Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

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Safety Investigation Report

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SERIOUS INCIDENT CESSNA 152 AT TEMPLOUX ON 31 OCTOBER 2017

AAIU-2017-55

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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 the determination of the causes, and to define recommendations in order to prevent future accidents and incidents.

In particular, Article 17-3 of EU regulation EU 996/2010 provides 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 BEA and the NTSB

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

SYMBOLS AND ABBREVIATIONS

’	Minute(s)
‘’	Second(s)
°C	Degrees centigrade
A	Aeroplane
AAIU(Be)	Air Accident Investigation Unit (Belgium)
AD	Airworthiness Directive
AGL	Above Ground Level
ATC	Air Traffic Control
ATPL	Airline Transport Pilot Licence
BCAA	Belgian Civil Aviation Authority
BEA	Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile (France)
E	East
EASA	European Aviation Safety Agency
EBNM	Aerodrome of Namur/Suarlée
EU	European Union
FAA	Federal Aviation Administration (USA)
FH	Flight hour(s)
ft	Foot (Feet)
hPa	Hectopascal
Kg	Kilogram
kt	Knot(s)
LH	Left hand
m	Metre(s)
m^2	Square metre(s)
mm	Millimetre(s)
Hz	Hertz
MHz	Megahertz
MPA	Motor-powered aircraft
N	North
NTSB	National Transportation Safety Board (US)
O/H	Overhaul
PMA	Parts Manufacturer Approval
QFU	Magnetic bearing of a runway
QNH	Pressure setting to indicate elevation above mean sea level
RH	Right-hand
RPM	Revolutions per Minute
RWY	Runway
SCF-PP	System/Component Failure or malfunction - Powerplant
SE	South-East
SEP	Single Engine Piston rating
STC	Supplemental Type Certificate
SW	South-West
TRE	Type rating examiner
TRI	Type rating instructor
UTC	Universal Time Coordinated[1]

[1] Note about 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 risks. In other words, it is something that, if it occurs 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 taken into account 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 communicate in an investigation report in the interests 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 a 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: A message focusing on 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.

Federal Public Service
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AAIU-2017-55

SYNOPSIS

Classification:	Serious Incident	**Type of operation:**	Non-Commercial - Local
Level of investigation:	Standard investigation	**Phase:**	Initial climb
Date and time:	31 October 2017 13:05 UTC	**Operator:**	Private
Location:	Off EBNM airfield	**Persons on board:**	2
Aircraft:	Cessna 152	**Aircraft damage:**	None
Occurrence category:	Powerplant failure (SCF-PP)	**Injuries:**	None

Abstract:

A Cessna 152 made a forced landing after take-off at the aerodrome of Namur-Suarlée (EBNM) due to a loss of power.

Cause(s):
<u>Direct cause</u>

The cause of the engine malfunction and the subsequent forced landing is the contamination of the carburettor float chamber by a small insect (fly) that obstructed the fuel feed to the main nozzle. The insect entered inside the float chamber of the carburettor via the vent of the float chamber of the carburettor.

<u>Indirect cause</u>

The combination of:
- The design of the carburettor featuring an internal line for the venting of the float chamber which is not protected by a filter and that is directly exposed to the carburettor inlet airflow, allowing the penetration of possible contaminants.
- The aeroplane induction system lacking a filtering system aimed to stop the penetration of contaminants when the air induction heater system (anti-icing system) is selected.

<u>Contributing factor</u>

Using the carburettor heater up to the landing on a grass runway where many insects are often present close to the ground.

1. FACTUAL INFORMATION

1.1 History of flight.

The pilot took the airplane from the airport of Namur-Suarlée (EBNM) for a flight of one hour, with one passenger on board. During this flight, the pilot did not notice any anomaly; all parameters were normal.

When returning back to EBNM, the pilot wanted to perform a series of touch and goes before making a full stop. In downwind, the pilot selected the carburettor heat and flaps fully down. The approach to the RWY 24 and the first landing were uneventful. When rolling, the pilot reapplied full power, set the carburettor heater off and retracted the flaps to 10°.

At the beginning of the downwind, at 1100 ft QNH (500 ft AGL), the engine experienced a loss of power. The pilot reset the carburettor heater 'ON' and checked the controls (mixture to full rich, primer locked, fuel tank shut off valve horizontal), without any improvement. When advancing the throttle, the engine regained some power for a short time, then lost power.

Already descended to 300 ft AGL, and still in the downwind leg, the pilot took the decision to make an emergency landing in a field. The airplane landed on an open field, rolled for 150 m and came to stop in an adjacent beet field without any damage The occupants could evacuate the aeroplane uninjured.

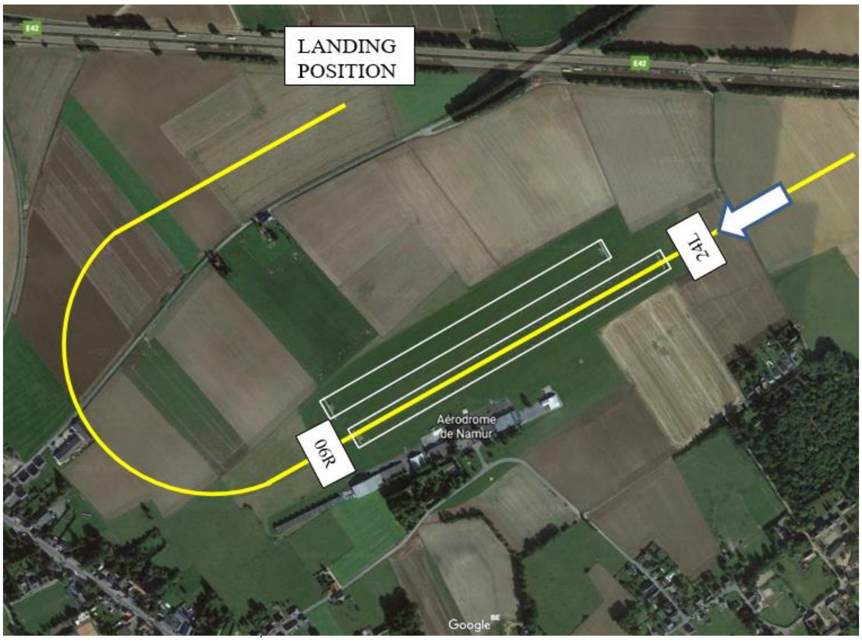


Figure 1: Approximate flight path and final position after the forced landing

1.2 Injuries to persons.

Injuries	Crew	Passenger	Others	Total
Fatal				
Serious				
Minor				
None	1	1		2
Total	1	1		2

1.3 Damage to aircraft.

Nil.

1.4 Other damage.

Nil.

1.5 Personnel information.

Pilot

Age:	48 years	**Medical:**	Valid Class 1 license
Nationality:	Belgian		
License:	ATPL(A)	**Injuries:**	None
Ratings:	B737, SEP (Land) TRI (MPA), TRE (A)	**Restraint used:**	3-point (Lap + single shoulder belt)
Flight experience:	Private Pilot license first held in 1988. Airline Transport Pilot License (A) first delivered in 2003. Total flight time: more than 8700 flight hours. Total General Aviation experience: 600 flight hours.		

The pilot renewed his SEP license in September 2017 and performed a couple of flights after that. He stated that during the preparation for the proficiency check (4 flights, totalling 3 flight hours in August 2017), he reviewed the emergency procedures with an instructor, including the simulation of an engine failure at take-off. The pilot stated that these exercises were fresh in mind at the time of the incident.

1.6 Aircraft information.

General

The Cessna 152 is an all-metal high-wing two-seat aircraft widely used as a trainer. It was introduced in 1978 as a successor of the popular 150. The Cessna 152 is powered by a Lycoming O-235-L2C or O-235-N2C engine, depending on the year of manufacture.

Characteristics:

Crew:	2
Length:	7,34 m
Height:	2,59 m
Wingspan:	10,16 m
Wing area:	14,86 m²
Standard Empty Weight:	490 kg
Max take-off weight:	758 kg
Fuel:	Two tanks located in the wings – Avgas

Airframe information.

Designer / Manufacturer	Cessna Aircraft Company
Type:	Cessna 152
Serial number:	15282624
Built year:	1979
Total flight hours:	11523:12 FH
Certificate of Registration:	Issued on 6 May 2011 by the Belgian Civil Aviation Authority (BCAA)
Certificate of Airworthiness:	EASA form 25 issued on 4 March 2008 by the BCAA
Airworthiness Review Certificate:	Valid until 2 March 2018.

Engine and propeller information.

Engine manufacturer:	Lycoming
Type:	O-235-N2C
Serial number:	L-12614-15
Total flight hours:	9269:12 hours
Total flight hours since O/H:	2836:30 hours (O/H September 2012)
Propeller manufacturer:	Sensenich
Type:	72CKS6O-56

Fuel system

The aircraft is equipped with 2 standard vented aluminium tanks, one in each wing. The system is gravity fed and both tanks supply fuel to a common line with a fuel shutoff valve. When the valve is in the 'ON' position, fuel flows through a fuel strainer to the carburettor.

Description of the carburettor air induction system.

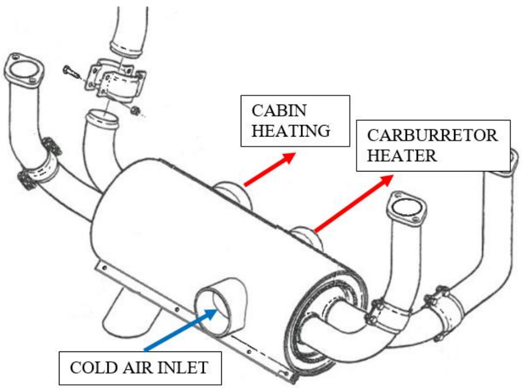
Ram air towards the engine carburettor enters the induction air box through an opening in the forward part of the lower engine cowling nose cap. Then, the air goes through a paper air filter and is further directed towards the inlet of the carburettor mounted on the oil sump of the engine.

The induction air system incorporates a valve allowing the pilot to select an exhaust heated source with the carburettor heat control in the cabin.

When the heat control is set fully forward, the air box valve position directs the cold filtered air to the inlet of the carburettor. When the carburettor heat control is pulled, the air box valve shifts causing the cold ram airflow to stop. In this position, the air originating from inside the engine cowl is directed to the carburettor via a heat exchanger and a flexible duct connected to the induction air box. Depending on the aeroplane date of construction and serial number, the heat exchanger of Cessna 152 consists either of:

- A chamber located between the shroud and the exhaust muffler. In this configuration, there is no filtering system installed, or
- A shroud located close to the exhaust pipe of cylinder 4. This shroud is equipped with a screen filter featuring a square-mesh size of about 3 mm.

The affected aircraft was equipped with the first type (a chamber between the shroud and the exhaust muffler).



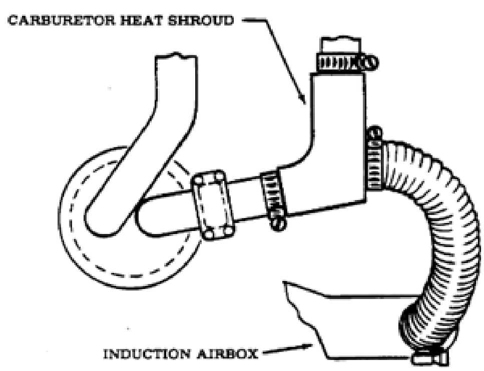


Figure 2: exchanger using the heat of the muffler. Figure 3: exchanger using the heat of an exhaust pipe.

1.7 Meteorological conditions.

Visibility:	more than 10 km
Wind:	210° - 9 kt
Temperature:	10°C
Dew point:	4°C
Atmospheric pressure:	1027 hPa

1.8 Aids to navigation.

Not applicable.

1.9 Communication.

The pilot was in contact with ‘Namur Radio’.

1.10 Aerodrome information.

The Namur – Suarlée airfield (EBNM) is located near the city of Namur, at 50 km SE of Brussels and 60 km SW of Liege. Coordinates are N 50° 29’ 17’’ – E 4° 46’ 08”.
Elevation is 594 ft above sea level.

The airfield was equipped with two grass[2] 06/24 bi-directional runways. Runway 06R/24L (696 m long x 27 m wide) is the primary runway for aeroplanes while runway 06L/24R is used for sailplanes. Both runways with orientation (QFU) 240° have a right-hand circuit. The airfield is operated during daytime hours.

Radio: ‘Namur Radio’ - 118.000 MHz - Information only, no ATC

1.11 Flight recorders.

The airplane was not equipped with a flight recorder nor was it required.

1.12 Wreckage and impact information.

The following systems were verified with the support of the maintenance organization: engine controls, cylinders compression, ignition system, engine air feed, fuel feed for possible line obstruction and/or fuel contamination, engine exhaust for obstruction and general condition of the engine. All 4 lower spark plugs were found significantly dirtier than the 4 upper ones. Two spark plugs (Nr 3 and Nr 4) were particularly fouled by contaminants. However, when tested, all 8 spark plugs were found delivering sparks.
As the above inspections did not reveal obvious evidence of malfunction, the investigation team decided to attempt to start the engine. All parts were reinstalled and the fuel circuit was fuel fed through the line located at the wing root.
After setting the magnetos on, several strokes of the fuel primer etc... and having pushed the throttle forward 3 times, the starter was engaged. The engine started, accelerated, but very rapidly the RPM decreased. The engine could only be kept running, very roughly, by continuously pushing the throttle back and forth, activating the accelerator pump.

The investigation then proceeded with the disassembly of the carburettor. Before removing the carburettor from the engine and opening the carburettor bowl, the fuel inlet strainer of the carburettor was inspected and found in good condition. No contamination was found.

[2] Situation at the time of the incident. At the time of publication of this report, the surface of runway 06R/24L has been changed from grass to asphalt.

Detailed inspection of the carburettor.

Identification of the carburettor, based on the yellow coloured data plate:

- Manufacturer: Marvel Schebler
- Engine MFR Part Number: LW-16907-70
- Model: MA-3PA
- Part Number: 10-5267 16 V
- Serial Number: MS645002 FAA PMA

The carburettor was removed from the engine sump and disassembled. After disassembly of the bowl and throttle body, it became possible to access the float chamber where a small dead insect was found inside the carburettor's mixture metering sleeve, at its bottom, leading to the fuel nozzle. The dead bug (about 2,7 mm diameter) was blocking the fuel flow to the fuel nozzle.

Figure 4 Location of the fly in the sleeve of the metering valve.

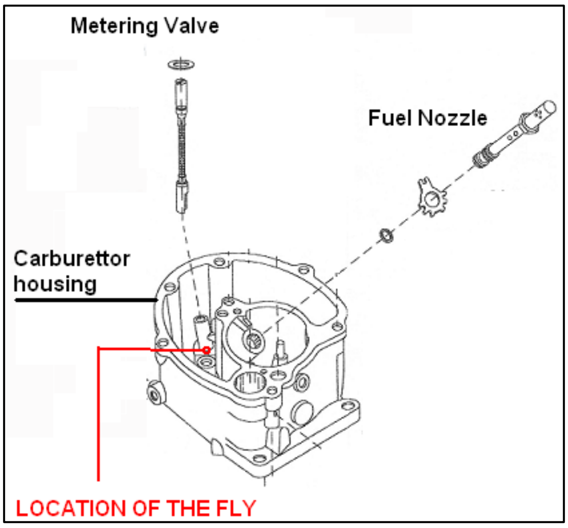


Figure 5/ View of the carburettor bowl

1.13 Medical and pathological information.

Not applicable.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

Before the forced landing, the pilot instructed his passenger to adopt the brace position. They both wore the 3-point safety belts (during the whole flight). The landing was made in a field neighbouring the airfield with a normal approach speed although an elevated groundspeed due to a tailwind of +- 8 kt. The touchdown and subsequent deceleration during the roll-out of +- 150 meters were definitely within structural and physiological limits. The aircraft was not damaged and the occupants could evacuate the aeroplane uninjured.

1.16 Tests and research.

Not applicable.

1.17 Organizational and management information.

Not applicable.

1.18 Additional information.

An engine failure caused by the contamination of the fuel chamber of O-235 engine carburettors is not an isolated case. A search on the accident and incident database of BEA France regarding Lycoming O-235 engines failure revealed 18 similar cases of carburettor contamination through the venting system or venting obstruction in the period 1990 to 2012, causing most of the time a forced landing and at least 3 accidents.

These cases of contamination occurred mostly to Robin Aircraft DR400, a very common aeroplane often used in France for training purposes, mostly on grass airfields. The manufacturer Robin Aircraft released several service bulletins to improve the filtration of the air induction system and also to avoid accidental detachment of particles originating from the induction system itself (filter element, air box paint, etc). These measures progressively reduced the recurrence of similar events.

DGAC France and later EASA also released several Airworthiness Directives to mandate the implementation of the different service bulletins and also to extend the implementation of the AD to other similar aeroplanes. Among others measures, Robin Aircraft released a service bulletin in May 2014 requesting to install an additional 1 mm square-mesh size screen filter at the air box warm air inlet. This last modification mandated by an EASA AD (No. 2014-0245) definitely excluded the possibility of contamination of the carburettor fuel chamber by flies entering the induction system via the hot air induction circuit.

1.19 Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

2.1 The path followed by the contaminant

The only possible way the bug entered the carburettor float chamber was determined to be through the vent of the float chamber. This vertical internal line has a diameter of about 6 mm and is provided parallel to the air inlet of the carburettor with the line inlet directly exposed to the airflow. The size of the bug (about 2,7 mm) allows it to easily pass through the vent passage. Insects or other small contaminants possibly transported by the carburettor airflow can enter in the carburettor vent line by inertia and climb further through the vent passage of the float chamber.

This vertical line ends in the throttle body where it is divided in 2 different channels having their own specificities:

- One for the venting of the carburettor float chamber.
- The other for the venting of the main nozzle and the idle tube assembly.

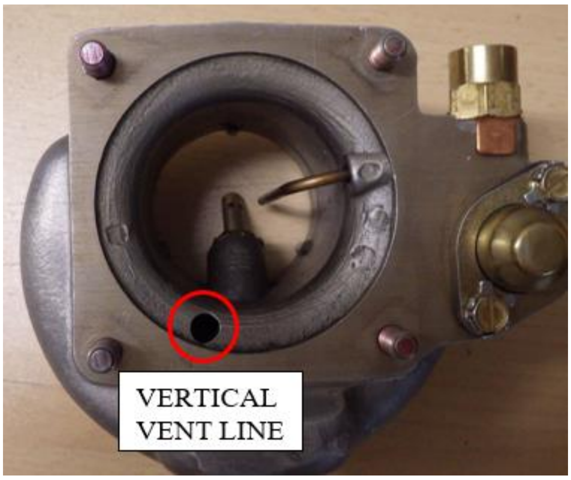


Figure 6: Bowl assembly (Picture taken upside down)

Although the vent line of the main fuel nozzle and idle is protected against the penetration of possible contaminants by a 6 mm diameter fine screen filter, there is no protection in the venting of the float chamber.

The screen filter of the vent line of the main fuel nozzle and idle is installed at the joint surface of the bowl and throttle body. The rationale for the installation of a filter at that place and not at the common vent passage of the float chamber and the main fuel nozzle and idle could not be determined.

After entering inside the carburettor through the vertical vent line, the contaminants will first fall on the gasket installed between the bowl and the throttle body before falling in the float chamber through the gasket's venting holes. If such a contamination of the fuel occurs, the contaminant will either float in the fuel or sink at the bottom of the float chamber depending on its density. Thereafter, it will be carried away by the fuel flow towards the carburettor's mixture control sleeve. This could obstruct the nozzle, causing an engine failure.

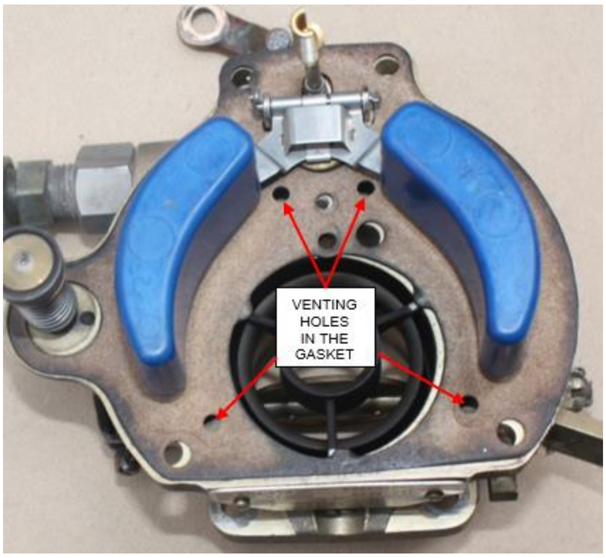
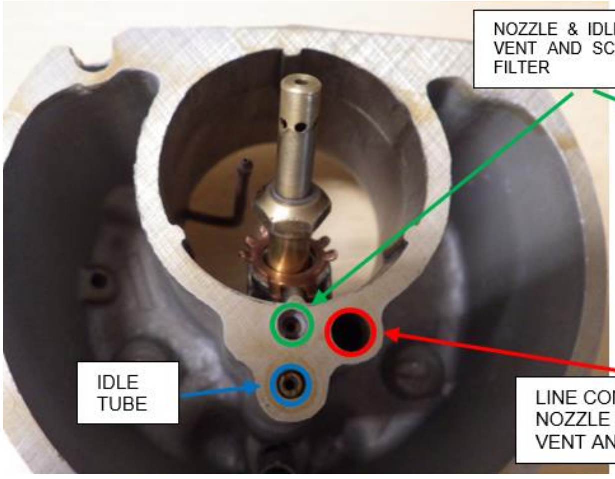


Figure 7: throttle body shown upside down before removal of the float and the gasket



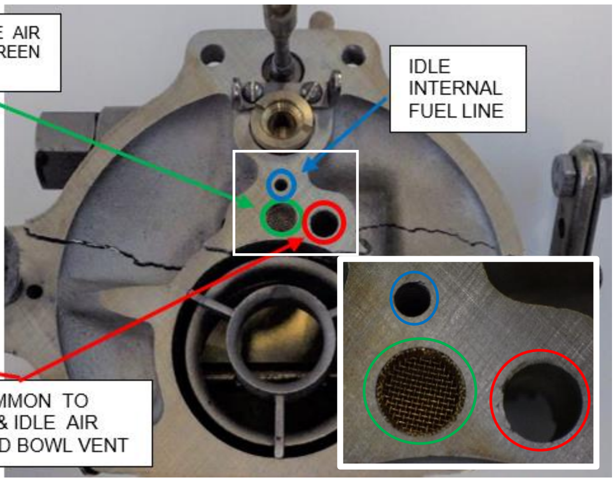


Figure 8: Bowl assembly

Figure 9: Throttle body, installed upside down

2.2 Design of air box, air filter and carburettor heater system.

Before entering the inlet of the carburettor the bug will first have to enter the induction air box which is possible through two possible paths:

- through the air filter (cold ram air circuit) or
- through the carburettor heater system.

The air filter installed in the aeroplane was a 'Brackett Air filter' installed in accordance with FAA STC SA71GL. This air cleaner, incorporating a foam filter element, was found in good condition and properly installed with no possibility that the bug could have entered through this way.

When the carburettor heater is selected by the pilot, the flap inside the heater box rotates anti clockwise (as shown in Figure 10) causing the interruption of the ram filtered airflow and the intake of non-filtered heated air coming from the heat exchanger. From that time, the airflow entering in the carburettor inlet can transport contaminants towards the carburettor inlet, presenting a serious risk of contamination of the float chamber.

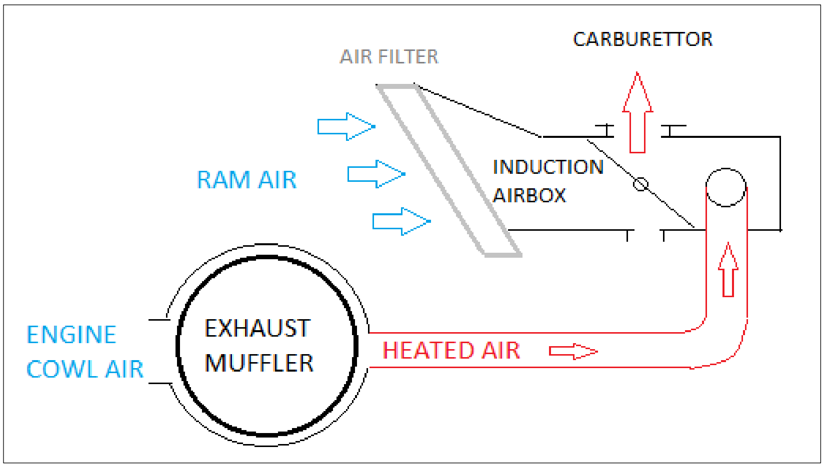


Figure 10: Sketch of the air induction system

It has to be noted that the last manufactured C152s incorporating a coarse square-mesh screen filter at the carburettor heat shroud will not be able to retain small bugs like the one that penetrated inside the carburettor bowl (the approximate largest dimension of the bug was 2,7 mm).

2.3 Engine manufacturer specification regarding the filtering of the air

Lycoming engine specification N°2581-A

The document “Lycoming engine specification N°2581-A” dated 8 December 2004 details the engine specifications applicable to the O-235 engine and provides some guidance and limitations regarding the engine installation. These specifications are intended to be used by the engine installer when developing the technical design for the integration of the engine in a new aircraft type.
In particular, chapters 37 and 38 of the engine specification cover the engine induction system requirements.

37. AIR INTAKE: The induction system should incorporate provisions for induction system icing protection in accordance with FAR 23.1093 or equivalent.

38. AIR CLEANER: The engine induction system shall incorporate a suitable air cleaner. Attention is drawn to the fact that operation under severe dust conditions will require additional air cleaner capacity to provide satisfactory engine life. These conditions may be encountered in aircraft operating from dusty fields or in dust storm areas. Air cleaner airflow at rated power is 775 lbs of air per hour.

Figure 11: Extract of Lycoming engine specification N°2581-A

With the exception of the airflow capacity per hour, the filtration characteristics, in particular the size of the contaminants to be stopped by the air cleaner, are not specified in this document.
Moreover, it is not specified whether the heated air must be filtered and, if that's the case, which particle size the filtration system is supposed to retain.

Textron Lycoming Service Instruction Nr 1002[3]

Textron Lycoming released the Service Instruction Nr 1002 "Proper Maintenance of Carburetor Air Filters" on 4 March 1960.

This document recalls the need to comply with the aircraft manufacturer instructions regarding the maintenance of air filters and recapitulates the purpose of the carburettor air filter and the way to use the carburettor heater system.

It states among others that:
"When the carburettor air filter has not been properly maintained, the result is the same as operating without a filter".

"*The most common damage caused by dirt entering the engine is worn piston rings and excessive ring groove wear resulting in parts that must be removed from service before their normal service life has expired"*.

"Ground operation should be kept at the minimum especially since on some installations the air coming into the carburettor completely by-passes the carburettor air filter when the carburettor heat is turned on. The only time the carburettor air heat should be used in this type of installation, is when icing condition encountered on the ground might affect take-off".

As seen above, this Service Instruction focusses on possible rapid engine wear caused by an improperly maintained carburettor air filter and/or an inadequate operation on the ground of the non-filtered carburettor heater system. However, a possible carburettor bowl contamination through the air vent causing a sudden and unforeseeable engine failure is not mentioned.

Lycoming Operator's Manual[4]

The Operator's Manual, in Section 3 - Operating Instructions: 'Use of Carburettor Heat Control' describes the carburettor icing phenomenon and its possible consequences. It also gives instructions on how to properly use the carburettor heater system during the different phases of the flight: Ground Operations, Take-off, Climbing and Flight Operation.

In particular, the Operator's Manual gives the following explanations about the Ground Operations:

[3] A copy of Textron Lycoming Service Instruction Nr 1002 is enclosed at the end of this report.
4 An extract of Lycoming Operator's Manual P/N 60297, 5th. Edition dated January 2007 with a revision to pages 3-5 dated September 2008 regarding the use of Carburettor Heat Control is enclosed at the end of this report.

> *Ground Operation* – Use of the carburetor air heat on the ground must be held to an absolute minimum. On some installations the air does not pass through the air filter, and dirt and foreign substances can be taken into the engine with the resultant cylinder and piston ring wear. Only use carburetor air heat on the ground to make certain it is functioning properly.

This chapter also focusses on possible rapid engine wear caused by an improperly maintained carburettor air filter and/or an inadequate operation on the ground of the non-filtered carburettor heater system. As in the Service Instruction Nr 1002, a possible carburettor bowl contamination through the air vent, having the capacity to cause an engine failure, is not mentioned.

2.4 Flight Manual recommended operation of the carburettor heater system.

Section 4 "Normal Procedures" of the Flight Manual recommends to set the carburettor heat ON before landing and to select the cold position after the landing.

There is thus a discrepancy between the recommendations released by both manufacturers:

Cessna: Recommends *'to set the carburettor heat ON before landing and to set it OFF after the landing'*

Lycoming: *Ground operation should be kept at the minimum especially when the carburettor heat is turned on. The only time the carburettor air heat should be used in this type of installation, is when icing condition encountered on the ground might affect take-off".*

It has to be noted that the 'Lycoming Operator's Manual' clearly states that it should always be referred to both the 'Pilot's Operating Handbook' and the 'Airframe Manufacturer's Manual' on the use of carburettor heat control.

Insects and grass particles can be present in great numbers not only on the ground but also at low height, in particular above grass airfields. The likelihood that a carburettor contamination occurs is therefore higher when the aeroplane is operated on a grass airfield, in particular if it performs frequent touch and goes as it is mostly the case for Cessna 152s used for training purposes.

2.5 Use of the carburettor heater system.

During the touch and go, the pilot selected the carburettor heat on before landing and set it off after the landing, as recommended by the Flight Manual.

The meteorological conditions (Temperature: 10°C - Dew point: 4°C) at the time of landing were conducive to carburettor icing. The figure below shows that "Serious icing at descent power" prevailed when the incident occurred.

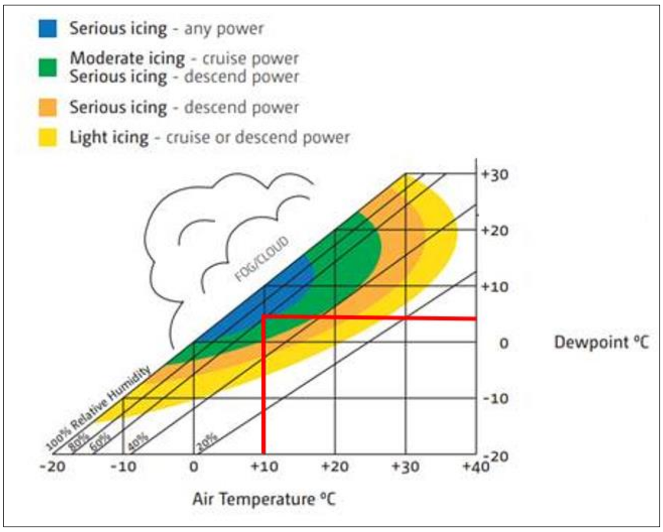


Figure 12: Figure showing that a risk of serious icing was present at descent power.

The use of carburettor heater, recommended as a standard procedure in the Flight Manual, was therefore justified and adequate during the descend.

However, applying the carburetor heater during the final approach, as recommended by the Flight Manual, implies a risk to ingest dust or insects at low altitude through the carburetor heat system. This can lead, as in this case, to the engine stoppage.

This risk was unknown to the pilot and the instructor. The pilot was taught to put the carburetor heater off after touchdown as instructed by the Flight Manual.

3. CONCLUSIONS

3.1 Findings

- The aeroplane was in airworthy condition and was regularly maintained in a BCAA approved Part M Subpart F maintenance organization.
- The pilot was qualified for the flight and was adequately prepared to eventually perform a forced landing, as he recently reviewed the emergency procedures with an instructor for the preparation of his bi-annual proficiency check.
- A small dead bug was found inside the housing of the metering valve located inside the float chamber of the carburettor.
- Engine stoppage, caused by the contamination of the fuel float chamber of O-235 engine carburettors, is not an isolated case.
- There is a discrepancy between what is recommended by the engine and the aircraft manufacturers regarding the use of the carburettor heater system when on the ground. Cessna recommends the use of the carburettor heater up to the touch down while Lycoming recommends that Ground operation with the carburettor heat on should be kept at the minimum.

3.2 Cause

<u>Direct cause</u>

The cause of the engine malfunction and the subsequent forced landing is the contamination of the carburettor float chamber by a small insect (fly) that obstructed the fuel feed to the main nozzle. The insect entered inside the float chamber of the carburettor via the vent of the float chamber of the carburettor.

<u>Indirect cause</u>

The combination of:

- The design of the carburettor featuring an internal line for the venting of the float chamber which is not protected by a filter and that is directly exposed to the carburettor inlet airflow, allowing the penetration of possible contaminants.
- The aeroplane induction system lacking a filtering system aimed to stop the penetration of contaminants when the air induction heater system (anti-icing system) is selected.

<u>Contributing factor</u>

Using the carburettor heater up to the landing on a grass runway where many insects are often present close to the ground.

4. SAFETY ACTIONS AND RECOMMENDATIONS

4.1 Safety issue: Carburettors exposed to the penetration of contaminants via the vent line of the float chamber with the possibility to obstruct the main fuel nozzle.

Certified aircraft equipped with a O-235 Lycoming engine use an air filter to clean the normal (cold) carburettor airflow but this filter is bypassed when the induction heater system is selected. This is a common installation which is even mentioned in both Lycoming Service Instruction Nr 1002 and the applicable Lycoming Operator's Manual.

These last documents from Lycoming clearly recommend to hold the carburettor heat on to an absolute minimum when the aircraft is on the ground and justify this recommendation because dirt can enter the engine through the carburettor, causing a reduction of the service life of the engine. However, the risk of a possible contamination of the carburettor float chamber and a subsequent possible sudden engine loss of power or stoppage is not mentioned in these documents.

It seems that aircraft manufacturers consider the absence of an air filter in the heated airflow as non-problematic because of the little use of the carburettor heater when the aircraft is on the ground. Nevertheless, experience shows that dry grass particles, dirt and insects are often in suspension in the air meaning that the use of the carburettor heater system in flight, in particular at low altitude, has also the potential to contaminate the float chamber of the carburettor, causing a significant risk of engine stoppage.

AAIU(Be) is of the opinion that the installation of an adequate filtering system in the vent line of the carburettor is the best way to prevent the contamination of the float chamber. It has to be noted that in the Marvel Schebler MA-3PA model carburettors, the common vent passage to the float chamber and the main fuel nozzle is not equipped with a filter but the main fuel nozzle has its own fine screen filter located further in the vent circuit. The justification for the installation of a filter at that place and not somewhere else in the common vent passage, which would have the advantage to protect both the float chamber and the main nozzle, could not be determined during the investigation.

Reportedly, some other types of carburettors installed on other engine models also feature a vent system with the inlet exposed to the penetration of contaminants. Therefore:

Safety recommendation BE-2019-0001:

It is recommended that Lycoming Engines identifies the different Lycoming engine models using a carburettor featuring a design similar to that of the Marvel Schebler MA-3PA carburettor where the vent of the float chamber is directly exposed to the penetration of contaminants, and installs a filter in the vent line of these carburettors to prevent the risk of contamination of the fuel chamber.

4.2 Safety issue: No information about the risk of contamination of the float chamber possibly leading to an obstruction of the main fuel nozzle

Lycoming Engine Specification N°2581, applicable to O-235 engines, lists several characteristics to be met by the induction system, but it doesn't give any technical recommendation or cautionary statement to avoid penetration of contaminants in the fuel chamber when the carburettor heater system is selected. Reference made to FAR 23.1093 in the engine specification only refers to the minimum capabilities of the induction system icing protection in terms of temperature.

Lycoming Service Instruction Nr 1002 focusses on possible rapid engine wear caused by an improperly maintained carburettor air filter and/or an inadequate operation on the ground of the non-filtered carburettor heater system. However, there is no mention of a possible carburettor float chamber contamination through the air vent.
Therefore, AAIU(Be) is of the opinion that this SI does not adequately inform the different aircraft designers/manufacturers about the danger of a possible float chamber contamination.

Lycoming Operator's Manual also focusses on possible rapid engine wear caused by an improperly maintained carburettor air filter and/or an inadequate operation on the ground of the non-filtered carburettor heater system.
As in the Service Instruction Nr 1002, a possible carburettor float chamber contamination through the air vent, having the capacity to cause an engine stoppage, is not mentioned.

Reportedly, some other types of carburettors installed on other engine models also feature a vent system with the inlet exposed to the penetration of contaminants. Therefore:

Safety recommendation BE-2019-0002:

It is recommended that Lycoming Engines identifies the different Lycoming engine models using a carburettor featuring a design similar to the Marvel Schebler MA-3PA carburettors with the vent of the float chamber exposed to the penetration of contaminants. Further, it is recommended that Lycoming Engines releases an information document, in the most appropriate form, to adequately inform all Type Certificate Holders of aircraft using the concerned engines about the risk of contamination of the fuel chamber by ingestion of dirt, dry grass particles, insects, possibly leading to an obstruction of the main fuel nozzle, if the carburettor heater system is not adequately filtered.

4.3 Safety issue: The air induction heater system of Cessna 152 aeroplanes not adequately filtered.

The lack of filtering, or the insufficient filtering characteristics of the heated air induction, combined with the venting of the fuel chamber of the carburettor Marvel Schebler MA-3PA model where the float chamber is directly exposed to the penetration of contaminants can lead to a possible carburettor fuel contamination and subsequently can cause an engine loss of power or even stoppage. Therefore:

Safety recommendation BE-2019-0003:

It is recommended that Cessna - Textron Aviation installs an adequate screen filter in the heater air induction system of Cessna 152 aeroplanes, to avoid the penetration of contaminants in the carburettor float chamber which have the potential to reduce the fuel flow at the carburettor main nozzle and cause an engine loss of power or stoppage.

4.4 Safety issue: Flight Manual stating that the carburettor heat induction system must be set off only after the landing, resulting in a greater risk of contamination of the carburettor.

As insects and grass particles can be present in great numbers at low height and on the ground, the likelihood of a carburettor contamination via the vent of the float chamber increases when the carburettor heater is used during final approach until the landing.

Most of the time, depending on the icing conditions, it is not necessary to hold this carburettor heater on up to the landing roll to prevent carburetor icing, but the Flight Manual does not leave any choice: it prescribes that the carburettor heater must be set off after the landing.

AAIU(Be) is of the opinion that the Flight Manual should be less prescriptive about the precise moment the carburettor heater must be selected off. In general, flight schools and other operators make their own checklist based on the procedures published in the Flight Manual combined with their own experiences and risk assessment, taking into consideration the local climate conditions, features and environment of the aerodromes frequently flown to.

Secondly, the Flight Manual states nothing on the danger that the use of the carburettor heater at very low height and on the ground could currently cause carburettor contamination, with a potential engine failure as a consequence.

Therefore:

Safety recommendation BE-2019-0004:

It is recommended that Cessna – Textron Aviation modifies the Flight Manual of Cessna 152, Section 4 – Normal procedures to move the item requiring to put carburettor heat on cold from the ‘After landing’ paragraph to the ‘Landing’ paragraph. This in order to leave the option to the pilots to put the carburettor heat on cold in the final phase before touchdown. Additionally, the flight manual should contain a warning on the dangers (like contamination) of the use of the carburetor heat on and close to the ground, especially at grass and other soft fields.

5. APPENDICES

5.1 Extract of Cessna 152 Flight Manual

CESSNA
MODEL 152

SECTION 4
NORMAL PROCEDURES

BEFORE LANDING

1. Seats, Belts, Harnesses -- ADJUST and LOCK.
2. Mixture -- RICH.
3. Carburetor Heat -- ON (apply full heat before closing throttle).

LANDING

NORMAL LANDING

1. Airspeed -- 60-70 KIAS (flaps UP).
2. Wing Flaps -- AS DESIRED (below 85 KIAS).
3. Airspeed -- 55-65 KIAS (flaps DOWN).
4. Touchdown -- MAIN WHEELS FIRST.
5. Landing Roll -- LOWER NOSE WHEEL GENTLY.
6. Braking -- MINIMUM REQUIRED.

SHORT FIELD LANDING

1. Airspeed -- 60-70 KIAS (flaps UP).
2. Wing Flaps -- 30° (below 85 KIAS).
3. Airspeed -- MAINTAIN 54 KIAS.
4. Power -- REDUCE to idle as obstacle is cleared.
5. Touchdown -- MAIN WHEELS FIRST.
6. Brakes -- APPLY HEAVILY.
7. Wing Flaps -- RETRACT.

BALKED LANDING

1. Throttle -- FULL OPEN.
2. Carburetor Heat -- COLD.
3. Wing Flaps -- RETRACT to 20°.
4. Airspeed -- 55 KIAS.
5. Wing Flaps -- RETRACT (slowly).

AFTER LANDING

1. Wing Flaps -- UP.
2. Carburetor Heat -- COLD.

1 July 1978

4-9

5.2 Extract of Lycoming Operator's Manual

WARNING

REFER TO THE PILOT'S OPERATING HANDBOOK OR AIRFRAME MANUFACTURER'S MANUAL FOR ADDITIONAL INSTRUCTIONS ON THE USE OF CARBURETOR HEAT CONTROL. INSTRUCTIONS FOUND IN EITHER PUBLICATION SUPERSEDE THE FOLLOWING INFORMATION.

F. *Use of Carburetor Heat Control* – Under certain moist atmospheric conditions (generally at a relative humidity of 50% or greater) and at temperatures of 20° to 90°F it is possible for ice to form in the induction system. Even in summer weather ice may form. This is due to the high air velocity through the carburetor venturi and the absorption of heat from this air by vaporization of the fuel. The temperature in the mixture chamber may drop as much as 70°F below the temperature of the incoming air. If this air contains a large amount of moisture, the cooling process can cause precipitation in the form of ice. Ice formation generally begins in the vicinity of the butterfly and may build up to such an extent that a drop in power output could result. In installations equipped with fixed pitch propellers, a loss of power is reflected by a drop in manifold pressure and RPM. In installations equipped with constant speed propellers, a loss of power is reflected by a drop in manifold pressure. If not corrected, this condition may cause complete engine stoppage.

To avoid this, all installations are equipped with a system for preheating the incoming air supply to the carburetor. In this way sufficient heat is added to replace the heat loss of vaporization of fuel, and the mixing chamber temperature cannot drop to the freezing point of water (32°F). The air preheater is a tube or jacket through which the exhaust pipe from one or more cylinders is passed, and the air flowing over these surfaces is raised to the required temperature before entering the carburetor. Consistently high temperatures are to be avoided because of a loss of power and a decided variation of mixture. High charge temperatures also favor detonation and preignition, both of which are to be avoided if normal service life is to be expected from the engine. The following outline is the proper method of utilizing the carburetor heat control.

(1) *Ground Operation* – Use of the carburetor air heat on the ground must be held to an absolute minimum. On some installations the air does not pass through the air filter, and dirt and foreign substances can be taken into the engine with the resultant cylinder and piston ring wear. Only use carburetor air heat on the ground to make certain it is functioning properly.

(2) *Take-Off* – Set the carburetor heat in full cold position. For take-off and full throttle operation the possibility of expansion or throttle icing at wide throttle openings is very remote.

(3) *Climbing* – When climbing at part throttle power settings of 80% or above, set the carburetor heat control in the full cold position; however, if it is necessary to use carburetor heat to prevent icing it is possible for engine roughness to occur due to the over-rich fuel/air mixture produced by the additional carburetor heat. When this happens, lean the mixture with the mixture control only enough to produce smooth engine operation. Do not continue to use carburetor heat after flight is out of icing conditions, and return mixture to full rich when carburetor heat is removed.

(4) *Flight Operation* – During normal flight, leave the carburetor air heat control in the full cold position. On damp, cloudy, foggy or hazy days, regardless of the outside air temperature, be alert for loss of power. This will be evidenced by an unaccountable loss in manifold pressure or RPM or both, depending on whether a constant speed or fixed pitch propeller is installed on the aircraft.

5.3 Lycoming Service Instruction N°1002

TEXTRON Lycoming

652 Oliver Street
Williamsport, PA 17701 U.S.A.
717/323-6181

SERVICE INSTRUCTION

Service Instruction No 1002
Approved by FAA

DATE: March 4, 1960

SUBJECT: Proper Maintenance of Carburetor Air Filters

MODELS AFFECTED: All Lycoming Opposed Series Aircraft Engines

TIME OF COMPLIANCE: Daily Inspection

It has become increasingly evident that operators are not adhering to carburetor air filter maintenance instructions as set forth by aircraft manufacturers. This shows up in complaints on parts removed from service before their normal service life has expired. In practically all of those cases analyzed by our laboratories, deposits have been found which conclusively prove the engine has been operated after dirt has entered the engine through the carburetor.

The purpose of the carburetor air filter is to remove dirt and abrasive particles from the air before it enters the carburetor. When the carburetor air filter has not been properly maintained, the result is the same as operating without a filter. The most common result of dirt entering the engine is worn piston rings and excessive ring groove wear. As ring groove wear progresses, ring breakage will eventually result.

Too much emphasis can not be put on the importance of keeping ground operation at a minimum. On some installations the air coming into the carburetor completely by-passes the carburetor air filter when the carburetor air heat is turned on. The only time the carburetor air heat should be used in this type of installation, is when icing conditions encountered on the ground might affect take-off. If the hot air duct to the carburetor is fitted with a filter, this too must be maintained in the same manner and with the same frequency as the carburetor air filter. It is recommended the operator run up his engine on a hard surface ramp or where dirt is at a minimum.

It is also imperative that the carburetor air filter be properly installed. If it fits loosely so that the air passes around rather than through the mesh, unfiltered dirty air will enter the carburetor. If there are any leaks in the induction system between the air filter and the carburetor the same problem will exist.

There are two types of carburetor air filters in use in installations which use Lycoming engines. These are a dry type paper filter and an oil wetted type mesh filter. The two types are serviced in a different manner, and the following procedure is a general recommendation. The airframe manufacturer should be consulted for specific recommendations.

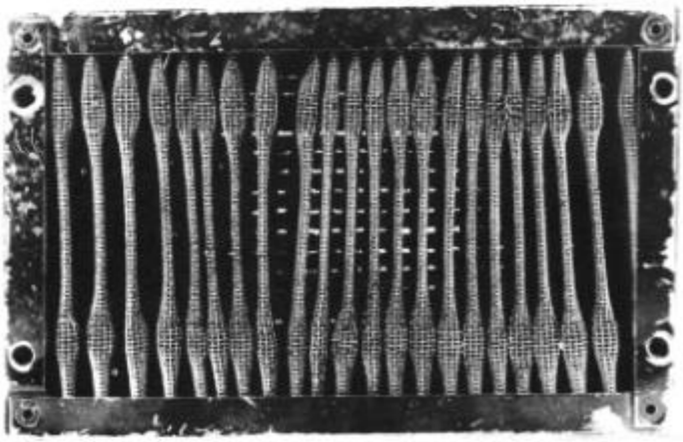


Figure 1. Example of Deteriorated Carburetor Air Filter

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March 4, 1960

Service Instruction No. 1002

DRY FILTERS:

a. The filter must be cleaned daily when operating in dusty conditions. When operating in other than dusty conditions, inspect the filter daily and clean when required. If any holes or tears are noticed, the filter must be replaced immediately. The required maximum time for servicing these filters is 25 hours.

b. Remove the filter element and shake off loose dirt by rapping on a hard flat surface, being especially careful not to crease or dent the sealing ends.

CAUTION

Never wash the filter element in any liquid, or soak it in oil. Never attempt to blow off dirt with compressed air.

c. The filter housing can be cleaned by wiping with a cloth soaked in gasoline. When the housing is dry, reinstall and seal the filter element.

OIL WETTED TYPE FILTER:

The filter must be inspected daily for dirt accumulation and proper oiling. When dirt is found the filter should be cleaned (recommended daily when operating in dusty conditions); or if the filter requires oiling, the following procedure should be followed:

a. Thoroughly wash the filter in petroleum solvent. Make certain all dirt is removed from the filter, and the filter unit is in serviceable condition.

b. Dry the filter at room temperature making certain it is thoroughly dry before proceeding with the next step. If the filter is not dry, the solvent will prevent the oil from adhering to the small surfaces of the filter, and thereby decrease its efficiency.

c. Immerse the filter in the recommended grade of oil for a period of five minutes.

d. After removal of the filter from the oil, allow to drain thoroughly before installation in the aircraft.

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Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

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