Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

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# Safety Investigation Report

Ref. AAIU-2014-AII-08
Issue date: 18 April 2016
Status: Final

## SYNOPSIS

| | |
|---|---|
| **Classification:** | Accident |
| **Level of investigation:** | Standard |
| **Date and time:** | 25 May 2014 at 08:40 UTC |
| **Aeroplane:** | Ultra-light aeroplane Alpi Aviation, model Pioneer 200 (SN: 170) put into service on 19 November 2007. The aeroplane was registered in France and held a 'Carte d'identification ULM' validated up to 19 April 2016 by another document called 'Accuse réception de la déclaration d'aptitude au vol d'un ULM'. |
| **Owner:** | Private |
| **Total flight time:** | 1200 FH |
| **Type of engine:** | One Rotax 912UL SN: 4408720 |
| **Accident location:** | Off EBSG airfield |
| **Type of flight:** | General aviation - Local |
| **Phase:** | Take-off |
| **Persons on board:** | One |
| **Injuries:** | None |

### Abstract

Immediately after take-off, the engine ran roughly, produced heavy vibrations and lost power. The pilot decided to make a forced landing, lowered the nose of the aeroplane, selected a field in front of him and secured the engine. During landing, both the right hand and nose landing gear were ruptured. The pilot climbed out, uninjured.

### Cause

The cause of the accident is an engine stoppage resulting from a fuel starvation due to a false air intake at a tee fitting connector located at the suction side of the fuel system. The air intake occurred as a consequence of a fuel pipe clamp not being properly tightened.

**Occurrence type**

Engine stoppage due to fuel starvation (FUEL)

**Contributing safety factors:**

- The lack of an adequate quality system when modifying the fuel system (such as, but not limited to the supervision by an independent and competent person) leading to not detecting the insufficient tightening of the fuel line clamp.
- Insufficient/inadequate preventive maintenance did not allow early detection of the insufficient tightening of the fuel line clamp.
- The absence of formal technical standards or guidance material for the hoses used in the ultralight aircraft.

## FACTUAL INORMATION

### History of the flight

The pilot wanted to perform a local flight from the airfield of St Ghislain (EBSG). He prepared his aeroplane, filled it with 20 litres of automotive 98 octane fuel and performed a pre-flight inspection.

About 20 minutes after start-up of the engine, and after having performed the engine test, the aeroplane took off from runway 27. The take-off and the first seconds of the climb out were uneventful.

Shortly after passing above the threshold, the engine started to lose power; making an abnormal noise and producing heavy vibrations. The aeroplane lost altitude leaving the pilot no other choice than to make a forced landing into a field located in front of him. He jumped over a low voltage power line located along a street, secured the engine close to the ground (ignition switch off, master switch off and fuel selector valve off) and managed to land.

The landing would have been successful if there had not been a horse standing in the middle of the field. The pilot made an evasive manoeuver close to the ground; lifted the RH wing, missing the horse. This evasive manoeuvre caused the plane to hit the ground on the LH MLG, ruptured the leg and then got its NLG into the ground, breaking it as well. The pilot climbed out, uninjured.

### EBSG Airfield information

The airfield of Saint-Ghislain is located 9 km west of the city of Mons. It is equipped with a 640 m long and 23 m wide asphalted runway, oriented 088° / 268°.

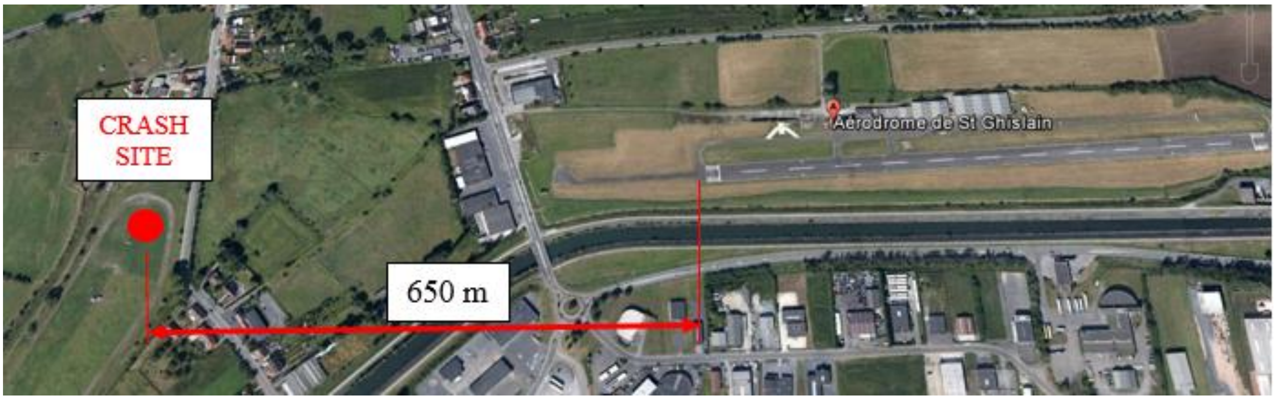


Figure 1: Aerial view of EBSG airfield including the crash site position

### Pilot information

Male, aged 63. He held an ULM pilot licence issued by the aviation authority of France (DGAC) on 20 August 2012. The pilot got his initial training on the accident aeroplane. At the end of his initial training, the pilot bought this aeroplane and accumulated 450 FH on it in two years.

### Meteorological information

Wind: 230° 8kts. Temperature: 16°C. QNH: 1020 mbar

**Damage**

Both the LH main and nose landing gear leg ruptured, causing additional damage to the belly of the fuselage and the engine cowling. One blade of the propeller was severed at about 40 cm from the root.

**Aircraft**

The Alpi Aviation Pioneer 200 is an ultra-light and light-sport aeroplane designed and produced by the Italian company “Alpi Aviation”. The aircraft is supplied as a kit for amateur construction or as a complete ready-to-fly-aircraft.

The Pioneer 200 was designed to comply with the “*Fédération Aéronautique Internationale”* microlight rules and “*US light-sport aircraft*” rules. It features a cantilever low-wing, a two-seats-in-side-by-side configuration enclosed cockpit under a bubble canopy, fixed tricycle landing gear and a single engine. The aircraft is made from wood. Standard engines available are the 80 hp (60 kW) Rotax 912UL and 80 hp (60 kW) Jabiru 2200.

Main characteristics: Wing Span: 7,55 m. Wing Surface: 10,5 $m^2$. Length: 6,15 m. In flight load factor: +4/-2 at 520 kg. Aluminium fuel tank positioned inside the fuselage, capacity: 54 l.

Figure 2: View of a similar airplane

Fuel System description.

The pilot/owner stated that the aeroplane's original fuel system featured only an engine driven mechanical fuel pump. The original fuel system incorporated the following components: the fuel tank, a fuel shut-off valve (not shown), a fuel filter, the mechanical fuel pump, a pressure regulating valve, a de-gasser and its associated return line and finally both carburettors.

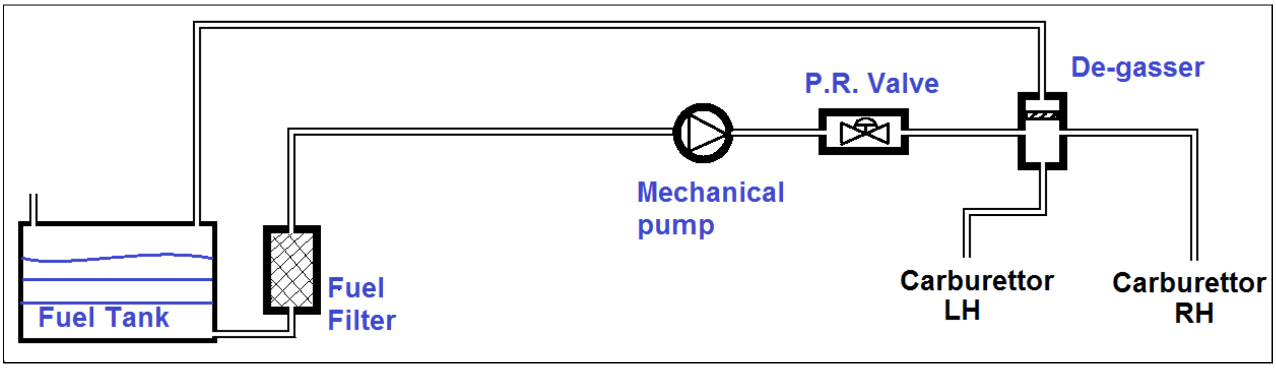


Figure 3: Original fuel system

At the new owner's request, when he bought the aeroplane, a back-up electrical fuel pump was added. The modification was carried out by the seller. After modification the fuel system was equipped with an electrical pump and its associated electrical wiring, a check valve and two tee connections. The electrical fuel pump was connected in parallel with the check valve. It has to be noted that the installation of this back-up fuel pump needed 10 additional connections (3 at each tee fitting + 2 at the fuel pump + 2 at the check valve).

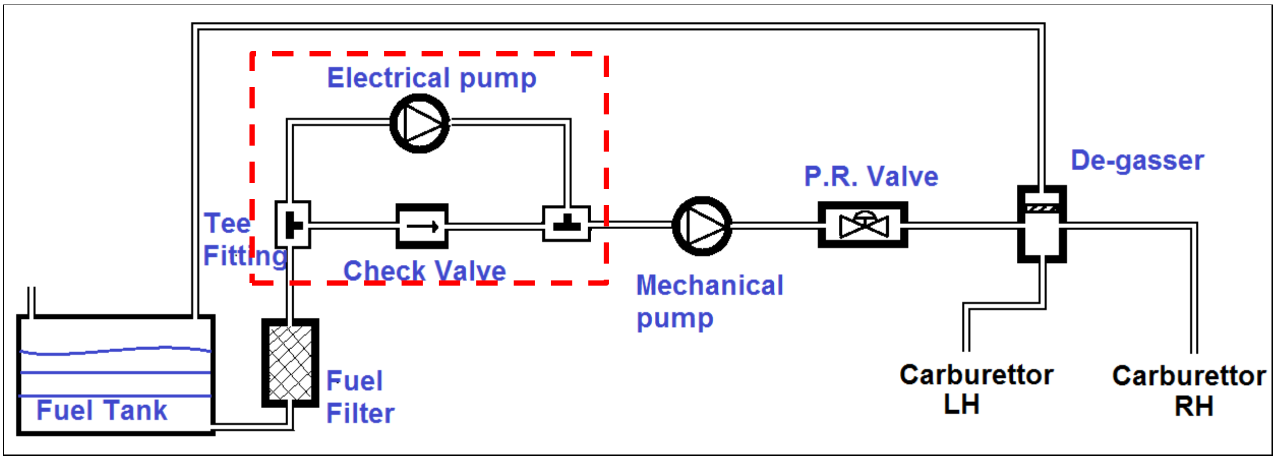


Figure 4: Fuel system after modification

## ANALYSIS

The circumstances of the power loss, showing the engine delivering normal power during the take-off and shortly after, losing power at low altitude during the climb out steered the investigation to first examine the fuel system.
The investigation could determine that the total fuel quantity available at take-off was about 35 litres meaning that a fuel starvation due to running out of fuel (fuel exhaustion) could be excluded.

The entire fuel system was first examined externally, showing the following:

- The housing of the electrical pump was on one side torn from the fire wall, however the pump was still operational.
- The mechanical pump was identified as being PN: 07-81355. According to a SB from the engine manufacturer “Rotax”, this fuel pump exceeded the manufacturer’s 5 year recommended life limit.
- Some rubber fuel pipes showed minor traces of chafing and small cracks but nothing that would cause a malfunction.
- The transparent plastic fuel filter was found to be about 70% filled with fuel, the remainder being air or fuel gases. The investigation could determine that such a presence of air or fuel gases in this type of fuel filter is not always an indication of an anomaly.

Thereafter, the bowl of each carburettor was carefully removed paying particular attention to avoiding fuel spillage. The fuel quantity in the left hand carburettor bowl was abnormally low and the right hand carburettor fuel level was worse, showing a much lower fuel level. The extremely low fuel level in both carburettor bowls could explain the engine stoppage. No other anomaly was found in the carburettors.

The electrical fuel pump was tested by reconnecting the battery and switching the pump on. After exhausting the fuel and the air present in the line, a regular fuel flow was observed. At first sight, the fuel flow was deemed to be sufficient to properly feed the engine.

Then, the carburettors and their fuel lines were reassembled and the electrical fuel pump was operated for 1 minute. Reopening of both carburettor bowls could determine that the level of fuel was significantly higher than previously observed, each carburettor showing an identical fuel level. This could conclude that the engine loss of power was due to an insufficient fuel feeding of the carburettors.

Figure 5: low fuel level

Figure 6: normal fuel level, after feeding

Just after the above test of the electrical fuel pump, a thorough inspection of all fuel lines and fuel line connections found a fuel leak indication (sweating) at the tee connection located before the electrical fuel pump.

Figure 7: tee fitting connection showing a sweaty leak

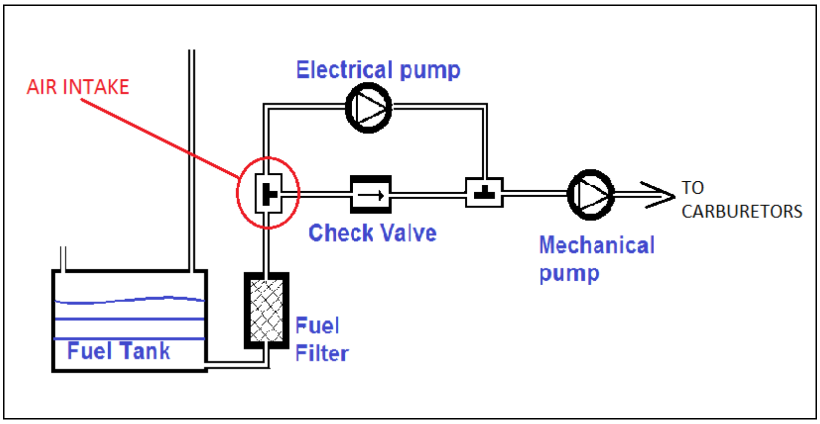


Figure 8: Position of the leaking tee fitting connection

A lack of sealing in the suction side of the fuel system will cause the fuel pumps to pump air, or a mixture of air and fuel, instead of liquid, reducing the fuel flow capacity of the system.

Further palpation of the 3 fuel pipes and clamps at the tee fitting increased the fuel leak and found that the leaking rubber pipe clamp was not properly tightened.

After removal of the clamp, a closer examination of the rubber pipe where the clamp was located showed no obvious sign of clamping in the rubber material (not any deformation of the rubber).

Examination of the two other clamps of the same tee fitting found the same anomaly. This suggests that the clamps had not been properly tightened during initial installation and subsequent inspections failed to identify the situation

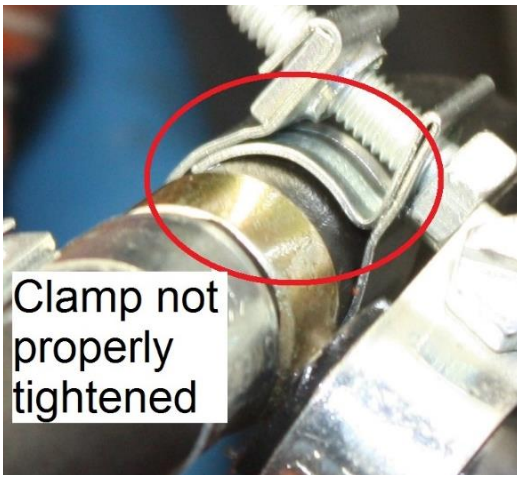


Figure 9: gap between the clamp and the rubber pipe.

If not properly designed and/or installed, each connection (10) needed for the installation of the back-up fuel pump has the potential to leak or cause an air intake, which raises the question of the actual added value of the modification (the best is sometimes the enemy of the good).

General assessment of the fuel system lines and connectors:

Examination of the fuel system showed that there was no standardisation in the fuel connectors showing different shapes and diameters and in the hose clamps.

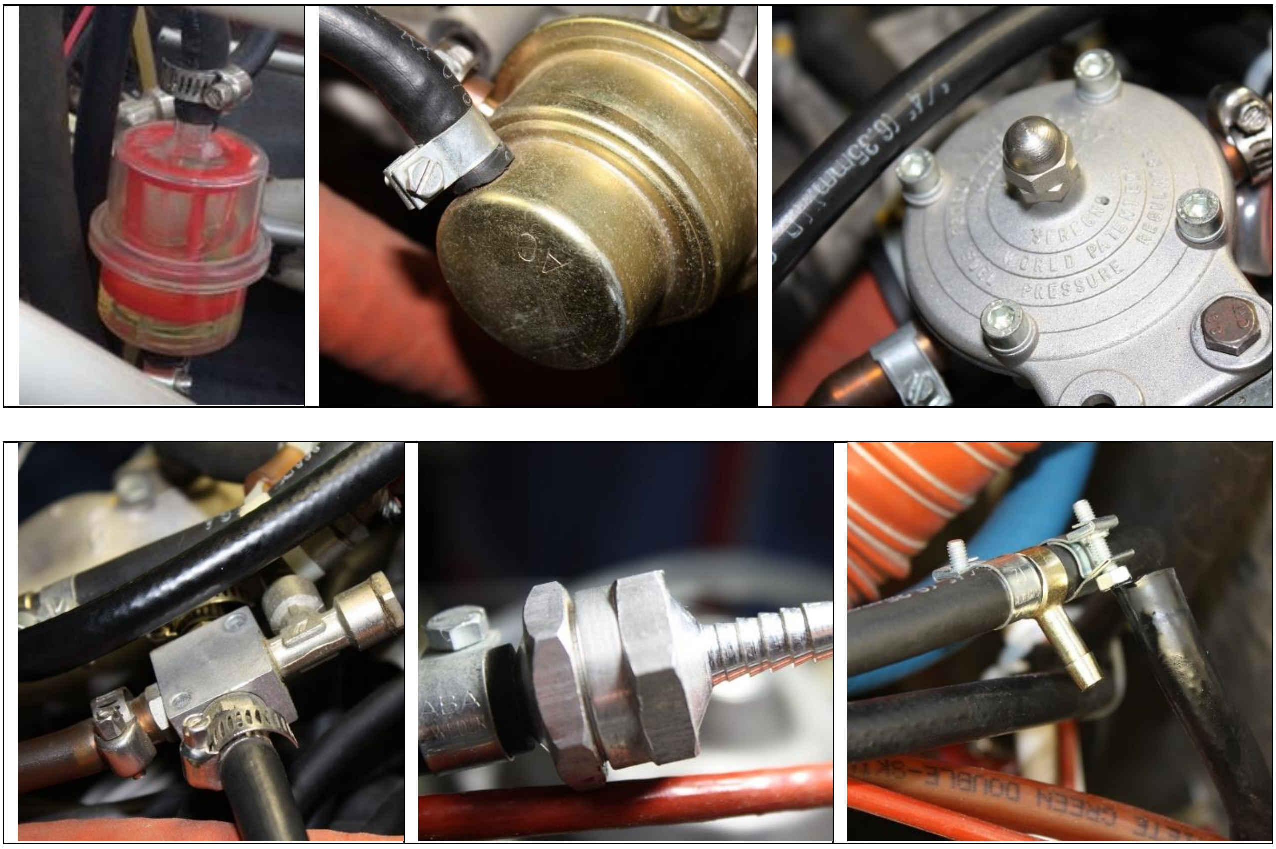

Figure 10: pictures showing different clamp and connection types.

The use of a large variety of clamps and connectors may be conducive to a possible inadequacy between the different connectors and the pipe used and prone to maintenance errors in particular regarding the size of the clamps and the way to tighten it.

The identification markings printed on some rubber lines show the cure date 6 September 2007, the inner diameter 1/4” (6.35mm) and a reference to the SAE standard 30R7-KX. According to ULM maintenance organizations renowned for their competence, it is common (good) practice to renew the rubber lines every 3 or 4 years depending on the material quality and the condition of use. Actually, the installed rubber lines were already 7 years old and showed ageing cracks in some places.

The measurement of the fuel lines and their connectors showed several discrepancies owing to a mismatch of metric and English units (inner diameter of the rubber line is 6.35mm while the outer diameter of the mechanical fuel pump connection is only 6mm …).

Defects such as traces of fraying in the rubber material were also found in a few places.

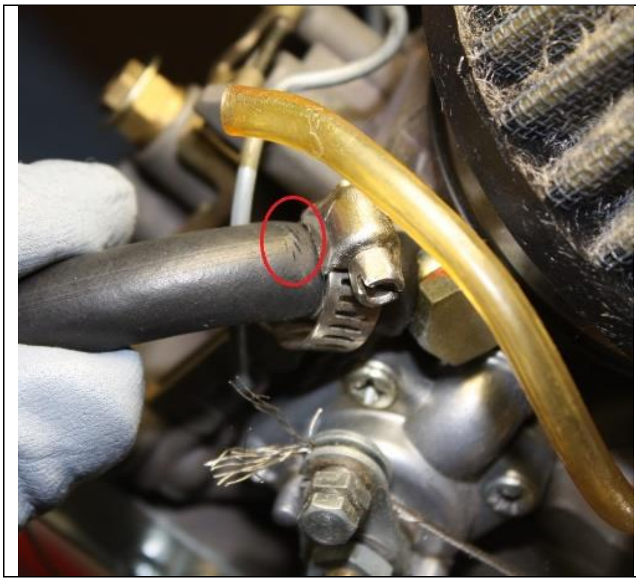

Figure 11: cracks in a rubber line

Figure 12: traces of fraying in a rubber line

Possible consequences of a lack of sealing in the fuel system

The adverse effects of a lack of sealing somewhere in the fuel system doesn't necessarily manifest itself in the same way:

If the lack of sealing is located on the suction side of the fuel system:
- No indication of an incipient fuel starvation was observed by the pilot during the engine test performed before the flight.
- As seen during the test performed during the investigation, there was no obvious fuel flow reduction when testing the fuel system with the electrical fuel pump.
- By contrast, the power loss demonstrated that the fuel flow was insufficient to properly feed the carburettors during the take-off and the first moments of the climb-out.

Many factors could explain why the fuel flow can become critical during take-off:
- The engine is set to full throttle for a longer period of time than during the engine test, which allows the fuel level in the carburettors to slowly decrease as a result of the fuel flow being slightly lower than the fuel consumption.
- While accelerating during take-off, the RPM will be higher at full throttle than during the engine test, due to the ram air in the inlet, causing the fuel consumption to increase.
- The aeroplane nose up attitude during take-off causes a higher height difference between the fuel located in the fuel tank and the fuel pump which will increase the tendency for the pump to pump air instead of liquid.

Other factors such as the amount of vibrations and a higher temperature can also influence the severity of the air intake.

If the lack of sealing is located on the pressure side of the fuel system:
A defect along the pressure side of the fuel system will cause a fuel leak in varying amounts depending on the fault. The leak will appear as soon as the fuel system is under pressure, such as when setting the electrical fuel pump on. Considering that the fuel pump(s) is(are) oversized, a fuel leak will only affect the carburettor feeding if the leak is significant.
Another problem related to a fuel leak is the reduction of the endurance of the aeroplane potentially causing it to run out of fuel.
In fact, the greatest danger with a fuel leak is that it sets fire to the aeroplane.
In summary:

| Fuel leak on the suction side | Fuel leak on the pressure side |
|---|---|
| • Leak not (or less) visible during inspection.<br>• Less fuel odour.<br>• Limited and temporary leak only after shut down of the engine and/or electrical fuel pump.<br>• Fuel flow is reduced proportionally to the false air intake.<br>• Insufficient fuel feeding may not be detectable during an engine run-up.<br>• Presence of a back-up fuel pump doesn't help.<br><br>⇨ Danger: Power loss at or just after take-off. | • Leak visible during inspection when back-up electrical fuel pump is set on.<br>• Chance of possible fuel odour.<br>• Fuel flow mostly remains sufficient to feed the carburettors except if the leak is significant.<br>• Presence of a back-up electrical fuel pump doesn't help.<br>• Significant risk of setting on fire.<br><br>⇨ Danger: Setting on fire in-flight.<br>⇨ Danger: endurance reduction |

## CONCLUSIONS

### Findings

- The aeroplane held a valid 'Carte d'identification ULM' delivered by the French aviation authority (DGAC).
- The pilot was duly qualified and licensed for piloting ultralight aeroplanes. He had flown his aeroplane extensively since purchasing it.
- The fuel system has been modified by installing a back-up electrical fuel pump 2 years before the accident, when the pilot bought the aeroplane.
- The engine stopped shortly after the take-off, during the first phase of the climb-out.
- Examination of the aeroplane after the accident determined that both carburettor bowls contained an abnormally low fuel quantity.
- Examination of the fuel system showed a mixture of different end connectors and different clamp models. Some clamps were found to be insufficiently tightened. Their examination suggests that they had not been properly tightened during initial installation and that they were likely never verified thereafter.
- The pilot kept flying the aeroplane and performed a forced landing to the front of him. An evasive manoeuver to avoid colliding with a horse just before the touch-down caused an improper touch-down, resulting in the landing gear collapse and substantial damage.

### Cause

The cause of the accident is an engine stoppage resulting from a fuel starvation due to a false air intake at a tee fitting connector located at the suction side of the fuel system. The air intake occurred as a consequence of a fuel pipe clamp not being properly tightened.

### Contributing safety factors

- The lack of an adequate quality system when modifying the fuel system (such as, but not limited to the supervision by an independent and competent person) leading to not detecting the insufficient tightening of the fuel line clamp.
- Insufficient/inadequate preventive maintenance did not allow to early detect the insufficient tightening of the fuel line clamp.
- The absence of formal technical standards or guidance material for the hoses used in the ultralight aircraft.

### About this report

*As per Annex 13 and EU Regulation EU 996/2010, each safety investigation shall be concluded with a report in a form appropriate to the type and seriousness of the accident and serious incident. 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.*