Air Accident Investigation Unit Ireland

SYNOPTIC REPORT

ACCIDENT
Tecnam P2002-JF, EI-GIS
Waterford Airport

11 March 2019

An Roinn Iompair
Turasóireachta agus Spóirt
Department of Transport,
Tourism and Sport

Foreword

This safety investigation is exclusively of a technical nature and the Final Report reflects the determination of the AAIU regarding the circumstances of this occurrence and its probable causes.

In accordance with the provisions of Annex 13[1] to the Convention on International Civil Aviation, Regulation (EU) No 996/2010[2] and Statutory Instrument No. 460 of 2009[3], safety investigations are in no case concerned with apportioning blame or liability. They are independent of, separate from and without prejudice to any judicial or administrative proceedings to apportion blame or liability. The sole objective of this safety investigation and Final Report is the prevention of accidents and incidents.

Accordingly, it is inappropriate that AAIU Reports should be used to assign fault or blame or determine liability, since neither the safety investigation nor the reporting process has been undertaken for that purpose.

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[1] **Annex 13**: International Civil Aviation Organization (ICAO), Annex 13, Aircraft Accident and Incident Investigation.
[2] **Regulation (EU) No 996/2010** of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation.
[3] **Statutory Instrument (SI) No. 460 of 2009**: Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulations 2009.

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In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No 996/2010 and the provisions of SI No. 460 of 2009, the Chief Inspector of Air Accidents on 11 March 2019, appointed Mr Howard Hughes as the Investigator-in-Charge to carry out an Investigation into this Accident and prepare a Report.

Aircraft Type and Registration:	Costruzioni Aeronautiche Tecnam S.r.l., P2002-JF, EI-GIS	
No. and Type of Engines:	1 X Rotax 912 S2	
Aircraft Serial Number:	191	
Year of Manufacture:	2011	
Date and Time (UTC)[4]:	11 March 2019 @ 11.40 hrs	
Location:	On approach, Waterford Airport (EIWF)	
Type of Operation:	General Aviation	
Persons on Board:	Crew - 1	Passengers - Nil
Injuries:	Crew - Nil	Passengers - Nil
Nature of Damage:	Substantial	
Commander's Licence:	N/A (Student Pilot, flying under authorisation of an Instructor)	
Commander's Age:	29 years	
Commander's Flying Experience:	57 hours, of which 11 were on type	
Notification Source:	ATC Duty Controller EIWF	
Information Source:	AAIU Field Investigation AAIU Report Form submitted by Pilot	

[4] **UTC**: Co-ordinated Universal Time. All timings in this report are quoted in UTC; Local time was the same as UTC on the date of the accident.

SYNOPSIS

The aircraft, with a solo Student Pilot on board, was carrying out circuit training at Waterford Airport (EIWF). As the aircraft commenced a turn onto the base-leg of its first circuit, the engine began to vibrate violently, lost power, and did not respond to throttle inputs. On final approach to Runway (RWY) 21, the Student Pilot declared an emergency (Mayday), and informed EIWF Air Traffic Control (ATC) that he was carrying out a forced landing. The aircraft touched down in a field, bounced, and continued through a boundary hedge. The aircraft came to rest, inverted, in the adjacent field. The Student Pilot exited the aircraft uninjured. The aircraft sustained substantial damage. There was no fire.

NOTIFICATION

The AAIU Inspector-on-Call was notified at 11.52 hrs by the Waterford Airport ATC Duty Controller. Two Inspectors from the AAIU deployed to the accident site and commenced a field investigation.

1. FACTUAL INFORMATION

1.1 History of the Flight

The Student Pilot had arranged to carry out a solo circuit flight detail with a Declared Training Organisation (DTO). During his pre-flight inspection of the aircraft, the Student Pilot noticed that the engine coolant level in the coolant overflow bottle was below the minimum level mark. This was brought to the attention of his Instructor, who added additional coolant to the overflow bottle.

The Student Pilot then boarded the aircraft, started the engine, and called for taxi clearance from Waterford Tower ATC. The aircraft was granted taxi clearance and it proceeded to the holding point for RWY 21, where engine power checks were completed.

The aircraft commenced take-off at 11.34 hrs. During the take-off and initial climb the Student Pilot noted that all engine indications were normal. However, as the aircraft commenced the left crosswind leg of the circuit, he felt liquid dripping onto his left shoe. The liquid continued to trickle onto his left shoe as the aircraft flew downwind. During this time he noted that the engine parameters were normal.

As the aircraft turned onto the base-leg, the Student Pilot reduced engine RPM, and at the same time severe engine vibration commenced. The Student Pilot informed ATC that he had an engine problem, and turned directly towards RWY 21, in order to reduce the track miles. The engine continued to run at a reduced RPM, but was no longer responding to throttle inputs.

When the aircraft was approximately 1 nautical mile (NM) from RWY 21 and at a height of approximately 200 ft, the Student Pilot transmitted a Mayday call to ATC and informed them that he had ‘*no* [engine] *power*’.

The Student Pilot also informed ATC that he was '*not too sure* [if he would] *make the runway'.* He then turned the aircraft slightly left, towards a large field, approximately 0.7 NM north-northeast of the runway, in which he attempted a forced landing, and informed ATC of this. The aircraft made a hard touch-down, approximately two thirds of the way into the field, and bounced. The aircraft then remained airborne, in ground effect[5], as it travelled 90 meters (m) towards the boundary hedge at the southern end of the field. As it passed through a gap in the hedge, the right wing impacted the trunk of a tree. The impact caused the aircraft to yaw to the right. During the yaw, the aircraft commenced a right roll, becoming inverted. The left wing tip struck the ground, followed by the nose of the aircraft, and it came to rest inverted, 40 m beyond the boundary hedge.

The Student Pilot exited the aircraft and made his way on foot to the main road nearest to the accident site. As he did so, he informed his Instructor by phone that he was uninjured. He was met by the emergency services and was taken to hospital for a precautionary check-up.

1.2 Interviews

1.2.1 Student Pilot

The Investigation interviewed the Student Pilot on 14 March 2019. He stated that on the day of the accident he had been cleared by his Instructor for an hour of solo circuits. He said that circuits at EIWF were usually flown at a height of 800 ft, and he would use QFE[6], which was 1022 hPa[7] on the day of the accident. He recalled the wind at the surface was approximately 220° at 9 kts. He also stated that during the pre-departure inspection (PDI), he noted that the engine oil level and engine oil colour were normal, the fuel quantity was sufficient for the circuit detail, and there was no water present in the fuel when he did the fuel check. He noticed that the coolant level in the overflow bottle was below the minimum level mark, and he brought this to the attention of his Instructor, who added additional engine coolant to the overflow bottle.

The Student Pilot informed the Investigation that power settings used on the subject aircraft were based on propeller RPM. He stated that typical values used were 2,400 RPM during take-off, 1,700 RPM for cruise and downwind, and 1,400 RPM when descending during the base-leg of the circuit. He said the engine would idle at approximately 650 to 700 RPM.

He also stated that as he commenced take-off for the first circuit all the engine indications appeared normal, but that on the cross-wind leg he noticed liquid trickling onto his left foot. The liquid was cold, and he recognised it as coolant from its colour and odour. As he knew this was not normal, he decided to discontinue the circuit detail, so he called ATC and told them he was '*crosswind for a full-stop landing*'. He continued the climb to 800 ft and turned onto the downwind leg, where he did the downwind checks, which included exercising the carburettor heating. He stated that all indications were normal, and noted that the coolant was still trickling onto his foot. In addition he noted that during troubleshooting of the dripping coolant the height of the aircraft increased to just over 1,000 ft, but that he corrected back to circuit height.

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[5] **Ground effect**: The increased lift and decreased aerodynamic drag that an aircraft's wings generate when they are close to the ground, or other surface.

[6] **QFE**: An altimeter subscale setting that will cause the altimeter to read zero at aerodrome elevation (or at runway threshold).

[7] **hPa**: Hectopascal.

As the aircraft turned onto the base-leg, the Student Pilot said he '*reduced the power back to approximately 1,400 RPM, and selected flaps one*[8]'. He informed the Investigation that as the power was being reduced he experienced severe vibration, which made it difficult to read the instruments: '*The engine started to rattle and shake, and the vibration was seen on the instrument panel too*'. He immediately selected carburettor heat on and checked that the choke had not been inadvertently selected. He then '*cut the corner* [of the base-leg] *to shorten the distance to the runway*' and he informed ATC that he had '*an engine issue and* [was] *on finals for runway 21*'. He stated that he tried moving the throttle, but there appeared to be no response from the engine, and that the RPM had now reduced to approximately 1,000 RPM.

The Student Pilot said that as the aircraft got closer to the airport he realised he would not make the runway. He advanced the throttle to maximum, but there was still no response from the engine. At approximately 200 ft, he informed ATC that he had no power, declared a Mayday, and picked a field in which to attempt a forced landing. He noted that the engine was still turning throughout the accident sequence until impact. He stated that he '*was a bit fast for landing in the field he had picked but was committed to landing'*, and put the aircraft down firmly and '*it was a hard landing and the aircraft bounced and ballooned*'. He said that when he realised he was not going to stop before reaching the hedge and raised bank at the end of the field, he held the nose up and tried to fly through a gap in the hedge.

He said he felt an impact with something and the aircraft spun to the right. He stated that it was not clear what happened next, but the aircraft impacted nose first into the ground. He noticed that there was no engine sound after impact. He saw a haze in the cockpit, but said it was not smoke. Although he did not smell fuel, he was concerned there might be a fire. He released the harness and evacuated the aircraft through his side of the cockpit. He noted that the canopy was already open, but he had to '*dig himself out of the cockpit*'. He said that he did not make any switch selections in the cockpit prior to exiting.

Once he was clear of the aircraft, he walked towards the road and as he did so he phoned his instructor to tell him he was uninjured. He stated that he met the emergency services as he approached the main road near the accident site and agreed to be taken to hospital for a check-up.

1.2.2 Instructor

The Instructor, who authorised the Student Pilot's solo circuit detail, recalled that the Student Pilot had brought to his attention the low level of coolant in the aircraft's overflow bottle. The Instructor stated that the overflow bottle was empty, and he topped up the overflow bottle to the '*Max*' marking on the bottle. The Instructor informed the Investigation that this was not the first time this aircraft needed to have coolant[9] added. The Instructor had flown the subject aircraft three days previously and he did not notice any engine vibration.

[8] This is a reference to the first flap position on the 'Wing Flaps' gauge on the instrument panel which is annotated as T/O, or Take-off Flap.
[9] The Investigation did not find any records noting that coolant was being added to the aircraft coolant system.

The Instructor stated that, as was normal practice, he would monitor radio communications between a solo student and Waterford ATC. On this occasion he was surprised to hear the Student Pilot calling that he was crosswind for a full stop landing, as the Student Pilot was authorised for approximately one hour of circuit flying. He stated that he could hear the various radio calls being made by the Student Pilot, and when he heard the Student Pilot radioing that he had engine difficulties he became concerned that there was a problem. He left the DTO's briefing room, and went outside to see if he could observe the aircraft.

He recalled receiving a phone call from the Student Pilot who told him that the aircraft had crashed but that he had exited the aircraft and was not injured.

1.2.3 Pilot of another Aircraft

At time of the accident, another aircraft was carrying out instrument flight training at EIWF. The pilot of the other aircraft noted that they had just completed a low approach and go-round from RWY 21 and were climbing up to hold at the Waterford NDB[10] when he heard EI-GIS calling the tower and using the '*Student Solo*' callsign. He noted that there would be a solo student in the circuit, which was '*something to keep an eye on*'.

As the other aircraft was in the hold, the pilot said he heard the Student Pilot informing EIWF ATC that he had an engine problem. He then heard EI-GIS calling that he had a loss of engine power, followed by a call that he had lost all engine power. Shortly after this he heard the Student Pilot make a Mayday call.

The other aircraft was inbound in the hold at 3,000 ft when the Mayday call was made, and the pilot saw the subject aircraft, low, and descending into a field. He saw EI-GIS hit the trees and '*flip over*'. He radioed this information to the tower. He then saw someone '*moving briskly away*' from the aircraft and assumed it was the Student Pilot. He relayed this information to the tower as well.

1.2.4 Chief Instructor

The Chief Instructor of the DTO informed the Investigation that he believed it was not unusual for the coolant level in the overflow bottle of this aircraft type to require regular topping up. He further stated that he recalled something being taped over the top of the overflow outlet bottle filler cap of the subject aircraft.

1.3 Injuries to Persons

There were no injuries reported to the Investigation.

1.4 Damage to Aircraft

The aircraft sustained substantial damage and was deemed to be damaged beyond economic repair.

1.5 Other Damage

The aircraft impacted into a grass field. There was associated ground scarring and damage to a hedgerow. Staining of the grass in the vicinity of the aircraft indicated that fuel had leaked onto the ground.

[10] **NDB**: Non-Directional Beacon.

1.6 Personnel Information

The Student Pilot was undergoing training for a Private Pilot Licence (Aeroplane) with a DTO, and as such, whilst under training, the Pilot did not require a licence, but could fly under the authorisation of an instructor. Prior to commencing training with the DTO, the Student Pilot had acquired just over 46 hours of flight time on a different aircraft type at another training facility in Ireland. The Student Pilot held an EASA Class 2 Medical Certificate, which was valid until 13 February 2024. The flying experience of the Student Pilot is set out in **Table No. 1**.

Personal Details:	Age 29 years
Licence:	N/A
Total all Types:	57 hours
Total on Type:	11 hours
Total P1 on Type:	3 hours

Table No. 1: Student Pilot's flying experience

The Flight Instructor was in possession of a valid licence, Instructor Rating, and medical certificate.

1.7 Aircraft Information

1.7.1 General

The aircraft was a Tecnam P2002-JF. The P2002-JF is a two-seat, low-wing aircraft, of aluminium construction, and powered by a single Rotax 912 S2 engine. The P2002-JF is equipped with a sliding canopy. The seating is configured side-by-side, and each seat is equipped with a four-point harness. The subject aircraft was factory-built, and equipped with a fixed tricycle undercarriage (**Photo No. 1)**. The aircraft was equipped with electrically operated wing flaps, with three positions: 0°, Take-off, and Full. It was also equipped with a two-bladed, fixed pitch propeller.

Photo No. 1: Accident Aircraft at time of purchase. (Courtesy of DTO). The previous registration identification has been removed from the image

1.7.2 Airworthiness Certification

A Certificate of Airworthiness was issued for the aircraft on 13 February 2019. The aircraft was operating on an Airworthiness Review Certificate (ARC), also issued on 13 February 2019, which was valid for one year.

1.7.3 Aircraft Engine

The Rotax 912 S2 engine is a naturally aspirated, horizontally opposed, four-cylinder, four-stroke engine delivering 100 hp (75 kW). The cylinders are air-cooled, whilst the cylinder heads are water-cooled, and each is fitted with two spark-plugs. As the engine is designed to operate at high RPM, it is fitted with a Propeller Speed Reduction Unit (PSRU). On the subject engine, the reduction ratio was 2.43:1. An RPM gauge fitted in the cockpit of the subject aircraft displayed the propeller RPM.

Figure No. 1 shows a plan view of a Rotax 912 engine, with the main components labelled. The intake manifolds on the subject engine each had a 6 mm threaded hole labelled '*Carburettor Synchronisation Tapping*', into which a blanking screw or brass carburettor synchronisation adaptor could be fitted.

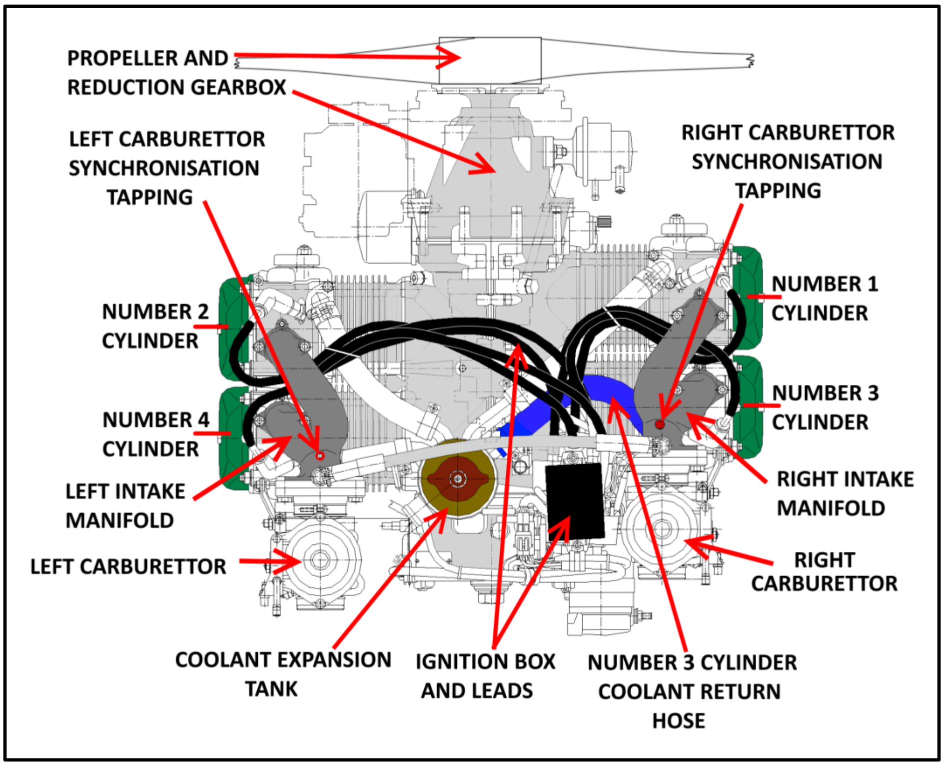


Figure No. 1: Plan view of a Rotax 912 engine. (Note: for clarity, fuel hoses are not shown, see also **Section 1.7.5.3**)

1.7.4 Maintenance History

On 30 January 2019, a routine 100 hour airframe and engine inspection was carried out by an IAA approved aircraft maintenance organisation. At the time of this inspection the aircraft had accumulated 1,490 hours, and no issues relating to the coolant, carburettor or air-induction systems were reported. At the time of the accident, the aircraft had flown approximately 27 hours since the last 100 hour inspection.

The number three cylinder head coolant return hose was last replaced on 24 November 2016, at 1,234 hours as part of a scheduled five year hose replacement. This was carried out by a UK CAA[11] approved aircraft maintenance organisation. In the period between this replacement and the accident there was no evidence to suggest that there was further work carried out on this coolant hose. The aircraft also underwent a number of scheduled '*Annual*', '*50 hour*' and '*100 hour*' inspections at various maintenance facilities with no evidence of the number three cylinder head coolant return hose being disturbed following its installation at 1,234 hours, on 24 November 2016.

The DTO informed the Investigation, that at the time of the accident, logging of fluid uplifts such as engine oil and coolant was not carried out. However, during the Investigation, the DTO advised that it had taken Safety Action whereby it had introduced a system for tracking uplifts of fluids for its aircraft.

1.7.5 Liquid Cooling System

1.7.5.1 General

A schematic diagram showing the flow of coolant through the engine cylinder heads and associated components of the coolant system is shown in **Figure No. 2**.

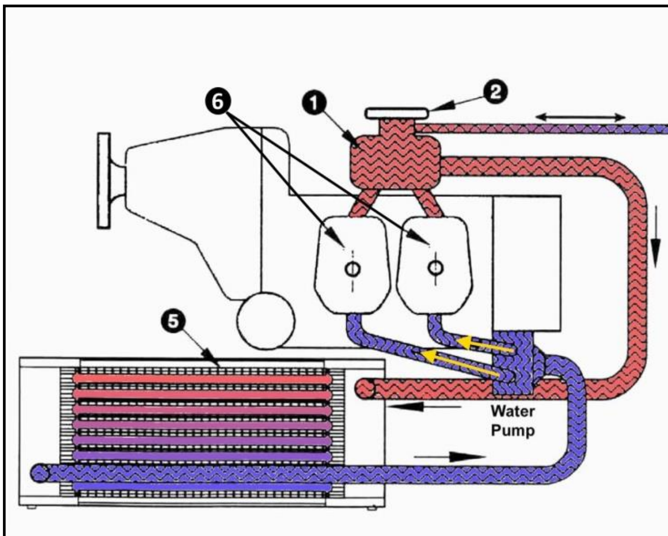


Figure No. 2: Schematic diagram of Rotax 912 water coolant system
(Adapted from the Rotax Operators Manual)

As stated in the Engine Manufacturer's Operators Manual[12]:

'The cooling system of the engine is designed for liquid cooling of the cylinder heads and ram-air cooling of the cylinders. The liquid cooling system of the cylinder heads is a closed circuit with an expansion tank.

[11] **CAA**: Civial Aviation Authority.
[12] Rotax Operators Manual OM 912. Page 7-2, Edition 4 / Rev 0. November 01/2016.

Section 3.1 '*Daily checks*', of the Engine Manufacturer's Operators Manual, includes the following on checking the Coolant Level:

> *'Step 2: Verify coolant level in the **overflow bottle**, replenish as required. The coolant level must be between max. and min. mark.'*

1.7.5.2 Expansion Tank

The expansion tank is connected to the four cylinder heads via four individual coolant hoses, labelled as shown in **Figure No. 3**.

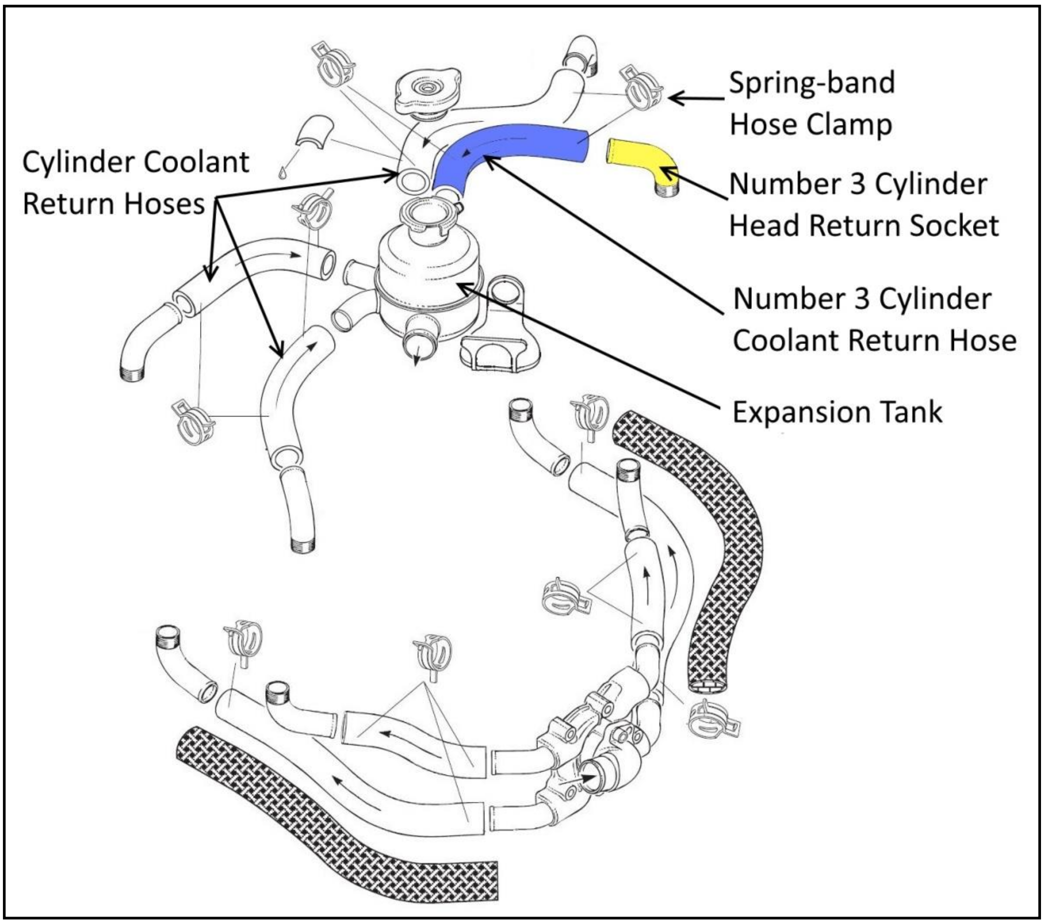


Figure No. 3: Rotax 912 Coolant Hose Schematic
(Adapted from Manufacturer's Heavy Maintenance Manual)

With reference to **Figure No. 3,** the number three cylinder coolant return hose (blue), connects the expansion tank to the number three cylinder head coolant return socket, (yellow), and is secured using a spring-band hose clamp.

The purpose of the expansion tank is to facilitate expansion and contraction of the coolant due to changes in temperature and pressure as it moves through the cooling system. The Engine Manufacturer's Operators Manual states:

> '*From the expansion tank the coolant is sucked thru the radiator back to the water pump. Additionally the expansion tank is closed by a pressure cap (with excess pressure valve and return valve).*

At temperature rise of the coolant the excess pressure valve opens and the coolant will flow via hose at atmospheric pressure to the transparent overflow bottle. When the engine is cooling down, the coolant will be sucked back into the cooling circuit'.

The expansion tank is fitted with a radiator cap, one function of which is to allow engine coolant to operate at a pre-set pressure value which is higher than atmospheric pressure, thus increasing the boiling point of the coolant.

Figure No. 4 shows the detail of the coolant expansion tank radiator cap. During normal operation, when pressure in the expansion tank reaches the pre-set value (1.2 bar), the pressure relief valve (1) lifts against spring (4), allowing excess coolant to flow through coolant line (5) to the overflow bottle. As the engine cools, coolant can return to the expansion tank via the return valve (2). In the subject aircraft, the pressure relief valve spring (4) was found to have failed, leaving the expansion tank open to atmospheric pressure via the coolant line and the overflow bottle.

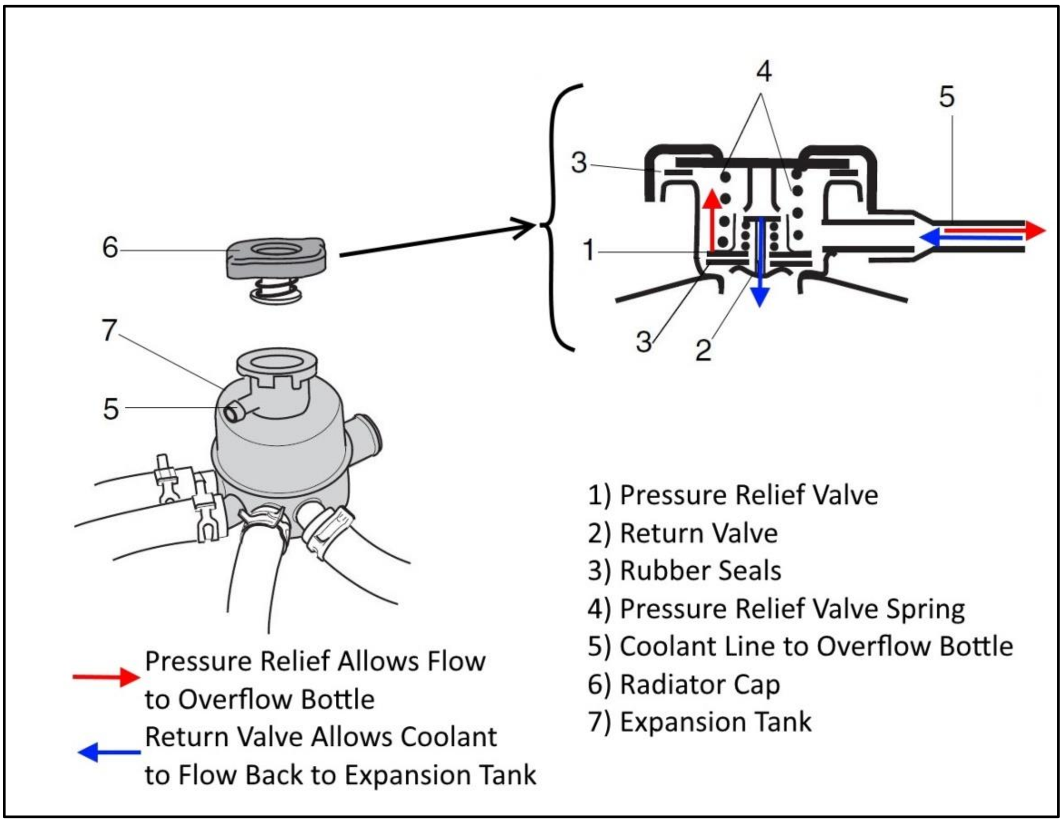


Figure No. 4: Schematic of Expansion Tank Radiator Cap

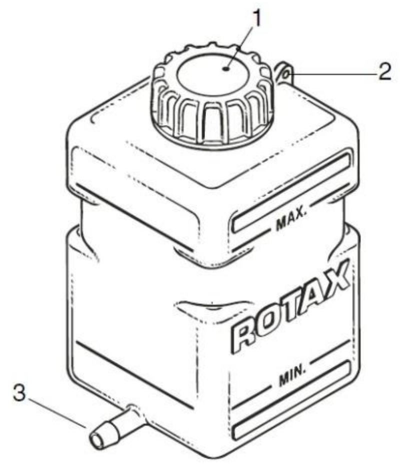
1.7.5.3 Location of Number Three Coolant Return Hose

The attachment point for the number three coolant return hose to the number three cylinder head coolant return socket is located under the right intake manifold. Both the hose and its spring-band hose clamp are coloured black. In addition, a number of ignition leads and fuel lines route over the top of the number three coolant return hose. The Investigation noted that this arrangement made it difficult to see if the subject coolant hose had been securely fastened to the number three cylinder head coolant return socket.

1.7.5.4 Coolant overflow bottle

A typical coolant overflow bottle for a Rotax 912 S2 engine coolant system is shown in **Figure No. 5.** It is made of transparent rigid plastic, and shows the level of coolant present in the bottle. Under normal conditions the coolant level in the overflow bottle will be between the '*Max*' and '*Min*' markings on the side of the bottle. During engine operation, as the coolant in the engine heats and expands, when the pressure in the expansion tank exceeds the pre-set value, the pressure relief valve in the expansion tank radiator cap allows a small amount of coolant to pass into the overflow bottle, via the coolant line hose connection (item 3 in **Figure No. 5**), thus maintaining the correct operating pressure of the engine's coolant system. In order to ensure coolant can pass into and out of the overflow bottle, the overflow bottle cap is equipped with a small hole (venting bore, item 1 in **Figure No. 5**), which allows air in the bottle to equalise with ambient air pressure.

Overflow bottle



Part	Function
1	Venting bore
2	Bracket
3	Hose connection

Figure No. 5: Coolant overflow bottle (from Engine Manufacturer's Line Maintenance Manual)

If the overflow bottle was to become full to the top of the bottle, as coolant from the expansion tank tried to flow into the bottle, it would encounter resistance, as it would be more difficult for liquid to pass through the vent-hole than for air. This would create a back-pressure into the coolant system, dependent, *inter alia,* on how quickly the coolant could pass through the small vent-hole in the overflow bottle cap.

1.7.6 Fuel/Air Induction System

The aircraft engine's four cylinders receive the required fuel/air mixture via a twin carburettor arrangement. Cylinders one and three are supplied from the right carburettor via the right intake manifold; cylinders two and four are supplied from the left carburettor via the left intake manifold.

With reference to **Figure No. 6**, both intake manifolds (item 5) are connected via a resonator hose and a compensating tube arrangement, (items 1 and 2 respectively). Whilst its main function is to balance intake manifold pressures during engine operation, it also facilitates one of four possible methods of carburettor synchronisation during engine maintenance.

Each manifold is also fitted with an M6 screw and washer combination as standard, (item 3 in **Figure No. 6)**. These M6 screws are used to blank off an M6 tapping in each manifold, which may also be used during carburettor synchronisation.

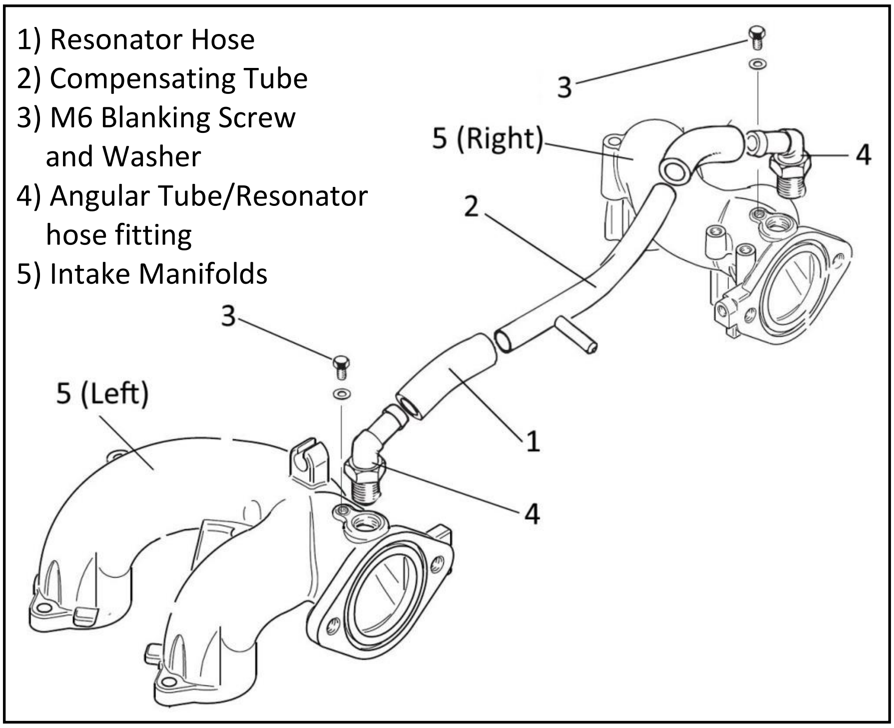


Figure No. 6: Schematic of Engine Intake Manifolds. (Adapted from Engine Manufacturer's Line Maintenance Manual)

The Engine Manufacturer's Line Maintenance Manual sets out a number of methods for carburettor synchronisation, without the need for using the Resonator Hose, and Compensating Tube. One method involves the use of additional equipment attached via the M6 tapping in each manifold.

To use this method, a third-party, proprietary carburettor synchronisation kit is required for installation on each of the intake manifolds of the Rotax 912 S2 engine. The carburettor synchronisation kit consists of three parts: an M6 brass adaptor, a rubber cap that fits over the top of the adaptor, and a gasket to seal the brass fitting when screwed into the top of the manifold. Instructions for its use are given in the Rotax 912 Series, Line Maintenance Manual, section 10.3, *Pneumatic Synchronization*, *Option 4*. A copy of this section of the manual is presented in **Appendix A**. The instruction in Option 4 of the manual states:

- *Install a hose nipple M6* […] *with sealing ring or O-ring* […].
- *After synchronization* ***remove the hose nipple*** *M6* […].
- ***Secure screw M6x6*** […] *with a new gasket* […] *and LOCTITE 221.*

[Emphasis added by the Investigation].

Proprietary equipment used for this method of carburettor synchronisation is available for purchase online. The instructions, on the website for one such carburettor synchronisation product, state:

- *A pair of fixed adaptors for* ***permanent connection to intake manifolds****.*
- *For connected to engines with a tapped M6 fixture in the manifold.*
- ***Can be left permanently in place****.*
- *Short type, M6 thread, nipple, sealing cap and washer.*

[Emphasis added by the Investigation].

Photographic evidence, provided by the DTO, showed that a synchronisation adaptor, sealing cap, and washer, were in place on the right intake manifold, on the subject engine, when purchased by the DTO in July 2018 (**Photo No. 2**).

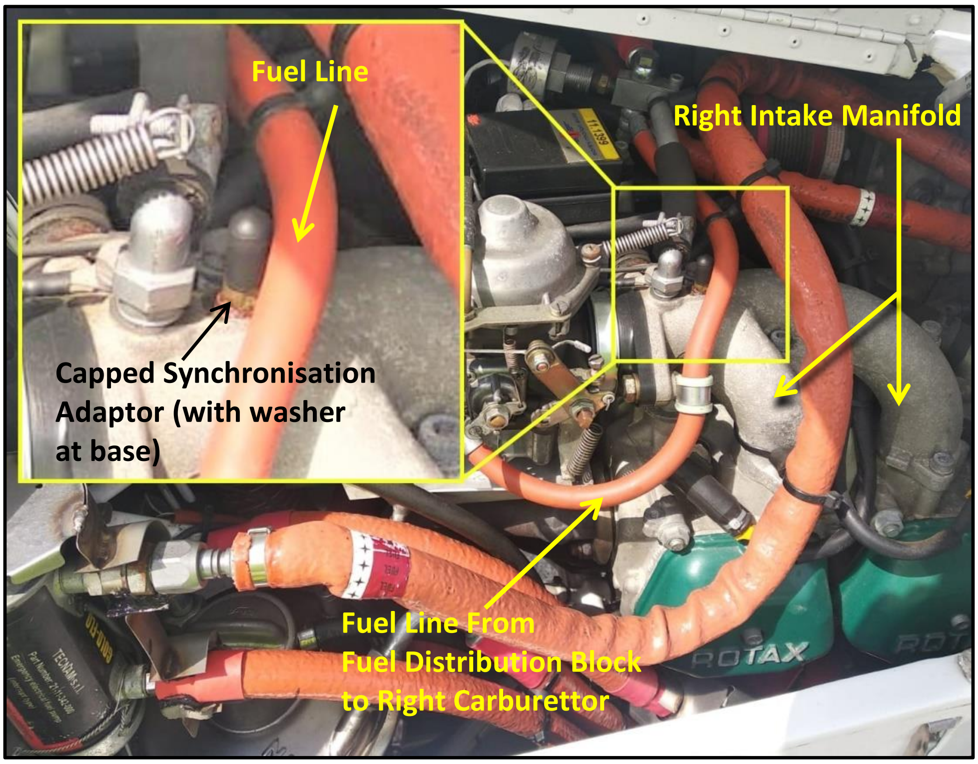
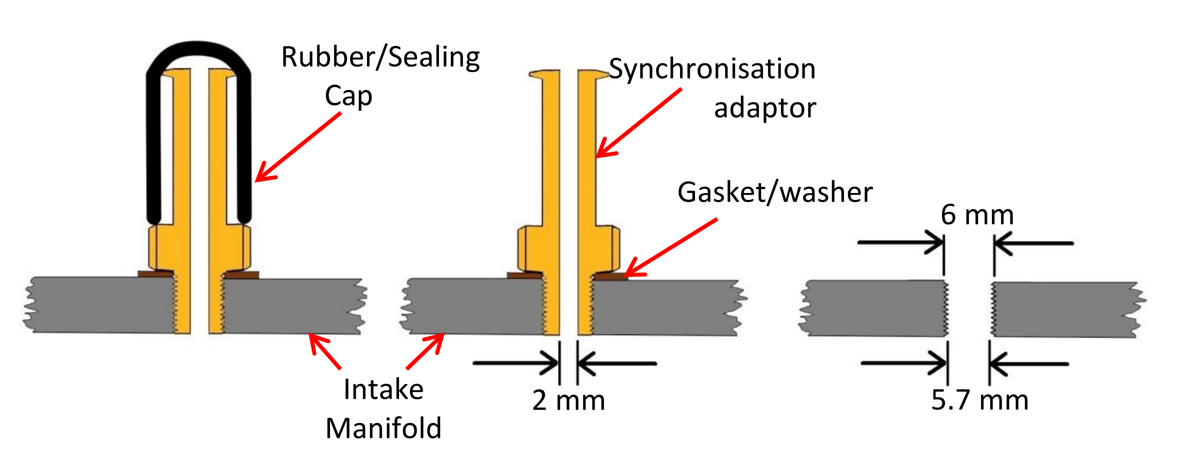


Photo No. 2: Engine in the accident aircraft, at time of purchase by DTO, showing the right intake manifold. Inset shows carburettor synchronisation adaptor

When fitted with its washer/gasket and rubber sealing cap, the synchronisation adaptor tapping is sealed, **Figure No. 7 (a)**. If the rubber cap is not fitted, this presents a 2 mm opening in the top of the affected intake manifold, **Figure No. 7 (b)**. When the synchronisation adaptor is completely removed, a tapped hole of approximately 5.7 mm diameter is present in the top of the manifold, **Figure No. 7 (c)**. The Rotax 912 Series, Line Maintenance Manual indicates that this hole is normally closed (or blanked off) with a 6 mm hexagonal screw and gasket.



(a): Synchronisation adaptor capped.	**(b)**: Synchronisation adaptor uncapped.	**(c)**: Synchronisation adaptor removed.

Figure No. 7: Cross section of a Carburettor Synchronisation Adaptor

1.8 Examination of Engine and Engine Testing

1.8.1 Examination of Engine (AAIU Wreckage Facility)

1.8.1.1 General

Whilst the engine had remained largely intact during the impact, examination showed it had been displaced approximately 65° up and 50° left of the aircraft's horizontal axis. This had resulted in rearward distortion of the engine mounting frame, and corresponding damage to the air-box, the left carburettor, the overflow bottle, and distortion of the fire-wall.

Testing of the engine ignition circuit showed electrical continuity from the ignition switch in the cockpit to the ignition box. When electrical power was applied to the electrical fuel pump it was found to operate. The fuel filters were found to be clear. Continuity of the engine throttle, choke, and carburettor heat controls was confirmed.

1.8.1.2 Examination of Carburettors, Induction Manifolds and Spark Plugs

Carburettors

The left carburettor was found damaged (fuel float chamber bowl punctured) due to the displacement of the engine at impact. The right carburettor was found intact, with fuel still present in the fuel bowl. The carburettors were dismantled for examination. Each float chamber housed two floats. An Engine Manufacturer's Service Bulletin, dated 13 November 2014, stated that the maximum combined weight for both floats in a carburettor float chamber should be 7 g (grams). The combined weight of both floats in the left carburettor float chamber was found to be 11 g, with one float weighing 7.3 g. The combined weight of both floats from the right carburettor was 6.4 g.

The heavy floats from the left carburettor were found to sink when tested in a sample of fuel from the aircraft. The presence of heavy floats in a carburettor can lead to a rich fuel/air mixture being delivered to the associated engine cylinders.

Manifolds

When inspected, it was found that EI-GIS did not have the standard M6 blanking screw and washer arrangement fitted to the manifolds as required (**Figure No. 6**, item 3).

On examination of the left intake manifold, it was found that the synchronisation adaptor had sheared; the threaded portion was in place in the tapped hole in the intake manifold and the remainder was found within the engine compartment. In addition, the resonator hose fitting was found sheared **(Photos No. 3 & 4)**.

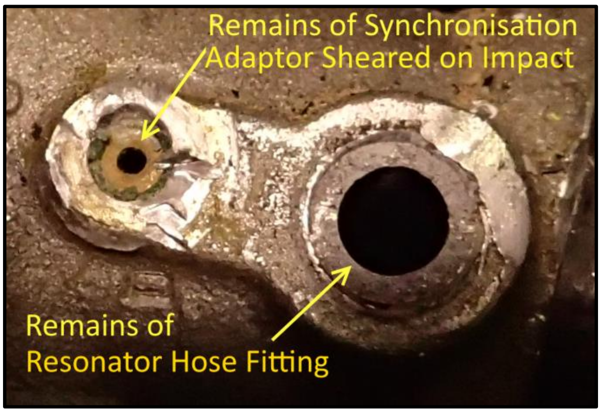


Photo No. 3: Top of Left Intake Manifold

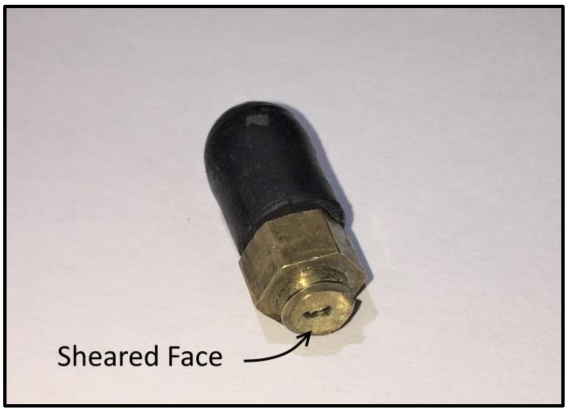


Photo No. 4: Left Synchronisation Adaptor

On examination of the right intake manifold, it was found that threads in the tapped hole of the intake manifold were stripped, and the right synchronisation adaptor was missing (**Photo No. 5)**. The right resonator hose fitting had sheared due to the impact.

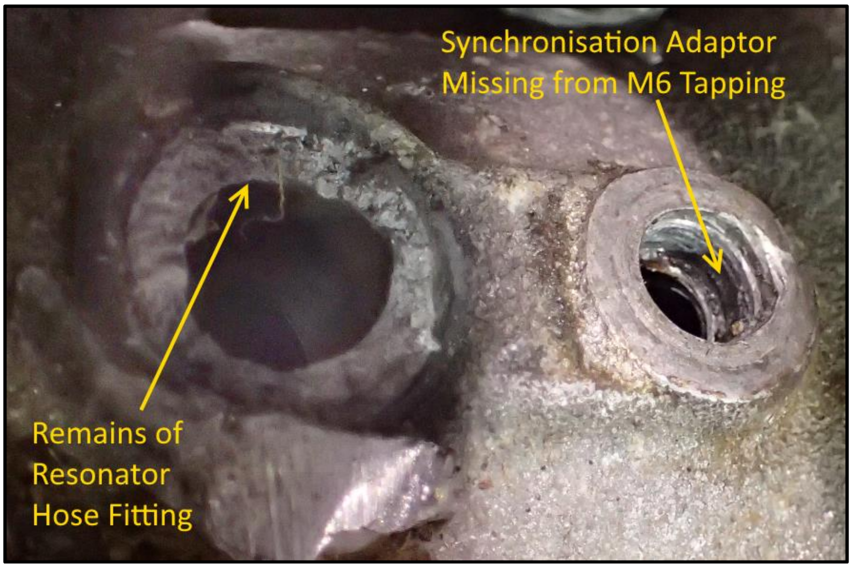


Photo No. 5: Top of Right Intake Manifold showing M6 Tapped hole for Right Synchronisation Adaptor

The presence of the open M6 tapping in the right manifold would allow additional air to enter the manifold downstream of the carburettor, thus leaning the fuel/air mixture ratio to engine cylinders one and three.

Spark Plugs

The eight spark plugs were removed and examined. They were found to be set to the correct gap, but it was noted that the plugs removed from both left engine cylinders (two and four) were black, indicating a slightly rich fuel/air mixture being delivered to the left cylinders. The plugs removed from the right cylinders (one and three) were a very light beige colour, indicating a lean fuel/air mixture being delivered to the right cylinders.

1.8.1.3 Examination of Coolant System

During examination of the engine it was found that the number three cylinder coolant return hose had detached from its corresponding cylinder head coolant return socket (**Photo No. 6**).

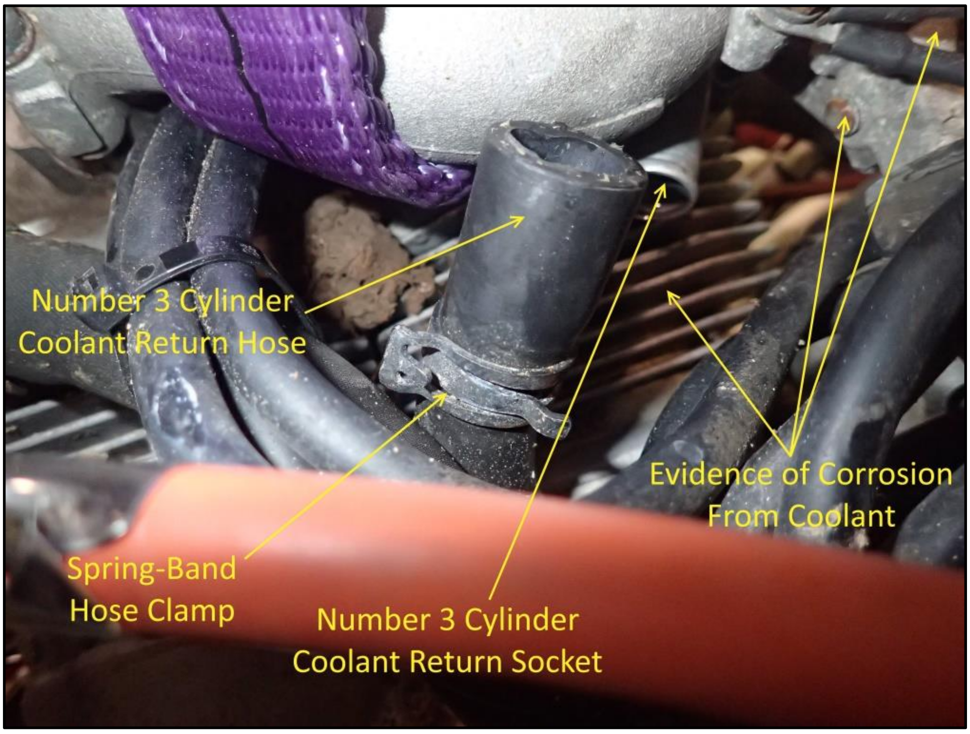


Photo No. 6: Number three Cylinder Coolant Return Hose Found Detached.
(Note: Purple strap is not part of engine)

Examination of witness marks on the number three cylinder coolant return hose showed that the spring-band hose clamp had not been secured at the end of the hose that fits over the cylinder coolant return socket at number three cylinder. The hose was removed from the engine for further examination (**Photo No. 7)**. With both spring-band hose clamps removed, witness marks indicated that the clamp at the coolant expansion tank end of the hose had been correctly fitted. However, witness marks at the end of the hose normally attached to the number three cylinder coolant return socket indicated that this particular clamp had not been fitted in the correct location to ensure secure attachment of hose and cylinder head coolant return socket.

There were also signs of corrosion to some components in the immediate vicinity of the number three coolant return hose. The signs of corrosion were confined to this area of the engine only.

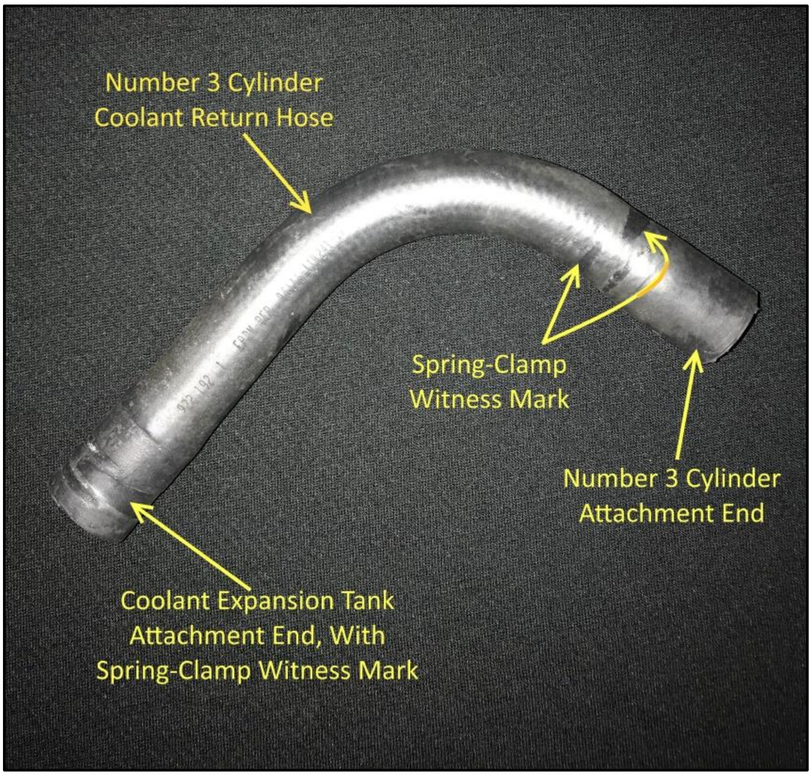


Photo No. 7: Number three Cylinder Coolant Return Hose

1.8.1.4 Internal Examination of Right Manifold

The right air intake manifold was removed from the top of engine cylinders one and three. The internal surfaces of the manifold and air intake flange were examined and this revealed evidence of liquid having entered the intake manifold during engine operation. The liquid had subsequently evaporated due to engine temperatures, leaving a crystalline deposit on the internal surfaces of the manifold and engine cylinder air intake flange, consistent with evaporated coolant liquid (**Photo No. 8** and **Photo No. 9**).

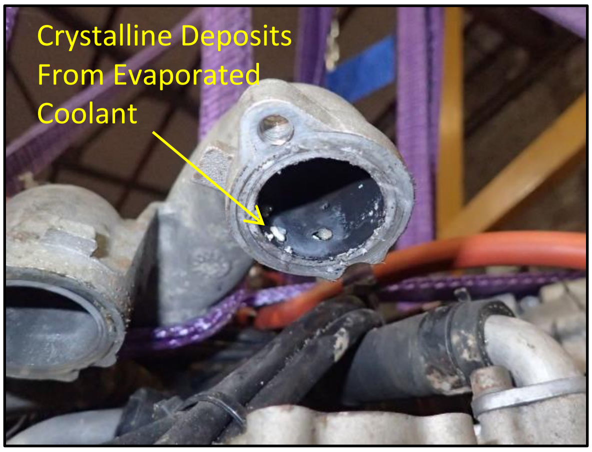


Photo No. 8: Right Manifold

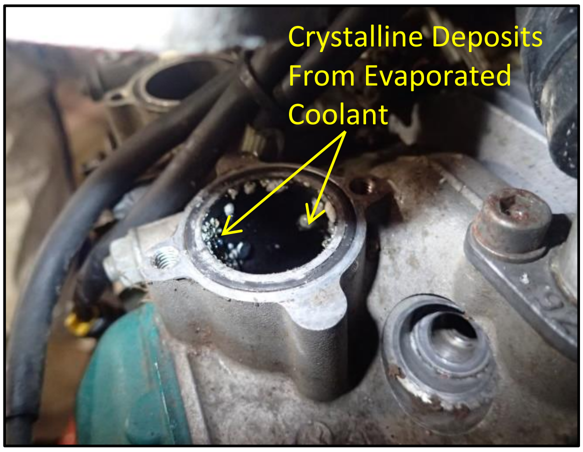


Photo No. 9: Number Three Cylinder Air Intake Flange

1.8.1.5 Coolant Overflow Bottle

The coolant overflow bottle was examined and it was determined that it had sustained some damage due to rearward displacement of the engine during the accident sequence (**Photo No. 10**).

Photo No. 10: Coolant Overflow Bottle from Subject Aircraft

Note the vent hole in the red bottle cap. This was measured and found to be 2.2 mm. The entire volume of the overflow bottle was determined to be 700 ml.

1.8.2 Engine Testing at an Approved UK Facility

Following the engine examination at the AAIU facility, it was removed for further examination and engine testing at an approved facility in the UK, under observation by AAIU Inspectors.

Prior to engine testing, a number of parts were replaced, due to damage sustained during the impact. These included replacement of:

- Carburettors
- Intake manifolds
- Propeller
- Oil filter
- Overflow bottle
- Coolant return hose from number three cylinder

The propeller reduction gearbox was stripped down and examined prior to the engine test, in case it had sustained damage during the accident. No faults were found, and it was re-assembled and used during the engine bench testing. Following mounting of the subject engine in the test bed it was successfully started and run through the full power range (idle to maximum RPM) using the replacement components, and the original ignition system, propeller reduction gear assembly, and mechanical fuel pump.

Following the engine test a report was furnished to the Investigation. The report stated *inter alia*:

> *The engine was found to operate within the required parameters for starting, power, vibration and leaks.*
>
> *The defects found during initial inspection at the aircraft wreckage were then replicated on the engine on the test bed.*
>
> *Simulated defect tests*
>
> *The engine was modified by removing the blanking screw from the RH intake manifold. The engine was started and ran. It could be operated through its entire RPM range although there was some slight vibration at lower power settings.*
>
> *The LH carb then had slave floats fitted that had been modified to match those found at the original inspection (11g total, 7g and 4g individual weights). The engine was found to reach full power, but the vibration at low power settings was now very pronounced.*
>
> *To replicate the possible effects of coolant leaking from the #3 hose in to the intake manifold, water was introduced via spray to the area above the removed blanking screw. When combined with the heavy floats, the addition of a large influx of water into the intake manifold produced a loss of power, poor throttle response and high amounts of vibration.*
>
> *The hose retaining clip from #3 cylinder was removed and the engine ran. The hose did not detach despite operating the engine to elevated temperatures around 120˚C. A pressure tester was then attached to induce a higher pressure in to the coolant system and the hose was found to detach at around 0.1 bar, whereas the system is designed to reach 1.2 bar in operation. Testing of the pressure cap showed that it did not hold any pressure when fitted to the expansion tank, despite being visually okay. There is no requirement in the maintenance manuals to perform anything other than a visual check.*
>
> *It is possible that between the time of fitting, and the time of the accident, the hose had gradually worked loose. Although this can only be supposition, this may have led to a sudden detachment of the hose, followed by a large volume of coolant entering the intake manifold via the adjacent hole left by the missing adaptor. This would result in the poor throttle response and vibration experienced in the test cell under these conditions.*

1.9 Meteorological Information

Met Éireann, the Irish Meteorological Service, provided the following aftercast for the accident location:

Report Validity	**11 March 2019, 11.40 hrs**
Meteorological Situation	There was a fresh southwest flow across Ireland with a high pressure ridge over the country during the morning and afternoon
Surface Wind	Southwest at 7-12 kts
2,000 ft Wind	Southwest at 20-25 kts
Visibility	In excess of 20 km
Precipitation	Possibility of a few light, isolated showers
Cloud	Few (1-2/8th) or Sct (2-4/8th) oktas of cloud with bases between 2000-2500ft Sct or Bkn (5-7/th) oktas of cloud with bases between 5,000-6,000ft
Surface Temp / Dew point	9/4 degrees Celsius
Mean Sea Level Pressure[13]	1026 hPa

1.10 Aids to Navigation

Not applicable.

1.11 Communications

All communication between the subject aircraft and Waterford ATC were carried out on the EIWF Tower Frequency (129.850 MHz). There is also a discrete UHF channel which is used for communications between ATC and the Waterford Rescue Fire Fighting services.

The Investigation obtained ATC recordings of the communications that took place for the time of the accident.

1.12 Aerodrome Information

Not applicable.

1.13 Recording Devices

1.13.1 General

The aircraft was not equipped with a Flight Data Recorder or a Cockpit Voice Recorder, nor was it required to be.

[13] Also referred to as QNH.

1.13.2 ATC Radar Data

EIWF is not equipped with ATC radar.

The ATC radar data from Shannon, for the period when the aircraft was in the circuit at EIWF was reviewed by the Investigation. There were no radar returns for the subject aircraft. This would be consistent with the aircraft having flown at approximately 800 ft in the EIWF circuit pattern.

1.13.3 Aircraft GPS Device

The aircraft was fitted with a removable GPS navigation device. This was removed from the aircraft by the Investigation. The device was powered up and the stored data downloaded. However, only data for previous flights were stored on the device. The Student Pilot informed the Investigation that, as he was on a circuit detail flight, he had not switched the device on.

1.14 Wreckage and Impact Information

The main aircraft wreckage was located in a small agricultural field, 0.6 NM north-northwest of the threshold of EIWF RWY 21. In an adjacent large field, to the north of the main wreckage site, the Investigation found witness marks from the three aircraft wheels. The marks were a distance of 90 m from the boundary hedge between the two fields, and 130 m from the main wreckage (**Photo No. 11**). A small portion of the fibreglass fairing from the aircraft nose wheel was also found at this location.

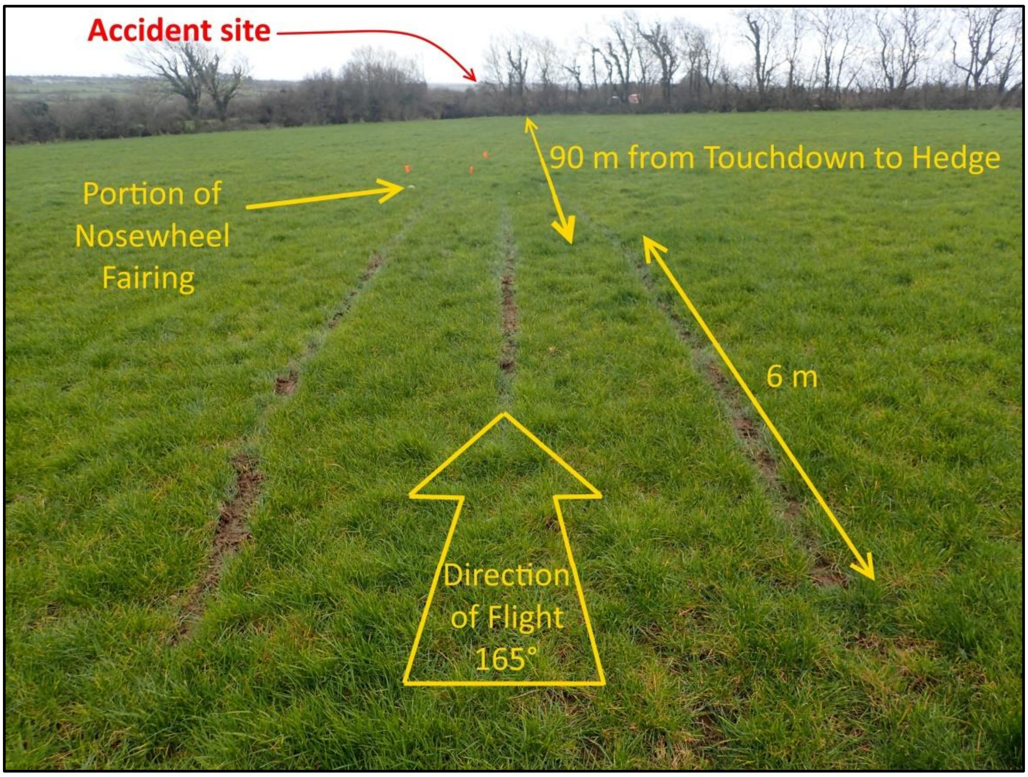


Photo No. 11: Initial touchdown point during forced landing

The Investigation found numerous small fragments from the aircraft in the boundary hedge, indicating that it had made contact with the branches of small trees and shrubs in the hedge. One tree within the hedgerow, situated on the right side of the path taken by the aircraft showed evidence of impact by the aircraft. This corresponded to damage found on the leading edge of the aircraft's right wing.

The main wreckage site was located 40 m beyond the boundary hedge, and contained all major parts of the aircraft. The aircraft was found inverted (**Photo No. 12**).

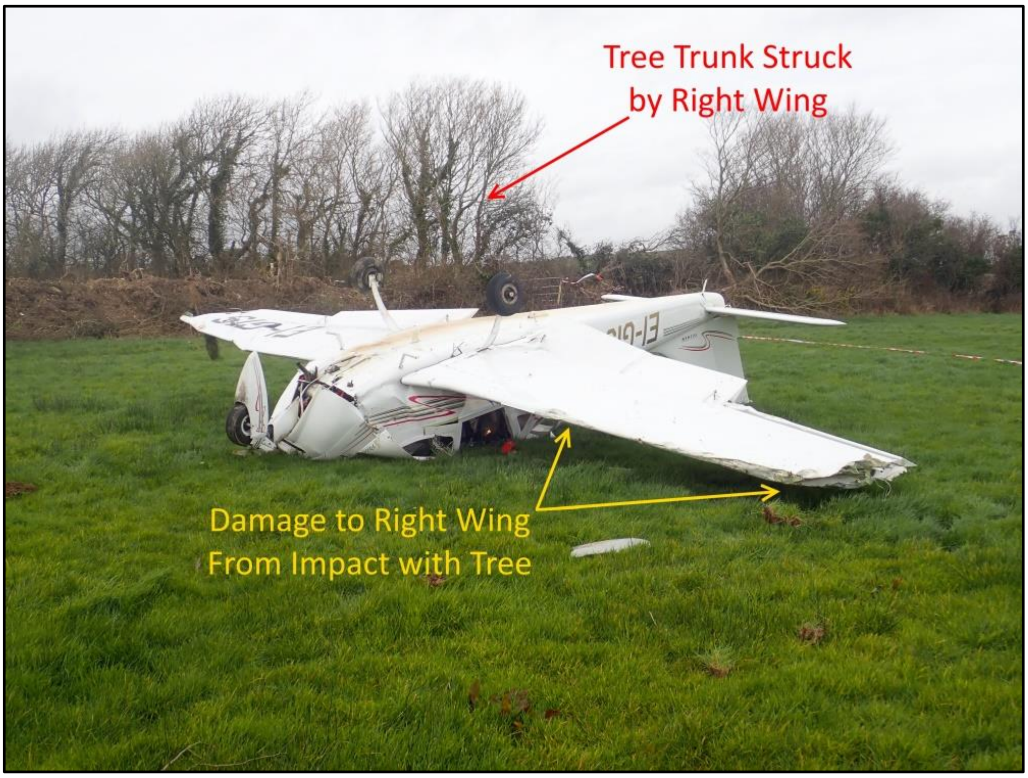


Photo No. 12: Final position of aircraft

The most significant damage to the aircraft was as follows:

- Outer half of the right wing leading edge and the wingtip damaged by impact with tree.
- Nose area of aircraft including the engine, was rotated up, and to the left of the aircraft's fore/aft axis, due impact with the ground.
- Left wingtip damage due impact with the ground.
- Upper frame of cockpit canopy crushed due impact with the ground.

Continuity of the aileron, rudder and elevator flight control linkages was confirmed at the accident site.

1.15 Injuries to Persons

No injuries were reported to the Investigation.

1.16 Survival Aspects

The Student Pilot was wearing the four-point harness as fitted to the aircraft. Although the cockpit area was distorted due to impact with the ground, whilst inverted, a liveable space remained. There was no fire.

1.17 Additional Information

1.17.1 Action Taken by Engine Manufacturer

Checking of Expansion Tank Pressure Cap

The Investigation noted that during examination of the Engine Liquid Cooling System, the pressure relief valve spring in the expansion tank pressure cap had failed. A review of the relevant section of the Engine Manufacturer's Maintenance Manual – Line (MML) with regard to checking of the pressure cap, suggested that only a visual inspection was required. During the Draft Final Report comment process, the Engine Manufacturer informed the Investigation that it had taken the following Safety Action:

> '[The Engine Manufacturer] *has* […] *reviewed the corresponding MML* […]. *It is understood that the "inspection" of the Pressure Cap which is required by the MML could be more specific in terms of how this inspection should be performed. Hence,* [The Engine Manufacturer] *decided to implement further guidance and more accurate explanation to the corresponding section of the MML in order to improve the functional check of the cooling system. The change will be implemented at the next regular revision of the MML'.*

Securing of the Number Three Coolant Return Hose

During examination of the number three coolant return hose it was found that the spring-band hose clamp had not been fitted in the correct location to ensure secure attachment of the hose and cylinder head coolant return socket. It was also noted that during a visual inspection of this area of the engine it was possible to miss this unsecured hose. During the Draft Final Report comment process, the Engine Manufacturer informed the Investigation that it had taken the following Safety Action:

> '[The Engine Manufacturer] *has* […] *reviewed the corresponding MML* […]. [The Engine Manufacturer] *decided to address this topic within the next regular revision of the MML. It will be highlighted with a suitable text, which should advise maintenance staff of the difficult (visual) accessibility of the attachment point from cylinder number 3 coolant return hose.*
>
> *Nevertheless* [The Engine Manufacturer] *again wishes to point out that it is indispensable for any kind of the installation, maintenance and safe operation of an aircraft engine that personnel involved in these activities are obliged to have appropriate knowledge and qualification in order to follow the Instructions for Continued Airworthiness (ICA) and to transpose this into corresponding actions'.*

Correct Use of the Synchronization Adaptor

The Investigation noted that during examination of the right-hand induction manifold, it was missing an M6 blanking screw. There was evidence that synchronization adaptors had been installed on both intake manifolds and left in place following carburettor synchronisation.

A review of the relevant section of the Engine Manufacturer's MML with regard to carburettor synchronisation indicated that such adaptors should be removed and replaced by the M6 blanking screw, once synchronisation was complete. However, it was also noted that instructions, from third party suppliers, for the use of third party proprietary carburettor synchronisation equipment stated that such equipment was suitable for permanent connection to intake manifolds and can be left permanently in place on the engine. During the Draft Final Report comment process, the Engine Manufacturer informed the Investigation that it had taken the following Safety Action:

> '[The Engine Manufacturer] *has* […] *reassessed the situation* […]. *Despite the fact* [The Engine Manufacturer] *is indicating that a synchronization adaptor is not intended to be utilized in flight and hence any operation in flight with an installed adaptor is a misuse, it has been decided to pro-actively react on this* [issue]. [The Engine Manufacturer] *will issue and provide appropriate information in order to indicate that the engine related guideline, not to use the balancing equipment in flight, has to be observed.*
>
> *Note:* [The Engine Manufacturer] *would like to point out that the balancing equipment is not delivered from* [The Engine Manufacturer] *and* [The Engine Manufacturer] *is not aware of the manufacturers/sellers of this equipment. The guidelines are depicted within the corresponding* [The Engine Manufacturer] *manual but nevertheless* [The Engine Manufacturer] *will provide this information within an appropriate document via our publication channel* [Engine Manufacturer's Website]'.

1.17.2 Emergency Procedures

The Aircraft Manufacturer's '*Flight Manual*' (AFM), gives procedures for use in the event of a forced landing. Two types of forced landing are covered: *'Forced Landing Without Engine Power*'; and '*Power-On Forced Landing*' which involves carrying out a '*Flyby*' to check the chosen landing site for obstacles and wind direction. Both of these procedures include the shutting down of the engine and switching off of the generator and master switch, once landing is assured. The Investigation notes that the subject accident fell into neither category.

2. ANALYSIS

2.1 The Forced Landing

During this short flight the Student Pilot, who had relatively little experience on type, was presented with a number of serious technical issues:

- Engine Coolant entering the cockpit.
- Severe engine vibration as he turned the aircraft onto base-leg, and throttled back the engine.
- Despite the severe vibration, the engine continued to run, leaving the Student Pilot needing to assess if the aircraft would reach the runway at EIWF.
- An engine that was running, but not responding to throttle inputs.
- The need to select a field and make a forced landing.

During all of the above, the Student Pilot demonstrated good presence of mind as he dealt with each problem as it arose:

- When he noticed the coolant dripping onto his foot he immediately informed ATC that he would be making a full stop landing.
- Once the severe vibration commenced, the Student Pilot immediately selected carburettor heat on, in case carburettor icing was the cause of the vibration. He also checked that the choke was not on – another possible cause of engine vibration.
- He then reduced the track miles between the aircraft and the runway at EIWF, by turning directly towards it.
- He maintained a good flying speed despite the difficulty reading the instruments, and did not try to reduce the aircraft's airspeed too much in order to try and make the runway at EIWF, which might have resulted in a stall.
- He informed ATC of the issues he was experiencing, finally declaring an emergency and telling ATC he would be making a forced landing in a field.

Most general aviation training prior to sending students solo, concentrates on teaching engine failures after take-off. Students are also instructed on how to perform a glide approach from the downwind leg. In both cases it is assumed the engine has stopped. It would not be expected, or required, for training organisations to cover a scenario such as the one experienced by the Student Pilot. In the accident flight, the Student Pilot was faced with an engine that had severe vibration, but was still operating. It would therefore have taken a certain period of time for the Student Pilot to determine that the aircraft would not reach the runway. During this time he did carry out some troubleshooting actions, after which, he believed there was no power from the engine. He then concentrated on flying the aircraft into the field selected for the forced landing.

However, the engine had continued to operate, albeit at reduced power. The residual power being developed by the engine resulted in the aircraft becoming high and fast on its final approach to the field selected for the forced landing. The Student Pilot continued to fly the aircraft onto the ground, but it bounced and remained airborne in ground effect, until it impacted a hedge and a tree, at the end of the field.

The Investigation is of the opinion that the unusual nature of the engine symptoms, the short time available to troubleshoot the situation and select a landing site, and the relative inexperience of the Student Pilot, contributed to the outcome.

The Investigation notes that often during occurrences involving a loss/reduction of engine power, failure to maintain flying speed has led to aircraft stalling, often with fatal consequences. In this instance the Student Pilot did not reduce speed in an effort to try and reach the runway at EIWF.

2.2 Reduction in Engine Power

2.2.1 Fuel Mixture Delivery to the Left and Right Cylinders

Examination of the engine indicated that the left cylinders (two & four) were running slightly rich prior to the accident and the right cylinders (one & three) were running lean.

Examination of the right carburettor showed that it appeared to be normal and was unlikely to have contributed to the lean mixture evident in cylinders one and three. However, examination of the right intake manifold revealed a tapped hole approximately 5.7 mm in diameter. This corresponded to the location on the intake manifold where an M6 brass fitting used for carburettor synchronising had been attached. This hole was open to the atmosphere, and examination of the M6 tapping indicated that the brass fitting had come out some time prior to the accident, as evidenced by the light coloured spark plugs on the right cylinders. Whilst this hole would have led to additional air entering the intake manifold downstream of the carburettor, and thus diluting or leaning the mixture entering cylinders one and three, engine testing simulating this condition showed that the engine ran normally with only slight vibration at lower engine RPM.

Examination of other similar engine installations, and photographic evidence of the subject aircraft, showed a fuel hose routed such that it would be in contact with the synchronisation adaptor installed in the right intake manifold.

It is possible that, over time, with normal engine vibration experienced during engine operation, the right carburettor synchronisation adaptor had been forced out of the M6 tapped hole, allowing a small amount of additional air to enter the intake manifold. As previously stated, this would account for the evidence of a lean mixture being burned in cylinders one and three.

The rich mixture being burned in cylinders 2 and 4 was likely caused by the sinking of one of the carburettor floats in the left carburettor bowl. As a result there were higher than normal fuel levels in the bowl, which, in turn, led to excess fuel entering the intake manifold for the left cylinders. Engine testing with a simulated sinking left carburettor float, and removal of the M6 blanking screw from the right intake manifold, showed that the engine would still run normally (with a slight reduction in power) at high RPM, but with noticeable vibration at low RPM.

Despite the engine test indicating that a combination of a missing M6 blanking screw in the right manifold, and a sinking float in the left carburettor float chamber, could cause vibration, neither the Student Pilot nor the Instructor reported unusual vibration from the engine prior to the day of the accident. As the engine test could not use the actual carburettor from the subject aircraft, due to the level of damage it sustained, it is possible that the subject engine did not operate with any significant vibration. The Investigation does not believe that the issues outlined above were a cause of the vibration experienced during the accident flight.

2.2.2 Coolant System

The Student Pilot had reported coolant flowing onto his left shoe shortly after take-off. The Investigation is of the opinion that the source of the coolant was from the overflow bottle situated on the left side of engine compartment fire-wall. There are a number of holes in the fire-wall to facilitate the passage of cables and controls from the cockpit to the engine, and thus coolant flowing out of the overflow bottle could have migrated to the cockpit side of the fire-wall just above the pilot’s feet.

During engine testing it was found that the pressure relief valve, in the pressure cap of the expansion tank, was malfunctioning and permitting coolant to flow to the overflow bottle at a much lower pressure than designed. With a failed pressure relief valve, and the vent hole in the overflow bottle, the engine coolant system was effectively operating at atmospheric pressure, and not at 1.2 bar, as designed. This would explain why the unsecured number three coolant return hose had not detached sooner.

The evidence of some corrosion in the vicinity of the number three coolant return hose indicates that during the time it had been installed, the hose had likely lost some of its elasticity, and without its spring-band hose clamp in place, coolant was beginning to escape from around the unclamped end of the hose. Whilst the amounts may have been quite small initially, it is possible that coolant loss had increased in the days prior to the accident. This would account for the need to top up the coolant in the system prior to the accident.

Prior to departure of the accident flight, the overflow bottle was found with very little fluid present, and it was topped up to the maximum level. The Investigation notes that the fluid replenishments were not being recorded by the DTO. Logging of aircraft fluid replenishments is desirable to identify developing problems.

Safety Action Taken

The DTO informed the Investigation that it had introduced a system for tracking uplifts of fluids for its aircraft. The Investigation therefore does not make a Safety Recommendation in this regard.

The Investigation notes that the Engine Manufacturer’s procedures for checking and replenishing the coolant in the overflow bottle state that the coolant level ‘*must be between max. and min. mark’*. With the overflow bottle filled to the ‘*Max*’ level, and with the malfunctioning pressure relief valve, any coolant from the engine flowing into the overflow bottle could have filled it beyond its capacity. The excess coolant would have been forced out of the cap of the overflow bottle and flowed down the firewall entering the cockpit above the Student Pilot’s left foot.

The air vent-hole in the overflow bottle filler cap is quite small and is present to allow the air pressure within the bottle to equalise with atmospheric pressure. It is likely that the excess fluid, due to the unserviceable expansion tank pressure cap, could not escape from the bottle’s air vent-hole fast enough. Consequently, a back-pressure would have built up within the coolant system. This back-pressure likely caused the unsecured coolant return hose to separate from the number three cylinder head coolant return socket, allowing coolant to spray over the number three cylinder and right intake manifold, where an induction leak was present.

The Investigation notes the action taken by the Engine Manufacturer with regard to the inspection of the Expansion Tank Pressure Cap, and their intent to implement further guidance and a more accurate explanation in the corresponding section of its MML in order to improve the functional check of the cooling system. Therefore the Investigation does not make a Safety Recommendation in this regard.

Examination of the engine after the accident revealed that the number three cylinder coolant return hose was not secured by its spring-band hose clamp, and had become detached from the number three cylinder coolant return socket. Examination of the inside surface of the right intake manifold, and cylinders one and three, revealed that liquid had been ingested and had boiled off due to the temperature of the engine. The source of the liquid was coolant from the number three coolant return hose. This could only have occurred if the coolant hose had become disconnected during flight, whilst the engine was running, and if there was a hole in the manifold for the coolant to enter.

During engine testing, it was shown that the engine could be run with a number three cylinder coolant return hose fitted – unclamped – to its coolant return socket, and the return hose would remain in place. However, when the coolant system was pressurised to 0.1 bar the unsecured coolant hose detached from its coolant return socket. From the engine testing, it was shown that the engine would continue to run whilst water was ingested, but it would not respond to throttle inputs in a normal manner. The engine would tend to 'hang' at an RPM similar to that experienced by the Student Pilot.

The Investigation notes that the attachment point of the number three coolant return hose and associated spring-band hose clamp are obscured from view and that the misplacement of the spring-band hose clamp on the coolant hose had not been detected during coolant hose replacement and subsequent inspections.

The Investigation notes the action taken by the Engine Manufacturer with regard to checking for the secure fitment of the number three cylinder coolant return hose. The Engine Manufacturer informed the Investigation that it has reviewed the corresponding MML and decided to address this topic within the next regular revision of the MML. The issue will be highlighted with a suitable text, which should advise maintenance staff of the difficult (visual) accessibility of the attachment point from cylinder number three coolant return hose and will implement further guidance and a more accurate explanation in the corresponding section of its MML in order to improve the functional check of the cooling system. Therefore the Investigation does not make a Safety Recommendation in this regard.

The Investigation noted a discrepancy between the instructions given for carburettor synchronising as stated in the Engine Manufacturer's maintenance manuals and the wording used to describe installation of proprietary carburettor synchronising equipment. The Engine Manufacturer's instructions under '*Option 4*' of section 10.3, '*Pneumatic synchronization*' stated:

- *Install a hose nipple M6 (5) with sealing ring or O-ring (6).*
- *After synchronization **remove the hose nipple** M6 (5).*
- ***Secure screw M6x6** (4) with a new gasket (6) and LOCTITE 221.*

The instructions for a product used for carburettor synchronisation stated:

- *A pair of fixed adaptors for **permanent connection to intake manifolds**.*
- *For connected to engines with a tapped M6 fixture in the manifold.*
- ***Can be left permanently in place**.*
- *Short type, M6 thread, nipple, sealing cap and washer.*

[Emphasis added by the Investigation].

The Investigation believes that a side-load exerted by a fuel hose, on the carburettor synchronisation adaptor fitted to the right intake manifold of the subject engine, may have, over time, caused it to become loose and detach from the intake manifold.

The Investigation notes the action taken by the Engine Manufacturer with regard to installation of carburettor synchronisation adaptors. The Engine Manufacturer informed the Investigation that it will issue and provide appropriate information in order to indicate that the engine related guideline, '*not to use the balancing equipment in flight*', has to be observed. The Engine Manufacturer stated that it will provide this information within an appropriate document of its publication channel. Therefore the Investigation does not make a Safety Recommendation in this regard.

3. CONCLUSIONS

3.1 Findings

3.1.1 The Flight

1. The Student Pilot was carrying out a solo circuit training exercise under the approval of an authorised Instructor.

2. The Instructor was in possession of a valid licence, Instructor Rating, and medical certificate.

3. The Student Pilot was in possession of a valid EASA Class 2 Medical Certificate.

4. The aircraft was operating on a valid ARC.

5. During the pre-flight inspection, the Student Pilot noticed that the coolant level in the overflow bottle was below the '*min*' level mark. The instructor added additional coolant to the overflow bottle, bringing the coolant level up to maximum mark on the bottle.

6. During engine start, taxi, take-off and on the downwind leg, all engine indications appeared normal to the Student Pilot.

7. As the aircraft commenced the crosswind leg of the first circuit, the Student Pilot noticed cold engine coolant trickling onto his left foot. The Student Pilot informed ATC that he was going to make this circuit to a full stop landing.

8. The Student Pilot selected carburettor heating on, and then off, during the downwind leg, as per the aircraft checklist. There were no indications that carburettor icing was present.

9. As the aircraft turned onto base-leg, and the Student Pilot reduced engine power, there was severe engine vibration.

10. The Student Pilot immediately turned directly towards the runway, informed ATC that he had an issue with his engine, and again checked for carburettor icing.

11. The engine continued to run, but with reduced power, and severe vibration. There appeared to be no response from the engine to throttle movement.

12. The Student Pilot declared a Mayday, and attempted a forced landing in a field 0.7 NM north of the landing runway at EIWF.

13. Due to the residual engine power, and the wing flaps remaining at the take-off position, the aircraft touched down at high speed, approximately two thirds of the distance into the field, bounced, and remained airborne in ground effect.

14. The aircraft flew through a boundary hedge at the southern end of the field.

15. The right wing impacted a tree which was located in the hedgerow, causing a rapid right yaw and roll, resulting in the aircraft impacting the ground inverted, and coming to rest 40 m beyond the boundary hedge.

3.1.2 Engine Power Loss Analysis

3.1.2.1 Coolant System

16. Bench testing of the subject engine showed no internal failure or fault that would account for the vibration and power loss experienced during this accident.

17. The severe vibration and significant loss of power experienced as the aircraft turned onto base-leg occurred as a result of coolant ingestion into the engine cylinder numbers one and three.

18. The source of the coolant was from the number three cylinder coolant return hose, which was unsecured. This coolant hose routes just beneath the right intake manifold, close to the location of the carburettor synchronisation tapping.

19. During inspection of the engine, post-accident, the number three cylinder coolant return hose was found detached from the number three cylinder coolant return socket, with the spring-band hose clamp located on the hose, but not in a position which would have secured the hose to the number three engine cylinder coolant return socket.

20. Maintenance records show that all coolant hoses had been replaced as part of a scheduled five year hose replacement, on 24 November 2016.

21. Witness marks on the subject hose indicate that the spring-band hose clamp had most likely not been in the correct position on the hose from the time the hose had been replaced on 24 November 2016.

22. The area of the engine in the vicinity of the number three coolant return hose showed evidence of corrosion, indicating that coolant had been escaping from the subject hose for some time.

23. The hose and spring-band hose clamp were both black in colour, and situated under the number three intake manifold. In addition, a number of fuel lines and ignition leads obscured the hose and spring-band hose clamp from view. It is therefore understandable that the incorrect location of the spring-band hose clamp was not noticed during coolant hose replacement and during subsequent engine inspections.

24. Engine testing with an unsecured number three return hose, pushed onto the number three cylinder coolant return socket, showed that it could remain in position with the engine running.

25. The pressure relief valve spring in the engine coolant expansion tank was found to have failed, allowing coolant to vent to the overflow bottle at pressures well below the design value. This would have caused excess coolant to fill the overflow bottle. Additional coolant escaping from the overflow bottle vent hole was responsible for the coolant dripping onto the Student Pilot’s foot.

26. During engine testing, an unsecured coolant return hose was found to detach at 0.1 bar coolant system pressure (above atmospheric pressure).

27. With the overflow bottle filled with coolant to the ‘*Max*’ mark, additional coolant venting into the bottle, due to the failed pressure relief valve, caused a back-pressure to build in the coolant system.

28. The back pressure in the coolant system caused the unclamped number three cylinder coolant return hose to detach from the coolant return socket.

29. Escaping coolant from the detached number three cylinder coolant return hose entered the engine’s right air intake manifold through a hole designed to take an M6 blanking screw fitting. The hole was open to the atmosphere as the screw was not in place, and a proprietary carburettor synchronisation adaptor that had been fitted, had separated from the M6 tapping.

3.1.2.2 Fuel/Air Induction System

30. Post-accident, the engine was found with the carburettor synchronisation tapping hole on the right intake manifold open. The left manifold was found with the sheared remains of a synchronisation adaptor in place.

31. Bench testing of the subject engine, with the blanking screw from the right intake manifold synchronisation tapping removed, showed that the engine could be operated through its entire RPM range, although there was some slight vibration at lower power settings.

32. The right synchronisation tapping had been open for a time prior to the accident flight, as the cylinders and spark-plugs on the right side of the engine showed signs of running lean. In addition, the right intake manifold showed the threads of the synchronisation tapping exposed, and with no evidence of the presence of a brass synchronisation adapter having been present pre-accident.

33. Carburettor floats in the left carburettor were found to be in excess of the prescribed weight for the subject carburettor. This would lead to it sinking in the float chamber, allowing additional fuel to be delivered to engine cylinders two and four. This was confirmed upon examination of the spark-plugs, pistons, and cylinder heads of these cylinders, which showed evidence of a rich mixture being delivered to them.

34. Although bench testing of the subject engine with simulated heavy floats in the left carburettor, and the missing blanking screw in the right intake manifold showed more significant vibration at low engine RPM, the Student Pilot did not report any vibration during engine start, and taxi out, when the engine would have been operated at low RPM. It is therefore likely that, despite the heavy floats found in the left carburettor, the subject engine was capable of running without noticeable vibration until the base-leg.

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3.2 Probable Cause

A forced landing due to insufficient engine power, attributable to coolant from unsecured coolant hose, being ingested into the right-hand engine cylinders.

3.3 Contributory Cause(s)

1. Impact with a tree during the forced landing.

2. An un-blanked tapping in the right intake manifold provided a path of entry for the coolant.

3. Residual engine power, coupled with a take-off wing flap configuration, resulting in a high speed touchdown.

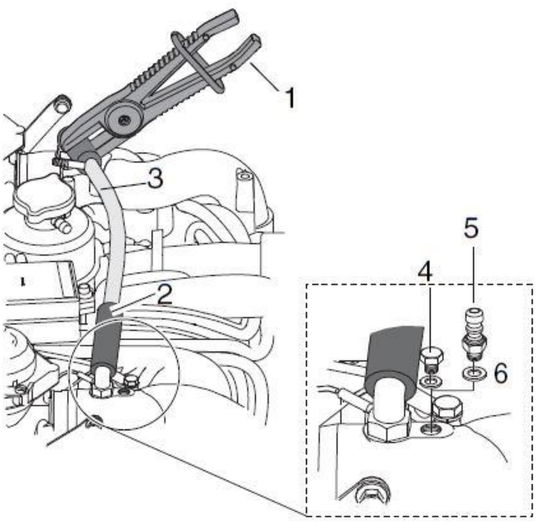
4. SAFETY RECOMMENDATIONS

As a result of the Safety Actions taken by both the Engine Manufacturer and the DTO, this Report does not sustain any Safety Recommendations.

- END -

Option 4	
Step	**Procedure**
1	Install the vacuum gauge.
2	Clamp the tube (2) with hose clamping pliers (1). Observe the position! Do not remove the compensation tube (3).
3	Unscrew the screw (4).
4	Install a hose nipple M6 (5) with sealing ring or O-ring (6).
5	After synchronization remove the hose nipple M6 (5).
6	Secure screw M6x6 (4) with a new gasket (6) and LOCTITE 221.

Graphic Option 4



Part	Function
1	Clamping pliers
2	Tube
3	Compensation tube
4	Screw
5	Hose nipple
6	Sealing ring

Fig. 20 *08661*

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No. 996/2010, and Statutory Instrument No. 460 of 2009, Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulation, 2009, the sole purpose of this investigation is to prevent aviation accidents and serious incidents. It is not the purpose of any such investigation and the associated investigation report to apportion blame or liability.

A safety recommendation shall in no case create a presumption of blame or liability for an occurrence.

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