Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

Air Accident Investigation Unit (Belgium)
CCN
Rue du Progrès 80 Bte 5
1030 Brussels

Safety Investigation Report

Ref. AAIU-2012-25

Classification:	Accident		
Level of investigation:	Standard		
Date and hour:	11 November 2012 at 14:00 UTC		
Aircraft:	Rockwell Commander 112 SN 196. The aircraft was registered in Belgium and held a Certificate of Airworthiness and a valid Airworthiness Review Certificate (ARC)		
Total flight time:	3347:57 FH		
Accident location:	Off EBTN airfield		
Type of flight:	Cross-country	**Phase**:	Landing
Persons on board:	The pilot was on board alone.	**Injuries**:	None

Abstract
A first touch and go was initiated on runway 24. Subsequently, the airplane went into the downwind leg to perform a second touch and go. At mid-section of the downwind leg the airplane was set in landing configuration but with no flaps. Few moments later, the engine started sputtering and stopped operating, forcing the pilot to perform an emergency landing off-field. The pilot climbed out uninjured leaving the airplane significantly damaged.

Cause
The cause of the accident is an engine failure due to a fuel system contaminated by water.

Contributing factors:
- Not fully adhering to the "Flight Manual" recommended pre-flight inspection.
- Lack of guidance in the airplane documentation to properly install the fuel tank drains.
- Draining the fuel system after having moved the airplane out the hangar.
- The fuel gascolator was not equipped with a remote system to control the drain valve.
- Fuel tank caps not fully watertight.
- Not draining the fuel system after the cleaning of the airplane.

Recommendations:
Recommendation 2014-P-3 to the FAA
AAIU(BE) recommends the FAA to require the airplane Type Certificate Holder to publish adequate information in order to properly verify and install PN: 1000B-2A valve drains, per SB, SL or any.

Recommendation 2014-P-4 to the FAA
AAIU(BE) recommends the FAA to require the airplane Type Certificate Holder to incorporate a 25 hrs maintenance operation in the "Inspection Intervals Chart" of the Maintenance Manual, reflecting the need of draining the gascolator.

Hazard identified during the investigation [1]: Fuel contamination.

Consequence [2]: Powerplant failure or malfunction (SCF-PP) and forced landing.

[1] Hazard – Condition or object with the potential of causing injuries to personnel, damage to equipment or structures, loss of material, or reduction of ability to perform a prescribed function.
[2] Consequence – Potential outcome(s) of the hazard

Factual Information

History of the flight

The flight started from EBCI, where the airplane was stationed. The purpose of the flight was to perform a series of touch and goes on the EBTN airfield. This day, the pilot pushed the airplane out of the hangar and made the pre-flight inspection on the parking. During the pre-flight, the pilot did a visual inspection of the airplane and drained both fuel tank sumps. He saw, among other things that both tanks were ¾ full, which was also indicated by the fuel meters. The take-off and subsequent flight to EBTN was uneventful. A first touch and go was initiated on runway 24. In the subsequent downwind leg abeam midfield the pilot again set the airplane in full landing configuration (gear down, switch to fullest tank, fuel booster pump on, mixer full rich, pitch fully fine, trim, landing light on but no flaps). Few moments later, the engine started sputtering and stopped operating. The pilot reacted immediately, turning the fuel tank selector to the other tank, checked the booster pump switch and manipulated the gas throttle. The engine kept on wind milling but did not pick up power again. The pilot then declared a mayday, and turned the airplane for a landing on Runway 24. The pilot tried to regain engine power by manipulating the gas throttle, without success. The fuel booster pump was ON during the whole manoeuver. As altitude was decreasing rapidly, the pilot realized he had insufficient clearance to cross an electrical power line and decided to perform an emergency belly landing off-field. He set full flaps and retracted the gear immediately before touch down to finally land on a cultivated field in front of Runway 24. After a short (40m) skidding on the beetroot field, the airplane came to a stop. The pilot switched off all systems, including the fuel selector valve, which was erroneously put on "both" (instead of "OFF"), and climbed out, uninjured.

Figure 1: View of EBTN airfield

Figure 2: Airplane after the forced landing

Airfield information

The EBTN Goetsenhoven airfield is a military base belonging to the Belgian Air Component. The airfield is located around 3 km South East of the city of Tienen. It is equipped with two asphalt 30 m wide runways, a 720 m long 06/24 and a 780 m long 17/35. Elevation of the airfield is 246 ft. All circuits are right hand at a height of 1000 ft AGL. The airfield is given in concession to a civilian aero club operator outside the military operational hours. The use of the airfield is subject to prior permission from the operator. On the day of the accident runway 24 was in use.

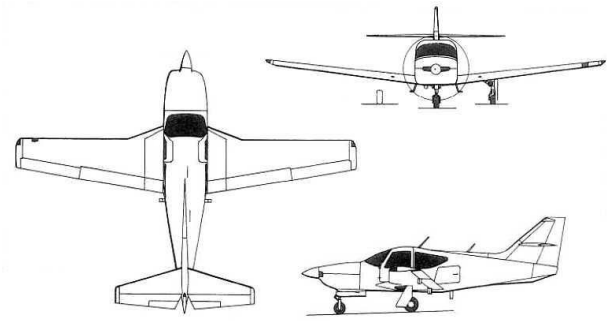
Pilot information

Age: 59 years old. Holder of a Private Pilot's Licence, first issued 26 September 2007, valid until 19 September 2017. Rating: SEP (land), valid until 30 September 2013. Total Flight Experience flying certified airplanes around 141 FH among which 31 FH on Rockwell Commander. Ultra-light airplane pilot experience around 780 FH.

Meteorological information (Based on EBBR Metar at 14:20 UTC)

Wind direction 250°, wind speed 7 kt, temperature 7° Celsius, dew point 6° Celsius, visibility 9 km, QNH 1024 hPa

Airplane information



The Rockwell Commander 112 is a four-seat cabin single piston-engine monoplane designed and built by North American Rockwell in the 1970s. It features a cantilever low-wing monoplane with a 7° dihedral. The fuselage is made of a conventional semi-monocoque light alloy structure. The Commander 112 is equipped with a retractable landing gear, a Lycoming IO-360-C1D6 engine and a Hartzell HC-E2YR-1BF variable pitch propeller.

Figure 3: Three views drawing

The fuel system is composed of two integral fuel tanks located in the wings, a selector valve, a gascolator, an electrical fuel pump and an engine driven fuel pump for delivery to the injection system. The gascolator is located inside the engine compartment.

As the schematic illustrates, drains are installed at each fuel tank and a drain system is incorporated in the selector valve.

A/C SN 196 did not incorporate fuel sump drains in the fuel lines between both tanks and the selector valve.

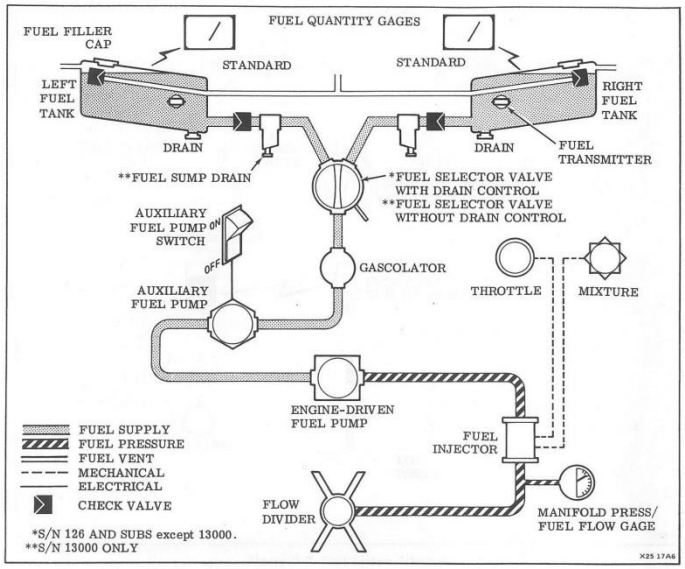


Figure 4: Schematic of the Fuel System

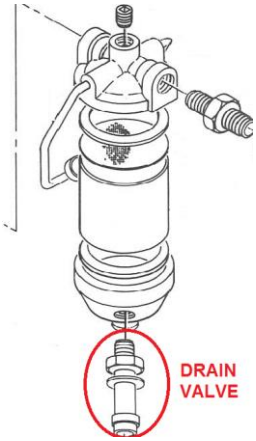


Figure 5: Gascolator

The gascolator was equipped with a drain valve accessible after removal of the engine cowlings. No remote control of this valve was installed.

However, the possibility exists to reach the drain valve without removal of the engine cowlings, but it was very difficult and required the pilot to lie on his back on the floor.

Airplane examination

First inspection on the crash site did not reveal obvious anomalies that could explain the engine failure. Sufficient fuel was present in both fuel tanks and the oil dip stick showed the engine oil level was normal. No fuel or oil leak was visible.

Further examination was conducted in the usual maintenance organization. As the engine failure occurred immediately after switching the fuel tank, the examination focused on the fuel system. The fuel selector valve handle, found in the “both” position after the crash, was first examined showing that the original placards had disappeared and had been replaced by others “home-made” of pink colour.

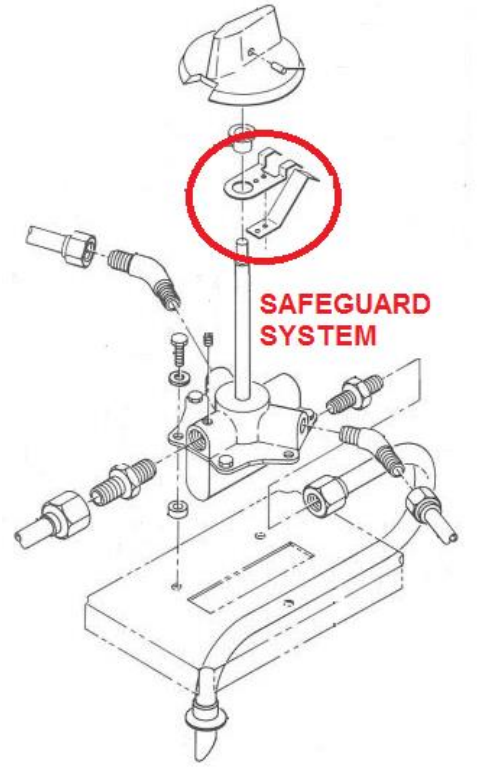


Figure 6: Fuel selector Valve

Figure 7: fuel selector Valve safeguard

It was also seen that the safeguard system preventing putting the selector valve inadvertently in the “OFF” position was plastically deformed with the consequence it was no more effective. The safeguard was also rusted.

It is therefore possible that the pilot could have (partially) closed the fuel selector valve when selecting the other fuel tank in downwind.

The fuel selector valve incorporated a drain valve operated by pulling up vertically the fuel selector valve handle. First attempt to open the drain by gently pulling up the handle showed the drain valve was seized. Further significant force allowed the drain valve to unlock and to move up.

No liquid came out the drain line. Actually, no more fuel was present in the fuel selector valve, likely because a leakage occurred at both connections of the fuel lines coming from the fuel tanks which had been disconnected during the wings disassembly and had not been caped.
After few up and down movements the drain valve control became light and smooth, closing properly when released under an internal spring action.

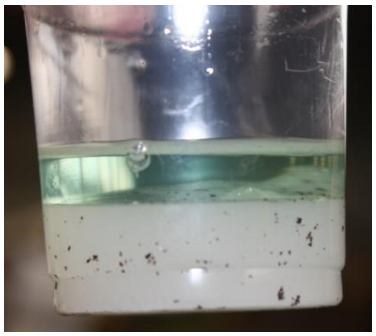


Figure 8: fuel contamination

Thereafter, the engine cowlings were removed and the gascolator installed on the firewall was drained in a clean container.
Obviously, the fuel inside the gascolator was contaminated by a whitish liquid likely to be water. Small black particles were also present.
A layer of green liquid, supposed to be the fuel, was present on the top while the white liquid rapidly settled at the bottom of the container.

Figure 9: Bottom cover of the gascolator

Figure 10: gascolator screen filter

The fuel gascolator was disassembled showing semi-solid other contaminants looking like a kind of white gelatine. Thereafter, the screen filter located inside the injection system was removed and the inspection confirmed the contamination. Droplets of water were found in the injection system.

Damage

The airplane sustained heavy damage to the LH wing, the fuselage and the propeller. The forced landing caused also minor damage to the cultivated field.

Analysis

The cause of the fuel contamination has been investigated in four areas:

- Determination why the contaminant products had not been properly drained
- Determination of the course followed by the contaminant products to enter the fuel system
- Determination of the contaminant products
- Analysis of the maintenance

The flight preparation – Pre-flight inspection

The pilot stated he performed the pre-flight inspection on the parking after having moved the airplane out of the hangar. The surface of the parking was very uneven due to works. This likely caused the water present in the fuel tank(s) to be mixed with the fuel, rendering the draining of water less effective.

Draining the Fuel Selector Valve

The airplane was owned by a group of pilots of which some were interviewed regarding the procedure they used to drain the fuel system. They stated they drained only the fuel tanks, as the selector valve drain was known as being unserviceable years ago. One pilot specified the selector valve drain was not used for the past 20 years. Although the drain control was found blocked during the investigation, it was demonstrated that after few up and down movements of the control, everything was fully operational. Service Bulletin NO. SB-112-44A “Replacement of Fuel Selector Valve” dated 23 March 1978 covers the replacement of the selector valve by a new design without drain valve and, at the same time, requires the installation of 2 additional drain sumps on the lines between both fuel tanks and the selector valve (A drawing extracted from this SB is enclosed at the end of this report). The reason for publication of this SB was “To Prevent Possible Leakage of Fuel Selector Valve”. Investigation showed that the repair of a leaking fuel selector valve was known to be a significant and costly work requiring the draining of the entire fuel system and the removal of the fuel selector valve. The risk of Fuel Selector Valve leak could explain why the airplane owners took, a long time ago, the decision not to use the fuel selector valve drain anymore.

Fuel tank drains

The fuel tank drains were examined and removed from their respective fuel tanks. The valve drains were held in place in the fuel tanks using an aluminum 1”1/8 castellated nut installed with the non-castellated surface in contact with the lower fuel tank skin i.e. with the castellated surface up. Examination of the valve showed no provision was made on the valve to receive any cotter pin. The drain valves were identified as per the applicable Illustrated Parts Catalog as being PN: 1000B-2A (Valve, drain -13330). They were originally installed on Model 112, serial numbers 126 thru 364.

Figure 11: Drain hole in the drain chamber

Figure 12: 1”1/8 castellated nut

A seen hereunder, a simulation with the nut installed in both positions was performed using a green paper sheet to represent the lower skin of the fuel tank.

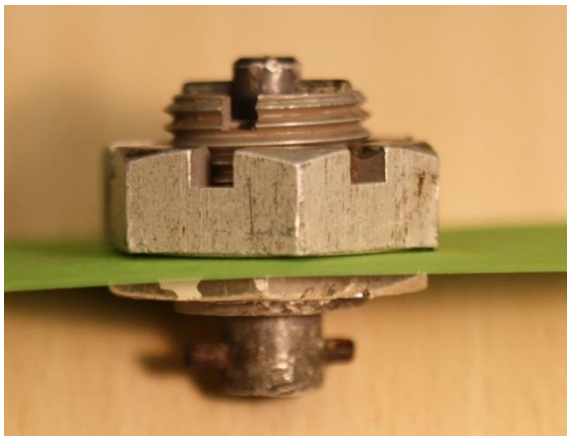


Figure 13: Nut position as found in the A/C.

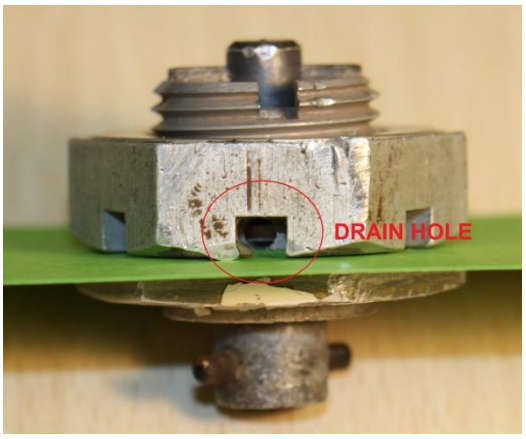


Figure 14: Free passage to the drain hole.

Drain valve and nut, as found installed in the airplane, shows the drain hole circonferential chamber is hiden by the plain (non-castellated) part of the nut.
By contrast, there is no flow obstruction when the castellated part of the nut is installed opposite, i.e. in contact with the lower fuel tank skin.

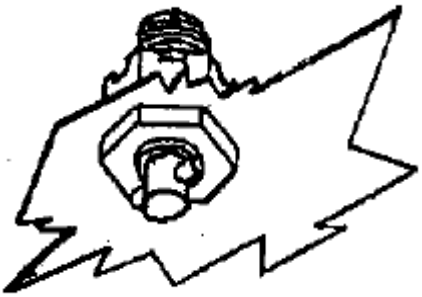


Figure 15: Drawing originating from another PC

No information could be found in the airframe manufacturer applicable documentation to determine the correct orientation of the fuel tank drain nuts.

The only information available is a drawing of the same drain, found in the Parts Catalog applicable to airplane SN: 1 to 125 (thus not applicable to SN: 196). This drawing shows the nut with its flat surface in contact with the lower fuel tank skin.

Thereafter, the drain valve was installed in a metal can for performing comparative testing of the draining efficiency with the nut installed in both positions. The tests showed that the flow and the pressure were significantly lower when the flat surface of the nut was in contact with the skin. Actually, the limited flow was only possible due to a lack of sealing of the nut along its thread and at the contact surface with the lower tank skin.

Maintenance records do not show who installed the nuts in this position and when it was performed.

Service Letter SL-112-16A « Improved Fuel Valve Installation » was published by the airframe manufacturer Rockwell International on 10 March 1977. The service Letter described the installation of other drain valves incorporating a nut definitively fixed inside the tank by a retainer. Reason of for publication was “Provide a fully sealed drain valve to lessen the possibility of fuel leakage”. Actually, the layout of the new valve prevented it from being installed incorrectly (A drawing of the new drain valve, extracted from this SL, is enclosed at the end of this report).

Fuel tank cap sealing

Figure 16: View of a fuel tank cap

Both fuel caps were inspected for proper sealing capabilities showing the small O rings installed on the central locking mechanism was in poor condition.

The fuel caps were thus no longer watertight.

Therefore water could enter the fuel tanks when raining or during the cleaning of the airplane.

Cleaning the airplane

The airplane had been cleaned by the maintenance organization after the last 50h maintenance dated 9 October 2012, spraying widely water on the airplane surfaces with a garden hose.
Nobody drained the fuel system after the cleaning and the airplane remained outside a few days without flying. The maintenance organization stated they considered the draining of the fuel system had to be done by the next pilot flying, during his pre-flight inspection.

Fuel contaminant analysis

Analysis of the liquid found in the gascolator was conducted by a specialized company which confirmed the contamination was mainly due to water. The analysis could not determine why the water had a whitish colour and why the 100LL fuel had a green colour instead of blue.

Maintenance programme

The last maintenance was a 50h inspection performed on 9 October 2012 when the airframe total time was 3339h09. This was done 34 days and 8:48 flight hours before the accident.
The BCAA approved maintenance programme specifies the scheduled maintenance will be performed according to Section 2 of the Maintenance Manual Commander 112 PN M112001-2 (Last revision). The maintenance frequency mentioned in the “Inspection Intervals Chart” found in Section 2 is 50 hrs, 100 hrs, 500 hrs and “As Required”. On the other hand, a careful reading of Section 2 subtitle “Drains” reveals the gascolator must be drained each 25 hrs for gascolator without drain remote control, and during each pre-flight inspection for airplane with a remote control of the drain.
There is no remark concerning the fuel system in the column “As Required” of the “Inspection Intervals Chart” which could indicate a specific maintenance action is recommended each 25 hrs.

112/B/TC/TCA
MAINTENANCE MANUAL

Section II
Servicing

INSPECTION	INTERVAL			
	50 HRS	100 HRS	500 HRS	AS REQ'D
FUEL SYSTEM 1. Drain valves, vent lines and vents. 2. Filler cap, anti-siphoning valves. 3. Fuel system placards. 4. Internal tank inspection, gage transmitters. 5. Fuel line fittings, vent lines and vents. 6. Remove and clean fuel vent line drain assembly beneath fuselage.	▮	▮		

Figure 17: Extract of the “Inspection Intervals Chart”

The maintenance records do not show any indication the gascolator was drained every 25 hrs.
However, the last 50 hrs inspection had been done only 8:48 flight hours before the crash meaning the lack of draining each 25 hrs is not the cause of the contamination.

Findings

- The airplane was in airworthy condition, which means properly certified, registered, maintained following an approved maintenance program and duly released to service after maintenance etc.
- A 50hrs maintenance had been performed 34 days and 8:48 flight hours before the accident.
- The fuel system was found contaminated by water.
- Before the last flight, the airplane had been moved out of the hangar before draining the fuel tanks.
- The nuts of both fuel tank drains were installed upside down.
- No information could be found in the airframe manufacturer documentation to avoid improper installation of the fuel tank drains.
- The Fuel Selector Valve drain was considered a long time ago by the pilots as unserviceable. It was habitual not to drain the Fuel Selector Valve despite that it was clearly a part of the Pre-flight inspection as per “Flight Manual” section II. This Fuel Selector Valve drain control was found operational during the investigation.
- The gascolator was not drained during the pre-flight inspection because its access was very difficult and additionally, its draining was not part of the pre-flight inspection.
- A remote control of the gascolator drain was installed as a factory improvement on later airplane production, from SN 221. From that SN on, draining of the gascolator was part of the pre-flight inspection.
- Draining of the gascolator was required each 25 hrs as per Maintenance Manual Section II. However, this 25 hrs maintenance operation is not mentioned in the “Inspection Intervals Chart” of the same Section II which could have contributed to a lack of attention from the owner’s in this particular case.

Conclusion

The cause of the accident is an engine failure due to the fuel system being contaminated by water. The contamination occurred due to the combination of the following factors:

- Not fully adhering to the “Flight Manual” recommended pre-flight inspection regarding the draining of the Fuel selector Valve.
- An inadequate upside down installation of both fuel tank drain nuts.
- Draining the fuel system after having moved the airplane out the hangar.
- The fuel gascolator was not equipped with a remote system to control the drain valve during the pre-flight inspection.
- The fuel tank caps were not fully watertight due to O rings in poor condition.
- The airplane had not been drained after the cleaning of the airplane performed at the end of the last 50 hrs maintenance.

Recommendations

Recommendation 2014-P-3 to the FAA
AAIU(BE) recommends the FAA to require the airplane Type Certificate Holder to publish adequate information in order to properly verify and install PN 1000B-2A valve drains, per SB, SL or any.

Recommendation 2014-P-4 to the FAA
AAIU(BE) recommends the FAA to require the airplane Type Certificate Holder to incorporate a 25 hrs maintenance operation in the “Inspection Intervals Chart” of the Maintenance Manual, reflecting the need of draining the gascolator.

Enclosures

Extract of Service Bulletin NO. SB-112-44A "Replacement of Fuel Selector Valve"

SERVICE BULLETIN NO. SB-112-44A

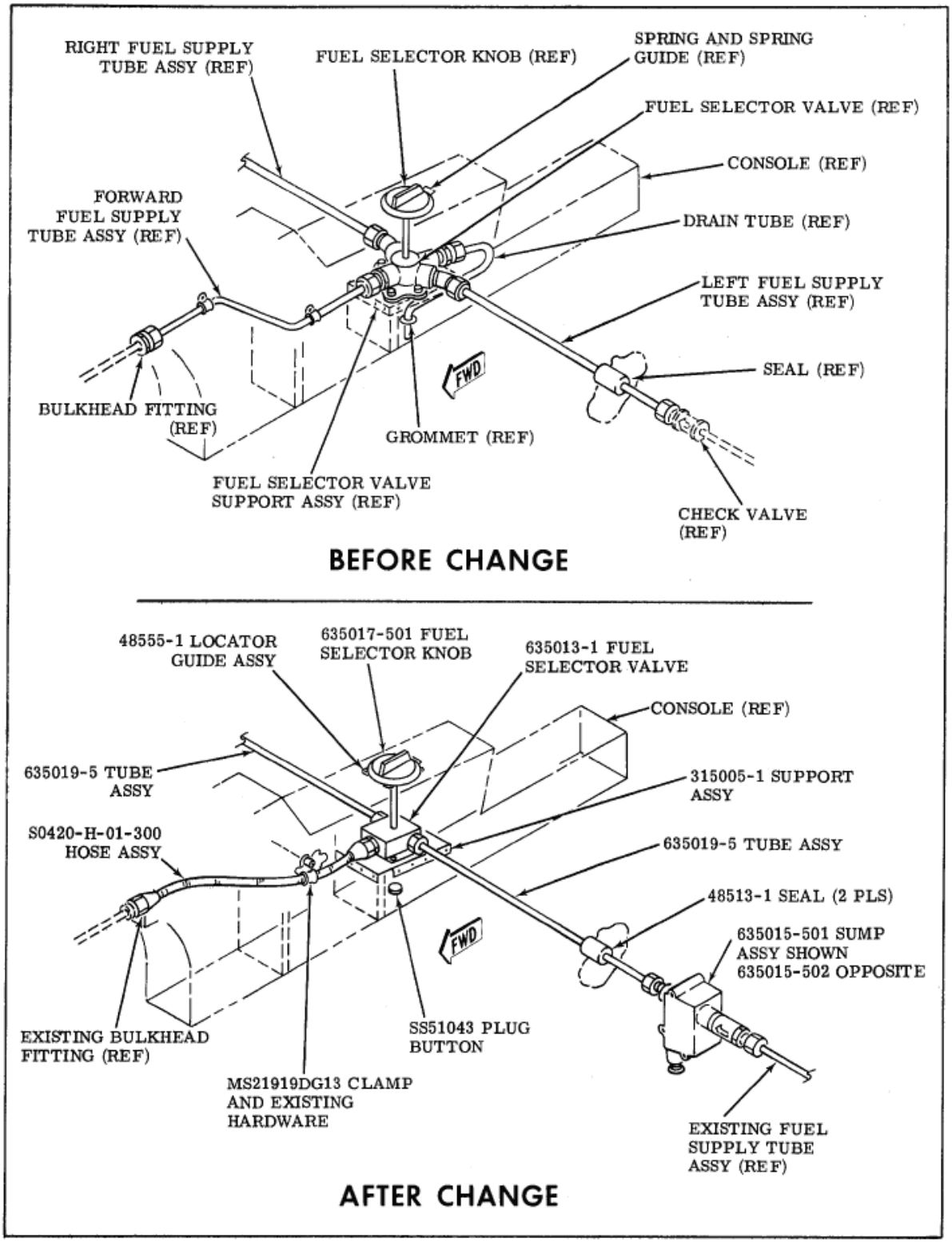


Figure 1.

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Extracts of Maintenance Manual Section II Systems and Components Servicing

INSPECTION	INTERVAL			
	50 HRS	100 HRS	500 HRS	AS REQ'D
FUEL SYSTEM 1. Drain valves, vent lines and vents. 2. Filler cap, anti-siphoning valves. 3. Fuel system placards. 4. Internal tank inspection, gage transmitters. 5. Fuel line fittings, vent lines and vents. 6. Remove and clean fuel vent line drain assembly beneath fuselage.	▮	▮		

DRAINS. On model 112/TC four fuel drains are provided at the lowest points of the fuel system to extract moisture and sediments entrapped in the system. On model 112B/TCA five drains are installed (see Figure 2-4). Draining the fuel tanks, tank sump and gascolator is accomplished by use of drain valves located adjacent to the tanks, sump or gascolator. All fuel drains except the gascolator should be drained prior to the first flight of each day. The gascolator should be drained and checked every 25 hours of operation. Drain a small quantity of fuel into a transparent container to permit inspection for presence of moisture or sediment. Fuel should be drained until all evidence of moisture or sediment disappears. Drain check the fuel system as follows:

a. Drain a fuel sample from the wing tank sumps on the inboard underside area of each tank.
b. On model 112/TC aircraft, place fuel selector valve on interior center console on BOTH and pull to drain selector valve through bottom of fuselage. An outside assistant will be needed to obtain fuel sample.

NOTE

The fuel selector remote drain valve will also permit draining of the individual tank lines by switching to either RIGHT or LEFT and pulling up on valve handle. Return fuel selector valve to RIGHT or LEFT position to prevent fuel from flowing from one tank to the other and overflowing out of tank vent line.

On model 112B/TCA aircraft drain a fuel sample from each wing tank sump located just forward of each main wheel well opening.

c. Drain fuel sample from the gascolator every 25 hours of operation by pushing in on drain or by pulling drain handle as applicable.
d. Visually check that all drain valves close after draining.

About this report

As per Annex 13 and EU regulation EU 996/2010, it is only obliged to perform a full investigation of accidents and serious incidents involving aircraft other than specified in Annex II to Regulation (EC) No 216/2008. For this occurrence, a limited-scope, fact-gathering investigation and analysis was conducted in order to produce a short summary report.

It is not the purpose of the Air Accident Investigation Unit to apportion blame or liability. The sole objective of the investigation and the reports produced is the determination of the causes, and, where appropriate define recommendations in order to prevent future accidents and incidents.