate from the dropping or fluctuating of oil pressure and/or governor problems. So, the mechanic logically started the troubleshooting looking at an impaired propeller control. Different hypotheses were considered amongst which a too viscous engine oil because of the low temperature that caused a possible malfunction of the propeller control system. However several occurrences of the propeller hunting with unquestionably warm engine oil demonstrated that this assumption was not correct. The oil filters were also checked and finally, the governor was replaced. However, a new engine run showed the same engine hunting and it was decided to reinstall the original governor.

At this stage, the mechanic stopped its troubleshooting in the direction of a propeller pitch control anomaly although it was not fully excluded that another part of the propeller control system could have been involved in a possible malfunction (internal oil leak between the governor and the propeller, propeller anomaly …).

Immediately afterwards the mechanic focused on a possible fuel feeding anomaly. He removed the fuel filter of the carburettor for inspection and opened the coarse fuel filter without any finding. The mechanic blew several fuel lines with air pressure, but he failed to inspect the fine fuel filter and there is no indication that the compensation tank was drained. Although no obvious anomaly was found in the fuel circuit, a new engine ground run was performed; this time it was satisfactory. Therefore, the mechanic had the impression that the problem was solved although he didn't know exactly how and why.

2.3 Findings made in the fuel system after the accident

The external inspection of the engine and the removal of the spark plugs didn't reveal any anomaly. The symptoms of the engine failure as described by the pilot and the maintenance organisation suggested a probable fuel feeding problem or a carburettor malfunction.
Additionally, the troubleshooting made the day before by the mechanic excluded a possible malfunction of the propeller governor. This prompted the investigators to thoroughly investigate the fuel system.
The investigation found several anomalies on the fuel system, some of which having the potential to cause the loss of power and/or engine power fluctuation.

The contamination of the carburettor by corrosion

As the symptoms of engine problems (propeller hunting, power fluctuations and engine loss of power) occurred randomly and most of the time at high power setting, it is possible that it was caused by a carburettor anomaly. The huge amount of crumbly white contaminants in the feeding chamber of the fuel regulator valve has undoubtedly the potential to partially or even totally, depending of the particle size, clog the valve, limiting the fuel flow and causing randomly a too lean non-flammable air fuel mixture. In particular, a partially clogged pressure regulating valve will cause an insufficient fuel flow that will mostly develop at high engine power. As the corrosion found downstream of the pressure regulator valve was only corrosion deposits, it can be concluded that all these particles went progressively through the pressure regulator valve before settling down further in the carburettor. Moreover, the corrosion deposits located downstream of the pressure regulator valve have also the potential to detach and to clog one or several calibrated orifices of the fuel metering needle or nozzle (see **Fout! Verwijzingsbron niet gevonden.** item 13 and 14).
The corrosion quickly developed inside the carburettor casing due to the presence of water located at the lowest points because of the water density. This casing is made of magnesium aluminium alloy, known to corrode easily in presence of water. This water contamination came through the compensation tank and the fine filter. As the fine filter was not equipped with a quick drain, it should have been maintained regularly (every 50 FH) to remove possible water and contaminants. However, there are indications that it had not be cleaned for a while. Additionally, water is obviously non-flammable and when mixed with fuel it also has the potential to disturb the combustion of the fuel air mixture in the combustion chambers of the cylinders.
Conclusion: The contamination of the pressure carburettor by corrosion products is the most probable cause of the engine loss of power. However, it is not excluded that water droplets mixed with the fuel could also have disturbed the combustion.

The contamination of the compensation tank by water

The compensation tank is equipped with a drain valve that should be used to remove possible water accumulation. The fact that the small quantity of liquid retrieved after the accident was exclusively water without fuel suggests that more water was present before the accident.
As the contaminants and the water retrieved in the fine filter went undeniably through the compensation tank, the presence of water in the compensation tank is seen as a possible pre-condition for the contamination of the fine fuel filter and ultimately the internal corrosion of the carburettor.

The contamination of the fuel fine filter

The fine filter assembly is equipped with a relief valve (by-pass differential pressure of about 0,1 Bar) that is deemed to open in case of severe clogging of the filter element to prevent an interruption in the fuel supply. Although a significant quantity of dirt was found in the filter element, the investigation did not find a similar contamination further in the carburettor. The mechanic also did not report a noticeable contamination of the carburettor fuel inlet filter when he performed its troubleshooting before the accident. It is thus likely that the relief valve did not open. However, the fine filter housing contained also a considerable amount of water as shown by the internal corrosion indications in the filter cover. Given the height of water in the fine filter it is likely that the filter element was no longer able to retain the water which therefore flew further in the fuel circuit. This is the origin of the corrosion found in the carburettor and finally its malfunction.
The fine filter element was amongst others contaminated with small yellow particles looking like the yellow paint used to paint the outside of the different components of the fuel system. The investigation found that fuel lines were yellow painted up to their ultimate ends with the risk to involuntarily scrape off paint particles inside the fuel circuit when connecting these lines to their respective components. As no indication was found showing that these lines were recently disconnected and/or painted, it suggests that the fine fuel filter was not cleaned for a long time.
The lack of adequate maintenance of the fuel fine filter was therefore considered as the pre-condition for the internal corrosion of the carburettor.

The plug close to the inlet of the shut off valve

The fuel line at the inlet elbow of the shut off valve was severed during the accident and had been found filled with a plug made of black debris being a mixture of plastic polyethylene, plastic polypropylene and plastic polycarbonate particles. The investigation determined that this plug was not present in the fuel line before the accident. As a matter of fact, a close examination of debris located very close from each other but inside and outside of the fuel line indicated the presence of the same nature of particles. The particles inside the line were also determined to be greasy which is not logical for debris that were supposed to have been in long term contact with fuel. Additionally, a thorough examination of the collector tank located upstream didn’t find any contamination. This indicates that the contamination occurred when the aeroplane impacted the ground or later, maybe during the wreckage transportation.
This anomaly was considered as not being found at the time of the accident.

Unreliable tightness at the inlet of the fuel pump

An untightened connection has the potential to disturb the working of the fuel pump by sucking at the same time a mixture of air and fuel, disturbing the fuel air mixture at the carburettor. As the installation of the fuel inlet elbow on the pump is a static assembly with the elbow securely tightened, a possible lack of tightness would have caused a rather permanent air inlet with a certain reproducibility in the adverse effects, which was not the case. Moreover, the engine problem occurred few months after the engine reinstallation, which suggests that the assembly was air tight despite the poor sealing system of the elbow. This anomaly was considered to be unlikely the cause of the engine loss of power.

2.4 Maintenance of the fuel system – Maintenance schedule

Fast Aero used a maintenance schedule omitting the cleaning of the fuel fine filter and the maintenance company was not aware that this item was missing. Although not required by the schedule, Fast Aero stated that during the maintenance of other YAK-52 they normally cleaned this fuel fine filter on a precautionary basis although they never found any serious contamination. As this item was not required by the maintenance schedule and given the fact that they never found any serious contamination, the maintenance company did not realize the importance of this cleaning.

The cleaning of the fuel fine filter was not performed during the last annual inspection performed in 2016 at the same time as the engine reinstallation. Later, the condition of this fine filter was not examined during the 2 different troubleshooting inspections made before the accident.

Examination of the maintenance documentation used by Fast Aero shows 2 significant anomalies regarding the maintenance of the fuel system:

- An error was introduced during the translation of the maintenance schedule requiring every 50 FH the replacement (or the cleaning) of the oil fine filter instead of the fuel fine filter.
- There is no requirement in the schedule for the draining of the compensation tank located just upstream the fuel fine filter.

Just as in the maintenance schedule used by Arion and Fast Aero, no specific requirement regarding the draining of the compensation tank was found in any other maintenance schedule used since 2003. It is thus likely that this compensation tank was not regularly drained causing after time a certain water accumulation. Water trapped in the tank will not stay at the bottom of the tank when flying inverted or when performing negative manoeuvres. In this case, the fuel and potentially the water in the compensation tank will be mixed and water droplets will be transferred downstream in the fuel fine filter causing after a while the possible saturation of the fuel fine filter and finally the transfer of water to the carburettor.

Additionally, as the aeroplane remained grounded for 11 months at the EBFN military airport located close to the north sea coast, it is possible that some ambient moisture condensed inside the fuel system and in particular inside the compensation tank. This could also explain the presence and the transfer of water further in the fuel circuit ending in the internal corrosion of the carburettor.

2.5 Inspection of the propeller oil feed system

Defect to the propeller control system may generate propeller pitch control anomalies (hunting propeller).
All the oil filters were verified by the mechanics during the troubleshooting performed on 2 January 2017 and no anomaly was found.
The day before the accident, the governor was replaced by another unit and subsequent tests did not show any improvement or change in the symptoms. This shows that the governor was not at the origin of the problem. Moreover, an anomaly between the governor and the propeller would normally have caused a rather permanent problem, which was not the case.
The visual inspection of the propeller control system did also not reveal anomalies susceptible to have caused the loss of propulsion power that led to the accident.

2.6 Maintenance of foreign registered historical aircraft based in Belgium

As pointed out in paragraph 1.17.2, there was no legislation at the time of the accident and thus no possibility to register ex-military, historical, or non-type certified aircraft on the Belgian register. However in October 2017, a Royal Decree was issued to provide a regulation for "historical" aircraft allowing the delivery of a restricted airworthiness certificate to the concerned aircraft.
Before the publication of this regulation, an amount of historical aircraft were already based and operated in Belgium, but they were exclusively foreign registered and were authorized to fly in the Belgium airspace with a limiting Permission to Fly Issued by the BCAA.
The maintenance of these aircraft was performed, where applicable, in an approved workshop located in the country of the registration, or in Belgium by foreign mechanics who were moving in Belgium specifically for the maintenance, or in a Belgian aircraft maintenance organization. In this last case, this means that the workshop needed to be familiar with all of those foreign national regulations for historical aircraft. In some cases a partnership had to be made with a foreign workshop to allow maintenance of the aircraft under their umbrella, which means relying on them for providing and covering all the legal requirements and correct maintenance procedures.
This complex situation could led to misunderstandings having an immediate effect on safety.

3. CONCLUSION

3.1 Findings

- The aeroplane was registered in the United Kingdom in 'Permit to fly category' and was flying under a UK permit to fly certificate.
- A temporary permission to fly over Belgian territory had been granted by the Belgian CAA (valid until 31 May 2017). The aeroplane was therefore in an airworthy condition which means registered and covered by a valid permit to fly certificate.
- The pilot held a valid Airline Transport Pilot Licence ATPL(A) with a valid SEP (Land) class rating and aerobatic privilege adequate for flying a YAK-52 aeroplane.
- Following a previous engine failure, the aeroplane was grounded at the EBFN airport located close to the north sea coast for 11 months, between July 2015 and June 2016 after which the overhauled engine was reinstalled.
- Several occurrences of engine loss of power and propeller hunting were experienced within the 3 months preceding the accident from end 2016 to the accident.
- The maintenance organisation came at the EBCF airfield twice for the troubleshooting of the engine, including the day before the accident.
- At the end of the last troubleshooting actions the engine trouble symptoms had disappeared although their causes could not be clearly identified.
- During the accident flight, the aeroplane first flew uneventfully in the vicinity of the airfield before flying southwards. The engine loss of power occurred after about 10 minutes of flight away from the EBCF airfield.
- Although the engine did not stop operating, the loss of power was such that the pilot could not maintain altitude and had no other choice than to make a forced landing.
- The aeroplane hit the top of a tree just before the landing, pitched down and impacted the ground with an approximate 26° flight path angle.
- Several anomalies were found in the fuel circuit. Amongst others, water contamination was found in the compensation tank and in the fuel fine filter as well as a severe contamination of the fine filter element.
- It was determined that the fuel fine filter cleaning was forgotten during the last maintenance performed in June 2016 at the same time as the engine reinstallation. Additionally there are also indications that this fuel fine filter had not be ultrasonically cleaned for a long time.
- The inside of the magnesium alloy casing of the carburettor was dramatically corroded at 2 low points in particular at the pressure regulator chamber causing a severe contamination by corrosion products and a partial obstruction of the pressure regulator valve.
- The maintenance schedules used during the last years are not the ones mentioned in the Airworthiness Approval Note NO: 28459 dedicated to this aeroplane.
- The schedule used for the last maintenance dated June 2016 omitted the cleaning of the fuel fine filter due to a typing error mentioning by mistake "Oil fine filter" instead of "Fuel fine filter".
- The draining of the compensation tank is not required in any of the used schedules of maintenance, including the one referred to in the Airworthiness Approval Note NO: 28459.

3.2 Cause(s)

Direct cause:

The cause of the accident is the collision of the aeroplane with the top of a tree when performing a forced landing caused by a significant loss of engine power.

Indirect cause

- The engine loss of power was most probably caused by the internal corrosion of the carburettor which partially blocked the fuel flow at the pressure regulator valve. The corrosion of the magnesium alloy casing of the carburettor was likely caused by water contamination.
- The limited height above ground level when the engine loss power occurred and the limited maximum lift to drag ratio did not leave the pilot much time to prepare the landing.

3.3 Contributing factor(s)

- The schedule used for the last maintenance dated June 2016 did not require the cleaning of the fuel fine filter.
- Unlike the fuel coarse filter, there is no drain provision at the fuel fine filter and this filter is black coloured while the vast majority of the fuel system components are painted in yellow. This might have confused the mechanics who involuntary disregarded the inspection of this filter.
- Although the compensation tank is equipped with a drain valve, no requirement was found regarding a periodical activation of this drain in any of the maintenance schedules pertaining to this aeroplane.
- Possible water condensation could have developed inside the compensation tank during the 11 months of grounding of the aeroplane close to the North sea coast where a high level of moisture is often present in the air.
- The releasing to service of an aeroplane where breakdown symptoms disappeared for an unknown reason.
- In February, there were no leaves on the trees making them hardly discernible.

4. SAFETY RECOMMENDATIONS AND SAFETY MESSAGES

4.1 Safety issue : Critical tasks not incorporated in maintenance schedule

Regarding the maintenance of the fuel fine filter.

The cleaning of the fuel fine filter was not incorporated in the maintenance schedule used by both ARION AVIATION Ltd and FAST AERO.

Regarding the maintenance of the fuel compensation tank.

The draining of the fuel compensation tank was not incorporated in the maintenance schedule used by YAK UK, HORIZON AIRCRAFT Ltd, ARION AVIATION Ltd and FAST AERO.

Both omissions in the schedules can cause an inadequate maintenance of the fuel system and a possible penetration of contaminant and water, ending eventually in the carburettor. Therefore:

Safety recommendation BE-2018-0001 to UK CAA

It is recommended that the UK CAA review all current YAK 52 maintenance schedules approved for use in the UK to ensure that the cleaning of the fuel fine filter and the draining of the fuel compensation tank are included and to ensure any future schedules submitted for approval also contain the tasks.

4.2 Safety factor: The releasing to service of an aeroplane where breakdown symptoms disappeared for an unknown reason.

The essence of troubleshooting is to apply corrective actions after having positively identified the cause of the defect. However, it may happen that the symptom of a defect disappears during the troubleshooting which in certain circumstances may give the impression that the problem is solved.

Safety message:

Releasing an aircraft to service when the malfunction symptoms concerning a critical system/item have disappeared without a recognized reason can lead to operate this aircraft with a remaining threat. It should therefore always be ensured that the cause of the defect has been positively determined and corrected before releasing such an aircraft to service.

5. APPENDIX

Analysis of contamination inside aircraft carburettor

Ecole Royale Militaire
Koninklijke Militaire School

Patrimoine - Vermogen
BE95 6790 0213 0158
VAT BE 0209.460.513

Brussels, 21st November 2017
Pages: 15
Annexes: 1

FEDERAL PUBLIC SERVICE
Mobility and Transport
Air Accident Investigation Unit
CCN – 2nd Floor
Rue du Progrès 80 – Bte 5
B-1030 Brussels
BELGIUM

CONCERNS: **Analysis of contaminations inside aircraft carburettor**

References:
1. Email Mr. METILLON d.d. 18 April 2017
2. Our quotation d.d. 19 April 2017
3. Your purchase order N° AD/E201705 d.d. 27 April 2017
4. RMA Materials Lab Activity 17-021-EXP-C.
5. Meeting between the involved parties d.d. 29 August 2017

1. Mission

RMA Materials Lab is asked to examine the carburettor of a crashed airplane in order to firstly determine the nature of an already found contamination and secondly to identify the root cause for failure of the carburettor.

2. Information obtained from FPS Mobility and Transport

Certain parts of the carburettor's fuel circuit contained water droplets, and one of the three filters in the system, the "fine filter", didn't seem to be have been cleaned recently, although the carburettor had been revised less than a year before the crash. This fine filter has been emptied upon the crash, but it still contained evidence of clogging and water droplets.
The carburettor is made of a magnesium alloy, and the initial working hypothesis is that the clogging is due to rapid corrosion of this alloy due to the water present in the fuel system.
There is evidence of a two-component paste used to seal the connection between the fuel inlet and the carburettor; a damaged thread of this connection has indeed been observed. The suspect contamination could thus also be the degradation of said paste.
The crashed airplane was a Russian-made Yakovlev YAK-52. Most of the mechanical information found is in Russian.

Correspondent : Luc RABET
Prof. dr. ir.
Tel. : +32 2 44 13997
Fax : +32 2 44 39186
E-mail : luc.rabet@rma.ac.be

ROYAL MILITARY ACADEMY
DEPT CIVIL & MATERIAL
ENGINEERING
Lab Materials
Renaissancelaan 30
B-1000 BRUSSELS

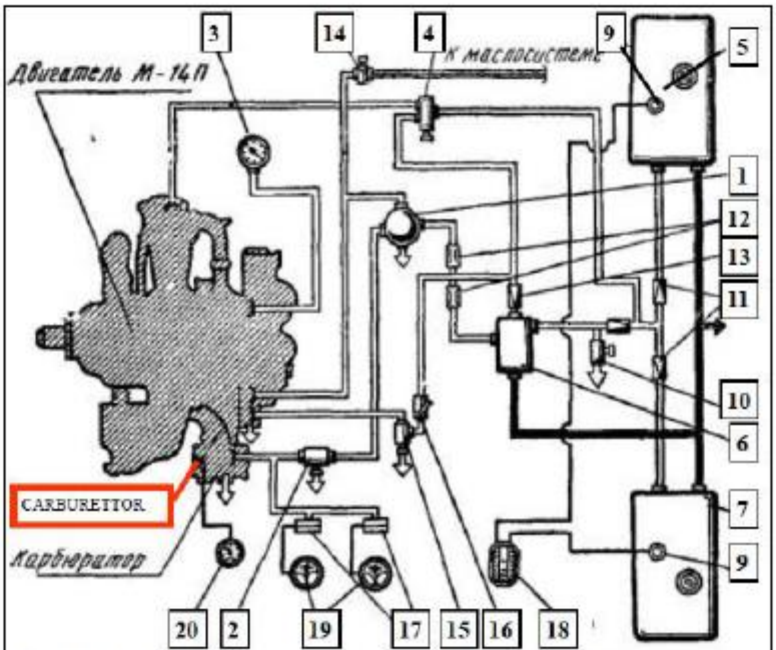
.be

2-

3. Parts examined

The Materials Lab received all the necessary parts from the carburettor and the fuel inlet system. The complete fuelling system is shown in figure 1. A detail of the carburettor is given in figure 2, and shown on the pictures in figure 3. The components of the fuel system and the carburettor that were examined more into detail are cited below:

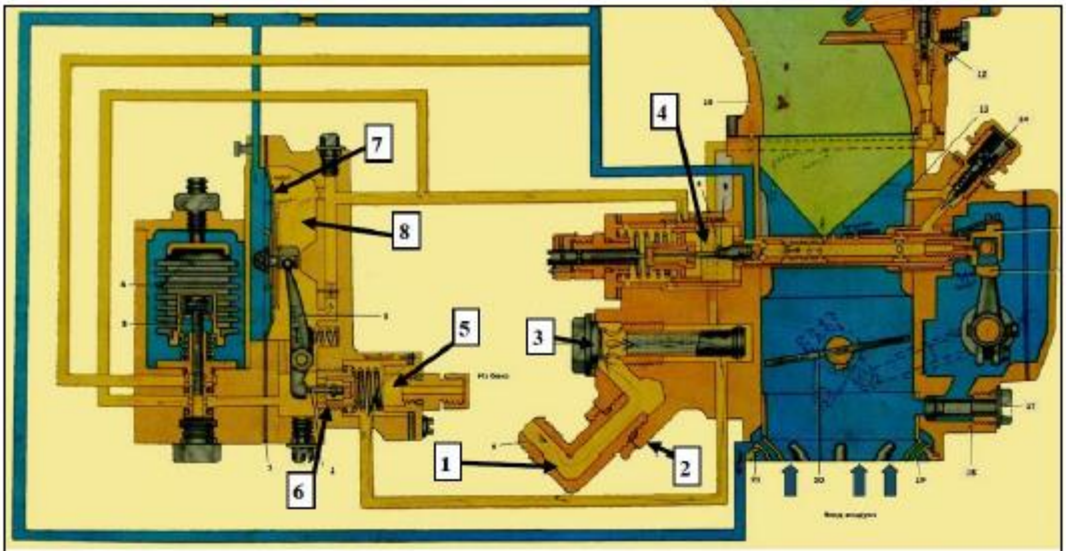
1. Main body of the carburettor.
2. Fuel inlet chamber (item 8 in figure 2).
3. Fuel inlet of the fuel regulator valve (item 5 in figure 2).
4. Fuel inlet bore (item 2 in figure 2).
5. Fuel inlet elbow (item 1 in figure 2).
6. Fuel screen filter (item 3 in figure 2).
7. Fine filter (item 2 in figure 1).
8. Metering valve fuel inlet (item 4 and 8 in figure 2).
9. Fuel shut off valve (item 16 in figure 1).



1. Compensation tank
2. Fine filter
3. Pressure and vacuum gauge
4. Filler syringe (primer pump)
5. Right fuel tank
6. Collector tank
7. Left fuel tank
9. Fuel gage sensor
10. Drain cock
11. Check valves (non-return valves)
12. Flow restrictor
13. Non-return valve
14. Oil dilution valve
15. Coarse filter
16. Fuel shut off valve
17. Pressure receiver
18. Fuel level alarm gauge
19. Fuel pressure indicator
20. Grease temperature gauge

Figure 1: YAK-52 fuel system

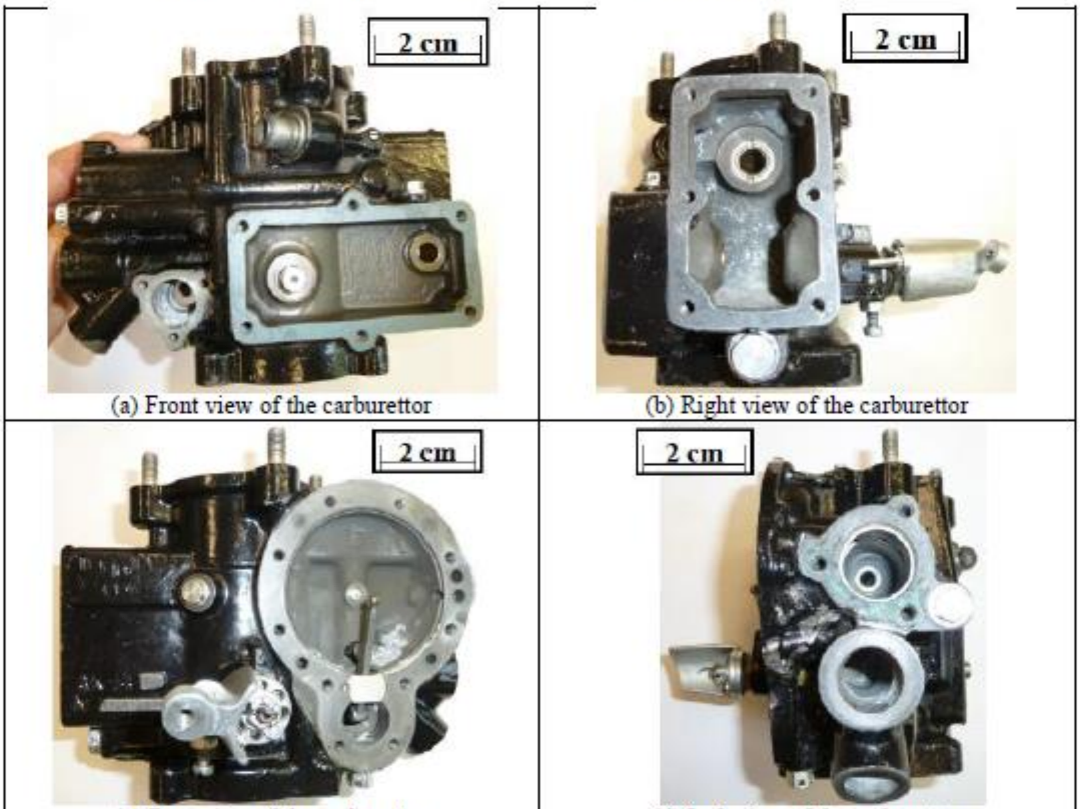
3-



1. Fuel inlet elbow
2. Fuel inlet bore
3. Fuel screen filter
4. Fuel inlet to the metering valve
5. Fuel inlet of the fuel regulator valve
6. Fuel regulator valve
7. Control membrane of the fuel regulator valve
8. Fuel inlet chamber

AIR:
FUEL:

Figure 2: Schematic representation of the carburettor and fuel inlet system. For this report, the as-shown view of the carburettor on the right will be designated as the front-view. The body of the regulator pressure regulator is shown as separate from the carburettor, but in reality they are one piece.



(a) Front view of the carburettor

(b) Right view of the carburettor

(c) Rear view of the carburettor

(d) Left view of the carburettor

Figure 3: Front, rear and side views of the carburettor, with the front being the side visible in Figure 2.

4. Methodology

Several investigation techniques were applied during the analysis, but not systematically onto all examined components, depending on the specific component and the results of previous steps:

a. visual examination of the parts to determine the necessary next steps;
b. visual examination using the light microscope and the SEM (*Scanning Electron Microscope*);
c. determination of the chemical composition using the EDX (*Energy-Dispersive X-ray spectrometer*) coupled to the SEM. The EDX allows the identification and standardless quantification of all elements starting from Na inside a specimen, with a precision of 0.1 mass percentage;
d. determination of the mineral content of granular residue using XRD (*X-Ray powder Diffraction*);
e. determination of the intermolecular bonds using FTIR (*Fourier Transform Infrared Spectroscopy*) by the department of chemistry of the RMA;
f. thermal analysis using DSC (*Differential Scanning Calorimetry*) by the department of chemistry of the RMA.

5. Results

5.1. Examination of the carburettor and the fuel inlet system (Figure 2)

a. Main body of the carburettor (Part 1)

The carburettor is made out of a magnesium alloy containing Al, Cu and Zn as alloying element (for the EDX analysis, see table A.1 in annex 1). For further use in this report, this specific alloy will be referred to as the Mg-Al alloy. Gray-white particles have been found on two places of the main body of the carburettor (figure 4). Also visible is the alleged two-component paste on the thread of the fuel inlet bore (figure 5).

(a) Gray-white particles found on the back side of the carburettor, inside the fuel regulator valve chamber. Picture taken from the back of the carburettor.

(b) Gray-white particles found in the fuel inlet of the fuel regulator valve. Picture taken from the front view of the carburettor

Figure 4: Gray-white particles found on the carburettor main body.

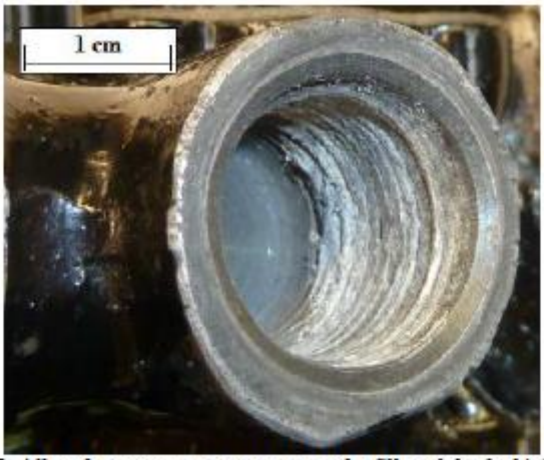
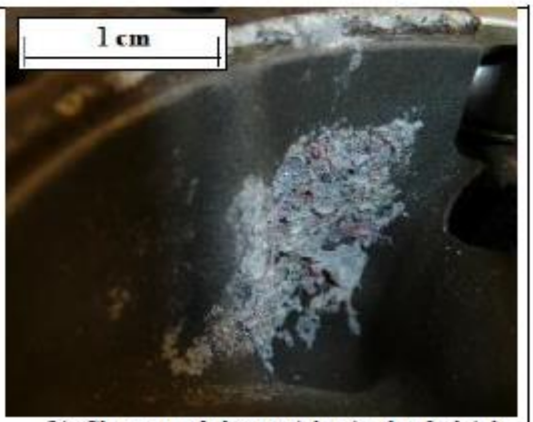


Figure 5: Alleged two-component paste on the fillet of the fuel inlet bore

b. Fuel inlet chamber (Part 2)

The particles from figure 4.a are shown in more detail in figure 6. A micrograph of a particle taken using the SEM is shown in figure 7. Table A.1 in annex 1 show the results of the EDX analysis for 2 particles and also for a milled sample. The particles are mainly Mg, Al, Br and Si with traces of S, Cl, Ca, Cr, Fe and Zn, which is in accordance with what we would expect after corrosion of the Mg-Al alloy. It is important to note that those particles do not originate from the fuel inlet chamber itself, but have been deposited on that location, since there is no evidence of corrosion of the underlying material.

(a) Detail of the particles in the fuel inlet chamber



(b) Close-up of the particles in the fuel inlet chamber.

Figure 6: Detail of the particles in the fuel inlet chamber.

6-

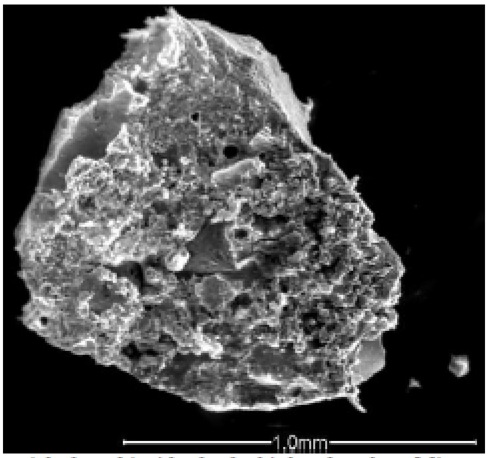


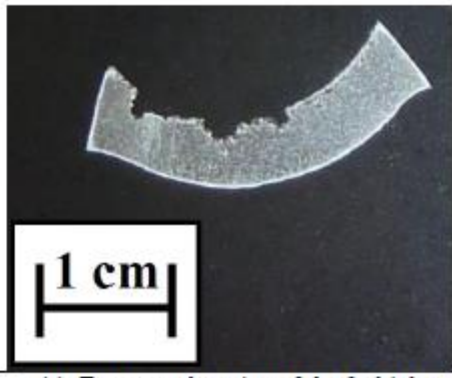
Figure 7: Micrograph of a particle found inside the fuel inlet chamber. Micrograph taken with the SEM at magnification 150x.

c. Fuel inlet of the fuel regulator valve (Part 3)

The fuel inlet of the fuel regulator valve, shown in figure 4.b, has the same particles as the fuel inlet chamber. The EDX analysis (Table A.1 in annex 1) shows a similar composition as the particles found in the fuel inlet chamber (paragraph 5.1.b), namely the corrosion product of the Mg-Al alloy. In order to verify whether these particles are a sediment, as in the fuel inlet chamber, or the result of corrosion inside the fuel inlet, a longitudinal cut of the fuel inlet was made. From this longitudinal section a transversal section was taken, embedded in a resin and polished, to be examined in the SEM (figure 8). The transversal section clearly shows signs of corrosion. Also visible inside the fuel inlet were several particles (figure 8). The inside of the fuel inlet has been galvanized (EDX analysis shows presence of Zn, table A.1 in annex1). The micrographs of the transversal cut taken with the light microscope (figure 9) show that the corrosion is clearly visible and has made several big craters in the material. Consequently, this part is a possible source of the deposited corrosion products found on other parts.

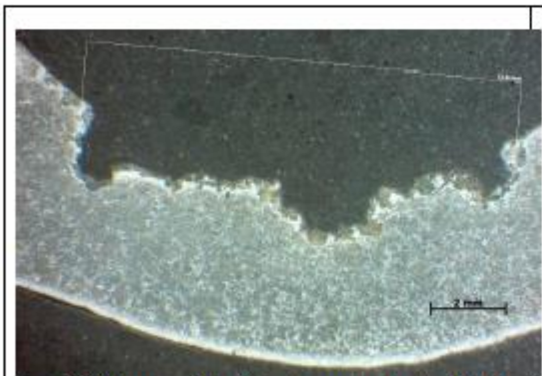
(b) Removed longitudinal piece of the fuel inlet of the fuel regulator valve.

(a) Cut of the fuel inlet of the fuel regulator valve shown on the bottom of the main body of the carburettor.

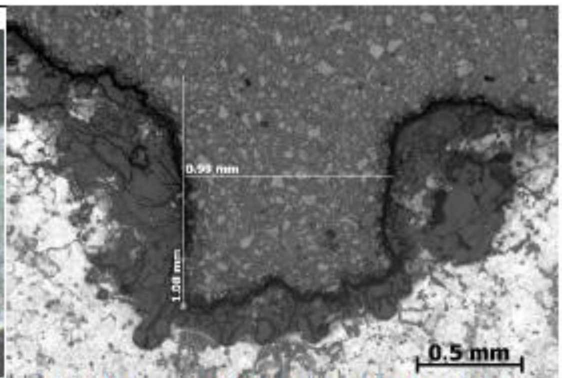


(c) Transversal section of the fuel inlet to the regulator valve. The section clearly shows corrosion of the piece.

Figure 8: Cut out specimen of the fuel inlet to the fuel regulator valve. (a) and (b) show the longitudinal cut, (c) shows the embedded transversal cut, with clearly visible signs of corrosion.



(a) Micrograph of the transversal cut with the light microscope, showing a crater with a width of 11.6 mm



(b) Micrograph of the transversal cut with the light microscope, showing a crater with a width of 0.99 mm and a depth of 1.08 mm.

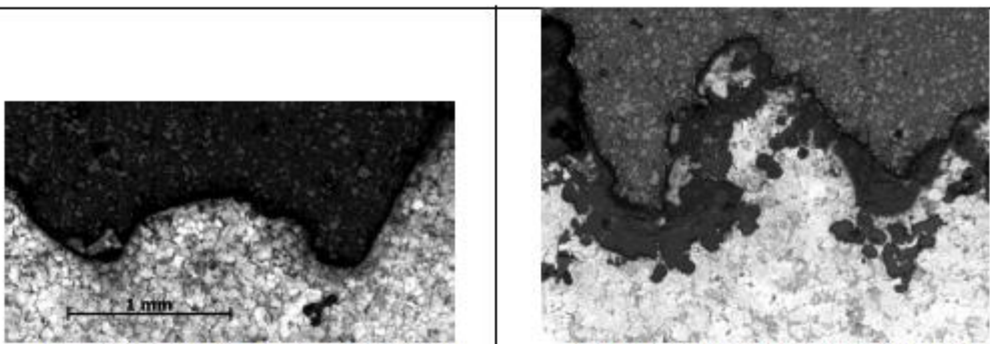
Figure 9: Micrographs of the transversal cut, taken with the light microscope, clearly showing the corrosion of the material.

d. Fuel inlet bore (Part 4)

The fuel inlet bore contains the fillet with the alleged two-component paste, as shown in figure 5. EDX analysis of these particles show that they have a composition similar to that of the other particles found in this report (mostly Mg, Al and Zn). This leads to the conclusion that these particles are not a two-component paste but rather deposited corrosion products originating from the Mg-Al alloy.
A longitudinal cut of the fuel inlet bore has been made, in order to check the eventual corrosion of the component. This semi-cylindrical sample was embedded, resulting in the two sections shown in figure 10. Figure 11 shows details of the corroded thread while figure 12 shows an uncorroded part of the thread for comparison.

(a) Photograph of the longitudinal section, side 1. (b) Photograph of the longitudinal section, side 2.

Figure 10: Photographs of the cut out section of the fuel inlet bore, showing signs of wear and/or corrosion.



(a) Micrograph of the corroded part of the thread of the fuel inlet bore. (b) Micrograph of the corroded part of the thread of the fuel inlet bore.

Figure 11: Detail of the corroded parts of the thread of the fuel inlet bore.

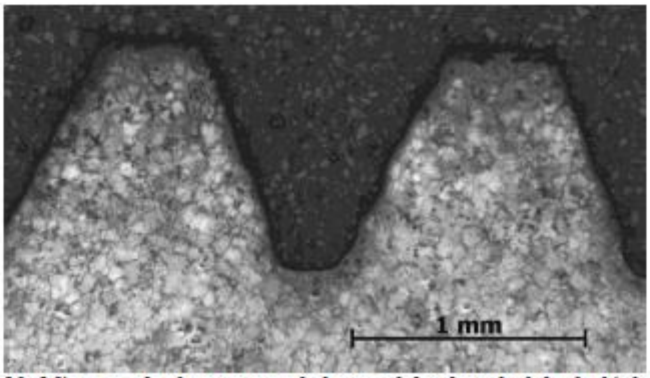
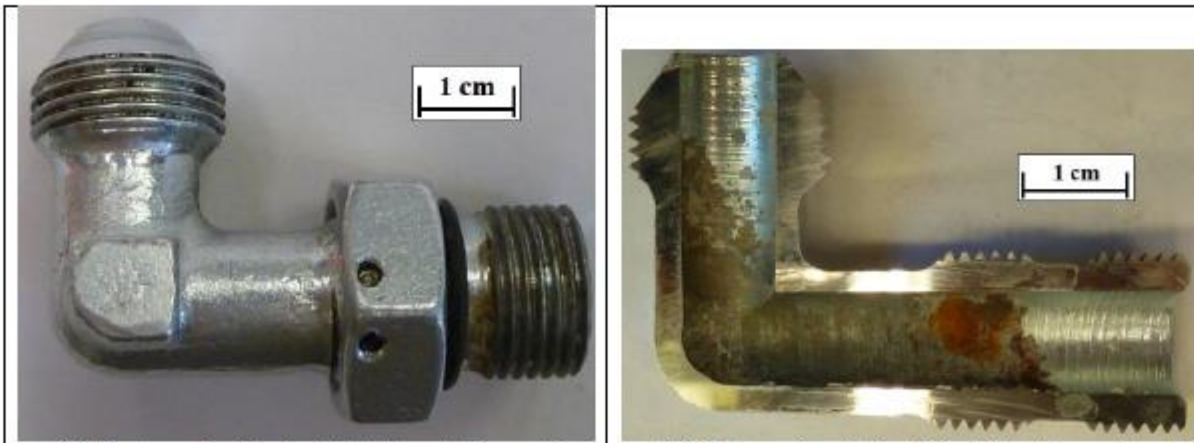


Figure 12: Micrograph of an uncorroded part of the thread of the fuel inlet bore.

e. <u>Fuel inlet elbow</u> (Part 5)

Inside the fuel inlet elbow several particles were visible. In order to be able to examine them, we made a longitudinal section through the elbow (figure 13). Two parts of this longitudinal section have been embedded and polished for examination in the SEM (figure 14). The micrographs taken with the SEM are shown in figure 15, clearly showing corrosion of the fuel inlet elbow. The EDX analysis (table A.1 in annex 1) shows that the base material is made from steel and that the part has been galvanised. The observed particles can be linked to three different origins:

- corrosion of the fuel elbow inlet itself;
- sediment of the corrosion of the Mg-Al alloy;
- parts of the galvanisation layer.



(a) Photograph of the fuel inlet elbow before cutting.

(b) Photograph of the fuel inlet elbow after the longitudinal cut.

Figure 13: Photographs of the fuel inlet elbow before and after cutting.

10-

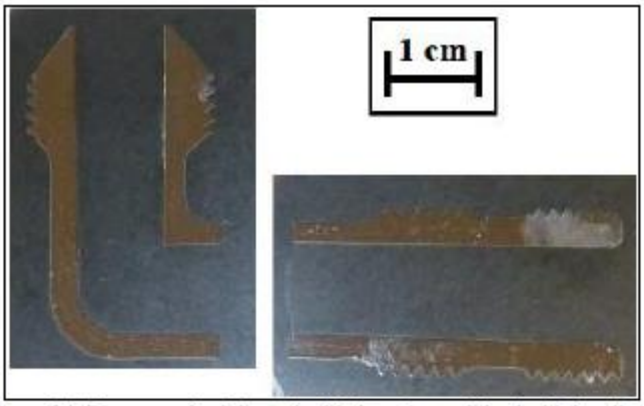
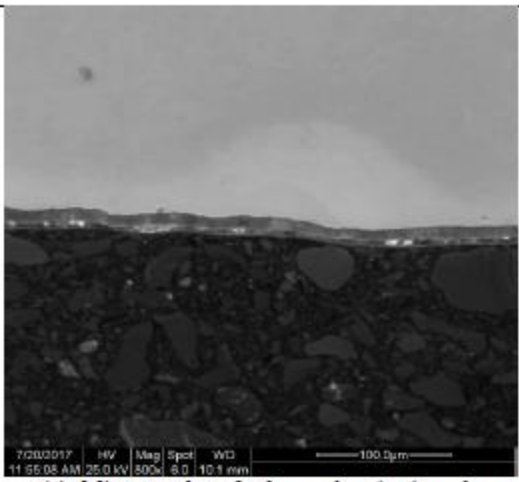
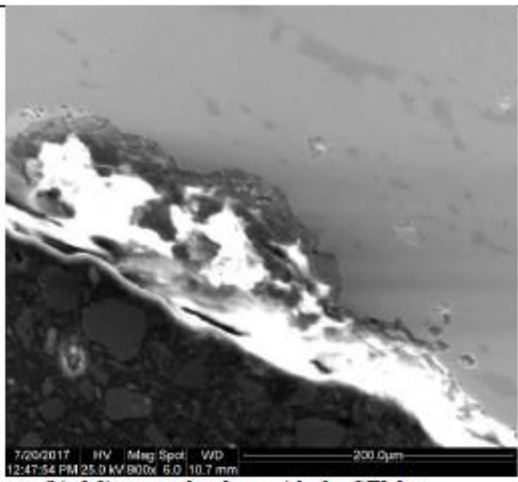


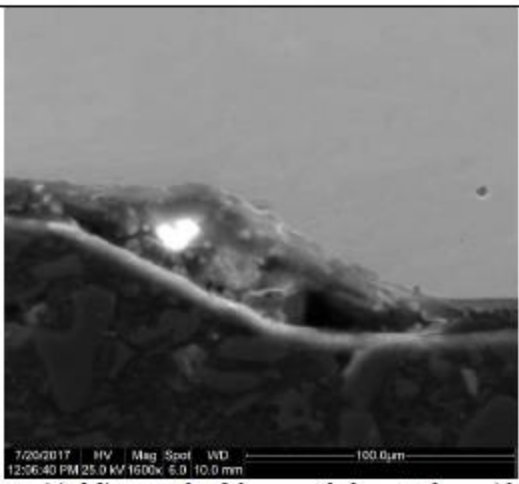
Figure 14: Photograph of the embedded sections of the fuel inlet elbow.



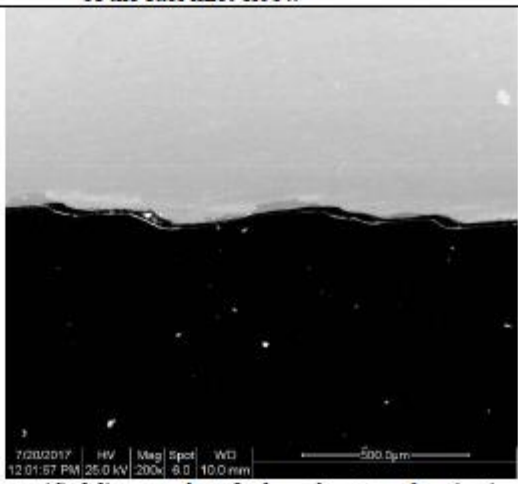
(a) Micrograph of the galvanisation layer, taken with the SEM at magnification 800x.



(b) Micrograph taken with the SEM at magnification 800x, showing the corrosion of the fuel inlet elbow



(c) Micrograph of the corroded part, taken with the SEM at magnification 1600x.



(d) Micrograph of the absent galvanisation layer, taken with the SEM at magnification 200x.

Figure 15: Micrographs of the embedded longitudinal cuts of the fuel inlet elbow, taken with the SEM.

f. Fuel screen filter (Part 6)

On thread of the fuel screen filter several particles were found (figure 16). These particle have a composition similar to the other particles found in the carburettor (EDX analysis, table A1 in annex1), coming from corrosion of the Mg-Al alloy, and containing particles of the galvanisation layer.

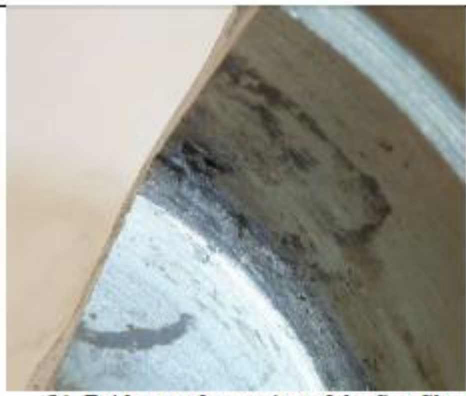
Figure 16: Photograph of the fuel screen filter, with the particles visible on the thread.

5.2. Examination of the other parts of the fuel system (Figure 1)

a. Fine filter (Part 7)

Inside the cover of the fine filter a large number of particles were found. These particles contained a significant amount of Al, with to a lesser extent Mg, Si, S, Cl, Fe, Ni, Cu and Br (EDX analysis, table A1 in annex 1). The base material of the cover is an aluminium alloy (92.7 mass percentage Al with additional Mg, Si, Fe, Ni and Cu). There are also clear signs of corrosion of the cover of the fine filter, which leads to the conclusion that the particles inside the cover come from the cover itself (figure 17). The Lab Materials also received the particles that were recovered after cleaning the fine filter. The gray-white particles have the same composition as the other particles found (corroded Mg-Al alloy), the black particles consist of Ba and S (EDX analysis, table A.1 in annex).

(a) Photograph of the inside of the fine filter cover.



(b) Evidence of corrosion of the fine filter cover.

Figure 17: Photographs of the cover of the fine filter, clearly showing the corrosion in (b).

12-

b. Metering valve fuel inlet (Part 8)

On the metering valve (figure 18) the same corroded Mg-Al alloy particles were found. (EDX analysis, table A.1 in annex). The base material of the metering valve is the Mg-Al alloy, but there are no signs of corrosion, leading to the conclusion that the particles have been deposited.

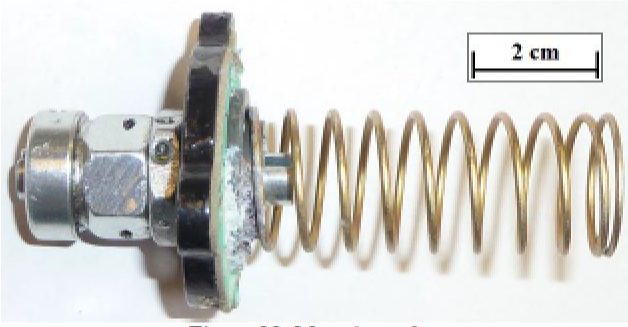


Figure 18: Metering valve

c. Fuel shut off valve (Part 9)

The fuel shut off valve and its connection to the coarse filter (figure 19.a) contain several particles and contaminations. Following particles have been examined:

(a) the particles found inside the shut off valve, received from the AAIU;
(b) the suspected sealant paste found on the connection (figure 19.b);
(c) the contamination found in the connection (figure 19.c and d).

These particles (a) and (c) were examined with the EDX (EDX analysis, table A1 in annex 1), and were found to be different from the corroded Mg-Al alloy particles found throughout the carburettor. The composition of the suspected sealant paste could not be determined by an EDX analysis, nor by an XRD analysis, due to the non-crystalline nature of the particles. All particles were forwarded to the department of chemistry of the RMA for a FTIR and DSC examination. The Chemistry department found that all transmitted samples are composed of a mixture of different types of plastic, more particularly polycarbonate, polyamide, polyethylene and polypropylene. The breakdown of the found particles is shown in table 1.

Table 1: Results of the FTIR analysis of the particles.

Particle	Description of the particle	Composition of the particle
(a)	Particles found in the fuel shut off valve.	Plastic: polycarbonate
(b)	Suspected sealant paste found on the connection.	Plastic: polyamide
(c)	Contamination in the connection, brown particles.	Plastic: polyethylene
(c)	Contamination in the connection, white fibres.	Plastic: polypropylene
(c)	Contamination in the connection, green fibres.	Plastic: polypropylene
(c)	Contamination in the connection, white particles.	Plastic: polycarbonate
(c)	Contamination in the connection, black residue.	Plastic: polyethylene

(a) Elbow connecting the fuselage fuel line to the fuel shut of valve at the firewall.

(b) Suspected sealant paste.

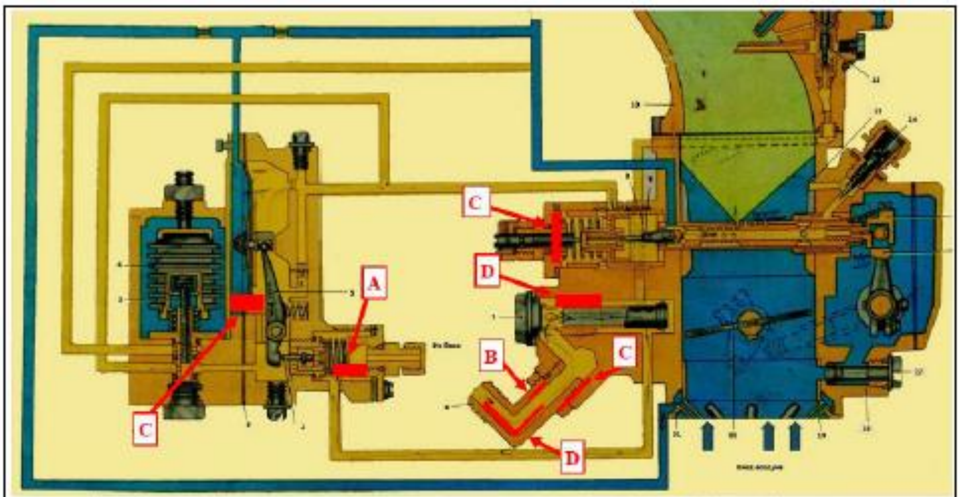
(c) Contamination before removal from the connection.

(d) Contamination after removal from the connection.

Figure 19: Contaminations found in the connection between the shut off valve and the main fuel line.

5.3. Summary of particle analysis results

A summary of all the parts analysed by EDX or the FTIR analysis is found in table 2. A graphical representation of the found particles, whether as sediment or direct corrosion, is given in figure 20 for the carburettor and in figure 21 for the fuel system.



A. Corrosion of Mg-Al alloy
B. Corrosion of steel
C. Corrosion of Mg-Al alloy + sediment
D. Sediment of Mg-Al corrosion + Zn

Figure 20: Graphical representation of the corrosion and sediment found inside the carburettor system

Overhaul report of the carburettor

T12512084 gyári számú AK-14P PORLASZTÓ

JAVÍTÁSI LAP

A berendezés összes üzmideje: ...... óra. Ebből az utolsó nagyjavítás óta ...... órát üzemelt

Eddig ...... -szer volt nagyjavítva. A javításba küldés oka ......

A javítás kezdetének időpontja: 2015.09.21 Motor gyári száma: 031002

A javítás során végzett munkálatok jegyzéke

Sorsz.	A művelet megnevezése:	Munkát végezte:	MEO:
1	A porlsztó szétszerelése		
2	Az alkatrészek lemosása benzinnel, szárítása sűrített levegővel		
3	Repedés vizsgálat		
4	A berendezés összes alkatrészének hibafelvételező át-vizsgálása, hibajegyzék elkészítése		
5	Az összes hiba kijavítása a javítási lap szerint		
6	Kiegészíteni a berendezést a hiányzó alkatrészekkel	MEO	
	Átvettem az alkatrészeket. Dátum:		
7	Elszívófúvóka csere ø140mm		
8	Összeszerelni és beszabályozni a berendezést		
9	Kipróbálni a berendezést és kitölteni a jegyzőkönyvet		

HIBALAPJA

Sorsz.	Az észlelt hiba megnevezése és a javítás módja	Munkát végezte:	MEO:
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

26

T12512084 gyári számú AK-14P PORLASZTÓ

LECSERÉLT ALKATRÉSZEK

Sorsz.	Az alkatrész	Száma:	A csere oka
1	Alátét, 1db	59002	Kötelező
2	Alátét, 1db	59003	Kötelező
3	Alátét, 1db	59511	Kötelező
4	Alátét, 1db	84012	Kötelező
5	Tömítőgyűrű, 1db	134.1103	Kötelező
6	Tömítőgyűrű, 1db	3044113	Kötelező
7	Csavar, 2db	3044114	Kötelező
8	Tömítés, 1db	171.501	Kötelező
9	Tömítőgyűrű, 1db	533.105-1	Kötelező
10	Rögzítőzár, 1db	633.109-1	Kötelező
11	Tömítés, 1db	533.120	Kötelező
12	Membrán, 1db	633.126-1	Kötelező
13	Tömítőgyűrű, 1db	633.128-1	Kötelező
14	Ólomzár, 8db	244A	Kötelező
15	Rögzítőcsavar, 2db	655.408	Kötelező
16	Alátét, 1db	3402A-0,5-410	Kötelező
17	Alátét, 1db	6N-5-10-1	Kötelező
18	Alátét, 29db	2651sz55-5	Kötelező
19	Kónuszos csap, 1db	N-4554	Kötelező
20	Tömítőgyűrű, 4db	40014A-1,4/1,5	Kötelező
21	Tömítőgyűrű, 1db	2609sz52-5-1,5G	Kötelező
22	Tömítőgyűrű, 5db	52-6-1,5-G	Kötelező
23	Tömítőgyűrű, 1db	52-8-1,5-G	Kötelező
24	Tömítőgyűrű, 5db	52-8-2-G	Kötelező
25	Tömítőgyűrű, 1db	52-9-1,5-G	Kötelező
26	Tömítőgyűrű, 3db	52-10-1,5-G	Kötelező
27	Tömítőgyűrű, 1db	52-10-2-G	Kötelező
28	Tömítőgyűrű, 1db	52-12-2-G	Kötelező
29	Tömítőgyűrű, 1db	52-14-2-G	Kötelező
30	Tömítőgyűrű, 1db	52-15-2-G	Kötelező
31	Tömítőgyűrű, 1db	52-16-2-G	Kötelező
32	Tömítőgyűrű, 1db	52-42-2-G	Kötelező
33	Sasszeg, 1db	1×6-216	Kötelező
34	Sasszeg, 3db	1,6×8-216	Kötelező
35	Sasszeg, 1db	1,6×10-216	Kötelező
36	Rugós alátét, 1db	2621sz55-5	Kötelező
37	Rugós alátét, 1db	2621sz55-6	Kötelező
38	Elszívó fúvóka, 1db	134-306/110	Kötelező
39			
40			
41			
42			
43			
44			

Dátum: 2015. 10. 07. Hibafelvételező:

27

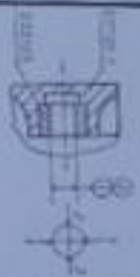
T12512084 gyári számú AK-14P PORLASZTÓ

MÉRÉSI LAP

	Csúsztató ív 655.118 max. ø9,07				Csúszócsap 655.119 min. ø8,96				Rés: +0,015 +0,10	
	Hibafelv.		MEO		Hibafelv.		MEO		Hibafelv.	MEO
	a	b	a	b	a	b	a	b		
1			9,	03			8,	98		0,05
2				03				99		

	Csúszópersely a csúszócsap végén 655-118 max. ø7,07				Csúsztató ív kar csapszeg 655.120 min. ø6,95				Rés: +0,015 +0,12	
	Hibafelv.		MEO		Hibafelv.		MEO		Hibafelv.	MEO
	a	b	a	b	a	b	a	b		
1			7,	02			6,	98	0,04	
2				02				98		

	Persely a házban 655.105 max. ø10,10				Adagoló tű kartengely 655.117 min. ø9,98				Rés: +0,013 +0,12	
	Hibafelv.		MEO		Hibafelv.		MEO		Hibafelv.	MEO
	a	b	a	b	a	b	a	b		
1			10,	01			9,	98		0,03
2				01				98		



	Persely a házban a másik oldalon 655.106 max. ø10,10				Adagoló tű kartengely 655.117 min. ø9,98				Rés: +0,013 +0,12	
	Hibafelv.		MEO		Hibafelv.		MEO		Hibafelv.	MEO
	a	b	a	b	a	b	a	b		
1			10,	01			9,	98	0,03	
2				01				98		

	Fúvóka cső 113.402 max. ø11,019				Adagoló tű 677.108 min. ø10,98				+0,006 +0,07	
	Hibafelv.		MEO		Hibafelv.		MEO		Hibafelv.	MEO
	a	b	a	b	a	b	a	b		
1			11,	01			10,	98	0,03	
2				015				95		

Megjegyzés:
Mindkét alkatrész maximális elhasználódása esetén selejtezni kell!
A rés-méret betartása lényeges előírás!

Dátum: 2015. 10. 07. Hibafelvételező:

28

T12512084 gyári számú AK-14P PORLASZTÓ

MÉRÉSI LAP

	Henger a házban 65152 max. ø25,10				Gyorsító pumpa dugattyú 65136 min. ø24,96				Rés. +0,02 +0,14	
	Hibafelv.		MEO		Hibafelv.		MEO		Hibafelv.	MEO
	a	b	a	b	a	b	a	b		
1			25	,01			24	96	0	06
2				,03				96		
	Adagoló tű villa belső része 655.220 max. ø8,12				Görgő 533.126 min. ø7,90				Rés +0,015 +0,15	
	Hibafelv.		MEO		Hibafelv.		MEO		Hibafelv.	MEO
	a	b	a	b	a	b	a	b		
1			8	04			7	96	0,08	
2				,05				96		
	Adagoló tű kar. görgő belső felület 655.225 max. ø4,07				Görgő csapszeg 655.226 min. ø3,96				Rés. +0,011 +0,08	
	Hibafelv.		MEO		Hibafelv.		MEO		Hibafelv.	MEO
	a	b	a	b	a	b	a	b		
1			4	,01			3	98	0,03	
2				,02				98		
	Persely a házban 655.103 max. ø10,10				Pillangó szelep tengely 171.201 min. ø9,97				+0,013 +0,13	
	Hibafelv.		MEO		Hibafelv.		MEO		Hibafelv.	MEO
	a	b	a	b	a	b	a	b		
1			10	01			9	98	0,	04
2				05				98		
	Persely a házban a másik oldalon 655.104 max. ø10,10				Pillangó szelep tengely 171.201 min. ø9,97				Rés. +0,013 +0.13	
	Hibafelv.		MEO		Hibafelv.		MEO		Hibafelv.	MEO
	a	b	a	b	a	b	a	b		
1			10	01			9,	98	0	04
2				03				98		

Dátum: 2015. 10. 07. Hibafelvételező: [stamp]

29

T12512084 gyári számú AK-14P PORLASZTÓ

KIPRÓBÁLÁSI JEGYZŐKÖNYVE

Sorsz.	A művelet megnevezése:	Munkát végezte:	MEO:
1	**Ellenőrző átadási kipróbálás**		
2	**Konzerválás:** a konzerválás érvényessége: Ø Hónap		
3	**Különleges észrevételek:**		

Záradék: A berendezés megjavítva, beszabályozva és kipróbálva az M-14V26/2-2/1 sz. technológia szerint. A próba alkalmával a berendezés paraméterei az előírtnak megfeleltek. A berendezés motoron való üzemeltetésre alkalmas, üzemidő a következő javításig: 500 óra.

.... MEO Dátum: 2016.02.16

30

Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

AAIU-2017-AII-02

Air Accident Investigation Unit - (Belgium)
City Atrium
Rue du Progrès 56
1210 Brussels

Phone: +32 2 277 44 33
Fax: +32 2 277 42 60

air-acc-investigation@mobilit.fgov.be
www.mobilit.belgium.be

PENDIX