Technical report

A-001/2021

Accident on 12 January 2021, involving a SOCATA TB-10 aircraft operated by Adventia European Aviation College S.A., registration EC-FTJ, at Salamanca Airport (Spain)

Please note that this report is not presented in its final layout and therefore it could include minor errors or need type corrections, but not related to its content. The final layout with its NIPO included (Identification Number for Official Publications) will substitute the present report when available.

GOBIERNO DE ESPAÑA
MINISTERIO DE TRANSPORTES, MOVILIDAD Y AGENDA URBANA
SUBSECRETARÍA
COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Notice

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident and its causes and consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.6 of Regulation (UE) nº 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1 and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

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SUBSECRETARÍA

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ABBREVIATIONS

AEMET	Spain’s State Meteorological Agency
AESA	Spain’s National Aviation Safety Agency
CAMO	Continuing airworthiness management organisation
CITAAM	Commission for the Technical Investigation of Military Aircraft Accidents
cm	Centimetres
ft	Foot (feet)
GMC	Ground movement control
GPS	Global positioning system
h	Hours
hPa	Hectopascals
km	Kilometres
km/h	Kilometres per hour
LH	Left hand
m	Metres
MHz	Megahertz
min	Minutes
mm	Millimetres
NBR	Nitrile butadiene rubber
NOTAM	Notice that contains information related to the establishment, condition or modification of any aeronautical facility, service, procedure or danger whose timely knowledge is essential for personnel in charge of flight operations (notice to airmen)
QNH	Altimeter subscale adjustment to obtain elevation while over land (precision adjustment to indicate elevation above mean sea level)
RH	Right hand

S.A.	Sociedad Anónima Unipersonal (Spanish Public Limited Company)
SSEI	Rescue and Firefighting Service
TWR	Control tower
VFR	Visual flight rules
UTC	Coordinated universal time

Technical report
A-001/2021

Owner and Operator:	Owner: Servicios y Estudios para la Navegación Aérea y la Seguridad Aeronáutica S.A. (Services and Studies for Air Navigation and Aeronautical Safety - SENASA); Operator: Adventia European Aviation College S.A.
Aircraft:	SOCATA TB-10, registration EC-FTJ (Spain).
Date and time of accident:	12 January 2021, 13:40 local time[1].
Site of accident:	Salamanca Airport (Spain).
Persons on board:	1 (crew).
Type of operation:	General Aviation - Instruction flight - Solo.
Phase of flight:	Taxi - taxi from runway.
Flight rules:	VFR.
Date of approval:	26 January 2022.

Synopsis

Summary:

On 12 January 2021 at 12:56 h, the SOCATA TOBAGO TB 10 aircraft, registration EC-FTJ, took off from Salamanca Airport with a single student pilot on board for a local training flight under visual flight rules.

At 13:40 h, having completed the flight without incident, the student pilot returned to Salamanca Airport, landing on runway 03. Following TWR instructions, he made a U-turn on the runway to leave it via taxiway C5.

When the aircraft was stationary at the holding point for taxiway C5, the student pilot became aware via a radio message that his aircraft was on fire. Then, according to his statement, the brakes stopped working, and the aircraft began to move forward in an uncontrolled taxi along taxiway C5, stopping several metres ahead.

Before the aircraft came to a stop at the end of taxiway C5, the student pilot secured it and jumped out on his own initiative. He did not sustain any injuries during the incident.

As a result of the fire, the aircraft sustained significant damage to several parts on its left side, including the brake, the skin of the intrados of the wing, the tyre and the main landing gear leg and fairing. The ventral skin was also damaged.

The investigation has not been able to determine the cause of the accident.

No operational safety recommendations are proposed.

[1] All times in this report are expressed in UTC. UTC can be calculated by subtracting 1 h from the local time.

1. FACTUAL INFORMATION

1.1. History of the flight

On 12 January 2021 at 12:56 h, the SOCATA TOBAGO TB 10 aircraft, registration EC-FTJ, took off from Salamanca Airport with a single student pilot on board for a local training flight under visual flight rules.

In an interview, the student pilot confirmed that he carried out a pre-flight inspection, which included inspecting the brakes for any signs of hydraulic leaks, but found nothing abnormal. Nor did he perceive any anomalies during the take-off or when he tested the brakes while taxiing.

At 13:40 h, having completed the flight without incident, the student pilot returned to Salamanca Airport, landing on runway 03.

During the landing roll-out, TWR instructed the student pilot to make a U-turn on the runway and exit via taxiway C5.

The student pilot followed TWR's instructions, made a U-turn to the left, and proceeded to the holding point for taxiway C5, where he stopped the aircraft.

While the aircraft was stationary at the holding point on the C5 taxiway (with the student pilot applying the brakes), the student pilot heard a message to TWR over the radio from the student pilot of an aircraft close to his own, indicating that he could see fire on the EC-FTJ aircraft. As the witnessing student pilot was later able to observe, the fire had originated in the left main landing gear leg.

As soon as the student pilot realised that it was his aircraft (given that until then, he had not perceived any indication that his aircraft was on fire), he contacted Adventia Operations to request emergency management instructions.

Moments later, despite the student pilot continuing to apply the brakes, they suddenly stopped working, and the aircraft began an uncontrolled freewheel along taxiway C5. He called Adventia Operations again and was instructed to shut down the engine, pump and alternator. As he followed the instructions, black smoke began to enter the cockpit.

Once he had completed the actions specified by Adventia Operations, the student pilot abandoned the aircraft, unassisted, while it was still moving.

Shortly afterwards, the aircraft came to a stop on its own at the end of taxiway C5 and the fire brigade arrived and proceeded to extinguish the fire.

When the fire was out and the situation declared under control, the aircraft was towed to a hangar for safekeeping.

The student pilot was unhurt.

1.2. Injuries to persons

Injuries	*Crew*	*Passengers*	*Total in the aircraft*	*Others*
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
Unharmed	1	-	1	-
TOTAL	1	-	1	-

1.3. Damage to the aircraft

As a result of the fire, the aircraft sustained significant damage to the brake, the tyre, and the left main landing gear leg and fairing. The left intrados wing skin and the ventral skin also suffered fire damage.

1.4. Other damage

There was no other damage.

1.5. Personnel information

On the day of the incident, the student pilot was 20 years old and completing a course to obtain an airline transport pilot licence, having already passed the theoretical training.

He had a Class 1 medical examination, valid until 04-11-2021.

Prior to the accident, the student pilot had accumulated a total flight experience of 25:35 h, all of which were in the SOCATA TOBAGO TB10 aircraft.

He had flown as the sole occupant of the aircraft on 4 occasions (2 traffic pattern flights and 2 in the sector), giving a total of 3 hours and 50 minutes.

According to the student pilot’s logbook, his last flights were as follows:

- 03-12-20: flight with instructor.
- 22-12-20: solo flight.
- 12-01-21: solo flight.

1.6. Aircraft information

1.6.1. General aircraft information

- Make: SOCATA
- Model: TOBAGO TB10
- Year of manufacture: 1993
- Serial number: 1573
- Maximum take-off weight: 1,150 kg.
- Type of engine: Lycoming O-360-A1AD
- Information about the operator: Adventia European Aviation College S.A.

The SOCATA TOBAGO TB10 aircraft, registration EC-FTJ and serial number 1573, is a single-engine low-wing aircraft. It is equipped with a Lycoming O-360-A1AD four-stroke engine consisting of two pairs of opposed cylinders and a Hartzell HC-C2YK-1BF two-bladed variable pitch propeller.

It has a fixed tricycle-type landing gear, a differential braking system and a parking brake.

The aircraft has a wingspan of 9.89 metres, a length of 7.75 metres and a height of 3.02 metres.

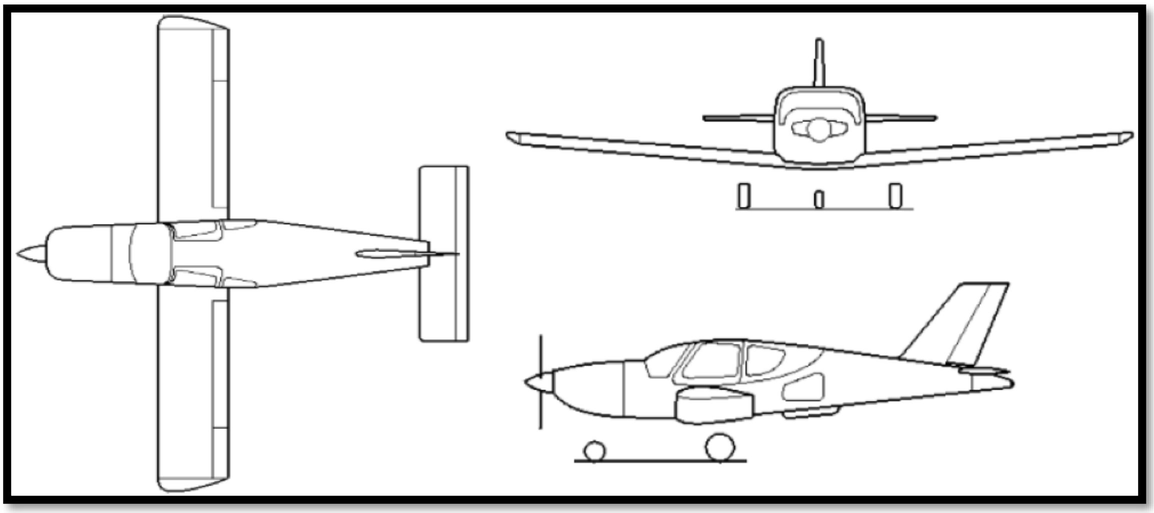


Figure 1: Images of the SOCATA TOBAGO TB 10 aircraft.

At the time of the accident, the aircraft's airframe had accumulated 10,722 h and 35 minutes and the engine 1,048 hours and 35 minutes of flight time since the last general overhaul.

The aircraft had an airworthiness review certificate valid until 21 November 2021, and its registration certificate was valid until 30 June 2022.

The last flights made by the aircraft were as follows:

- 15-12-2020: 2 flights, one student only and another student with instructor.
- 11-01-2021: 1 flight student only.
- 12-01-2021: 1 flight student only (day of the accident).

1.6.2. Aspects related to the aircraft brakes

The SOCATA TOBAGO TB-10 aircraft is equipped with a differential-type hydraulic braking system, which acts independently on the two main landing gear wheels, as shown in the diagram.

The wheels are fitted with disc brakes, which are operated by the cockpit pedals in the pilot's and co-pilot's positions. As the brakes are differential, they can be applied to each wheel independently, braking either the left wheel, right wheel or both simultaneously.

The aircraft is slowed by the friction produced when the brake pads rub against a disc that rotates with the wheel. The brakes are identical on the left and right sides and therefore interchangeable.

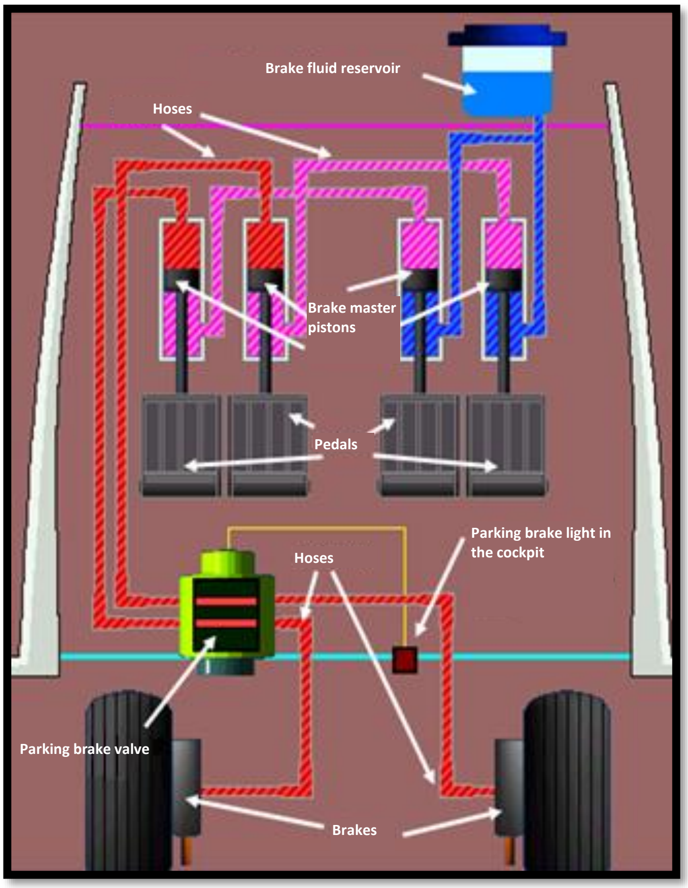
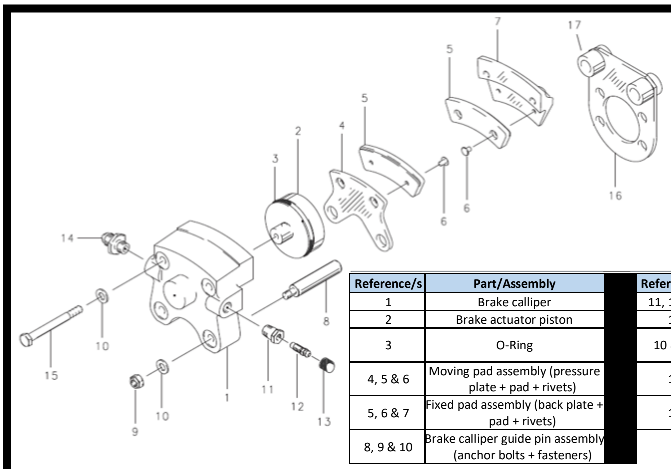


Figure 2: Diagram of the aircraft's brake system.

A schematic description of the brakes is illustrated in the following figure:



Reference/s	Part/Assembly	Reference/s	Part/Assembly
1	Brake calliper	11, 12, 13	Brake calliper bleed assembly
2	Brake actuator piston	14	Brake calliper hydraulic inlet
3	O-Ring	10 & 15	Fixed pad attachment to the brake calliper
4, 5 & 6	Moving pad assembly (pressure plate + pad + rivets)	16	Torque plate (mounted on landing gear leg)
5, 6 & 7	Fixed pad assembly (back plate + pad + rivets)	17	Torque plate bushings
8, 9 & 10	Brake calliper guide pin assembly (anchor bolts + fasteners)		

Figure 3: Diagram of the aircraft's brake.

The appendix at the end of this report contains detailed information on the components that make up the brake system and how it works to facilitate understanding of the above diagram and this report.

1.6.3. Aspects related to the maintenance of the brake system

According to the information provided by the aircraft manufacturer in the maintenance manual, the brake system should be inspected at the following time intervals[2]:

- 50 hours / 6 months.
- 100 hours.
- 2,000 hours.
- Annual.

In addition, the manufacturer defines brake system hoses as life-limited parts that must be replaced after the time specified by the manufacturer, irrespective of their condition and whether they have been in storage or installed on the aircraft. For these hoses, the time is measured in months. Specifically, 60 or 120 months, depending on the hose in question.

Lastly, unscheduled maintenance tasks may also be carried out (corrective maintenance) in response, for example, to defects noted in the aircraft's flight logbook.

The most recent scheduled maintenance inspections, life-limited part replacements, and corrective maintenance tasks carried out on the aircraft were as follows:

SCHEDULED MAINTENANCE		
Type of inspection	**Date of last inspection**	**Aircraft hours**
50-hour / 6-month inspection	20-11-2020	10,689 h 00 min
100-hour inspection + Annual inspection	07-10-2020	10,638 h 45 min
2,000-hour inspection	30-08-2018	9,872 h 35 min

These inspections did not find any abnormalities in the brake system.

In regard to the life-limited brake hoses:

LIFE-LIMITED PARTS		
PART	**Date of last substitution**	**Limited life**
Hose - brake system	26-02-2016	60 months
Hose - Co-pilot brake master cylinder	26-02-2016	120 months
Hose brake - systemPistonL	30-04-2013	120 months
Hose brake - systemTank	30-04-2013	120 months

lastly, in regard to unscheduled corrective maintenance, according to the aircraft's flight and maintenance logbook, there was no record of any incident involving the brake system in the month prior to the event.

The investigation also verified that the aircraft had no deferred maintenance on the day of the incident.

With regard to the brake components, the most recent part replacements were as follows:

[2] Only the scheduled inspections involving an inspection of the brake system components are included.

LEFT SIDE	
PART	LAST REPLACEMENT
LH pads	05-10-2020
LH disc	25-02-2020
LH brake calliper	Before 2014[3]

RIGHT SIDE	
PART	LAST REPLACEMENT
RH pads	05-10-2020
RH disc	25-02-2020
RH brake calliper	23-10-2020

As can be seen, the brake pads and discs were changed on the same dates on both sides.

In addition, we requested data on any repairs carried out on the LH and RH brake system during the last two years. The data showed that the left side had not required any more significant repairs than the right. Furthermore, the brake pad changes on both the LH and RH sides were in line with normal replacement frequencies (as compared to other aircraft in the same fleet).

With regard to the aircraft manufacturer's guidelines for brake system inspections during scheduled maintenance inspections, the maintenance manual specifies the following:

During the annual, 50 and 100-hour inspection:

- *Visually inspect the braking systems for condition, attachment, brake plate and disk wear.*

During the 2,000-hour inspection:

- *Remove and thoroughly inspect the braking system for condition, attachment, brake plate and disk wear; look for cracks on the brake unit and thrust plate. Install the braking system - refer to 32-42-02 201.*

Point 32-42-02 201 mentioned above provides instructions for fitting and disassembling the brake from the aircraft, but in relation to inspections, only refers to checking the condition of the pads and disc and looking for hydraulic leaks.

Maintenance guidelines are also established by the brake manufacturer in document AWBCMM0001 (edition 24, November 2019), which is intended to complement the information provided by the aircraft manufacturer in regard to the tasks that should be carried out and the correct way to perform them. This document is divided into two main sections: "on-aircraft" inspection and "off-aircraft" inspection.

With regard to the instructions for inspecting and subsequently assembling the aircraft brake during the on-aircraft inspection, the following should be noted:

- *Check fit of brake cylinder anchor bolts in torque plate bushings for sloppiness. This can be accomplished by grasping the cylinder and moving it; slight movement is normal. Excessive movement is cause for removal and detailed inspection.*

- *Slide pressure plate with new lining over anchor bolts and install brake calliper into torque plate. Lubricate the anchor bolts with a dry film lubricant (Appendix B, Section B3) specified for your climate environment: amphibious/ extremely wet or non-amphibious. DO NOT USE GREASE OR OIL. These materials will attract dirt and enhance the wear of the anchor pins.*

With regard to the instructions for inspecting and subsequently assembling the aircraft brake during the off-aircraft inspection, the following should be noted:

[3] It should be noted that the brake calliper is an 'on-condition' part, which means its condition is checked at every scheduled inspection. It is only replaced if it is no longer fit for service.

- *Inspect anchor bolt bushings in torque plate for internal corrosion or contamination. If present, clean with emery and apply a light coat of dry film lubricant (Appendix B, Section B3 for your climate environment). DO NOT USE GREASE OR OIL. Exercise care in removing corrosion from torque plate bushings to prevent material removal.*

- *Check for steps in bushing holes, which indicate severe cocking of the cylinder anchor bolts in the torque plate. Bushing damage is cause for torque plate replacement.*

- *Install cylinder assembly in torque plate by sliding anchor bolts into bushings. A dry film lubricant (Appendix B, Section B3 for your climate environment) should be applied to anchor bolts and torque plate bushings to assist sliding motion. Exercise care to insure that linings do not become contaminated with fluid or lubricant.* ***For best service life, cylinders must slide freely in torque plate.***

1.6.4. Aspects related to the pre-flight inspection of the aircraft

Before each flight, the pilot must carry out a pre-flight inspection of the aircraft.

Specifically, Adventia Flight School establishes in its manuals that crew members have an unavoidable obligation to carry out the external inspection with the precision and meticulousness described in the “Normal Procedures. Exterior Safety Inspection” section for each fleet.

In relation to the brake system, the operator’s procedures state that pilots must carry out the following tasks during the pre-flight inspection:

- Check for hydraulic leaks from the brakes.
- Perform an operational brake check when taxiing.

The aircraft flight manual does not specify any checks on the condition of the brakes during the pre-flight inspection. However, it does stipulate that an operational test of the brakes should be carried out on commencing the taxi.

1.7. Meteorological information

According to the information provided by the AEMET, on a synoptic scale at medium/high levels, the situation on 12 January 2021 was characterised by a broad anticyclonic circulation over the Atlantic, which, after Storm Filomena moved away to the eastern Mediterranean, gradually introduced generally stable conditions.

The METAR report provided by the airport at the time closest to the accident provided the following information:

Date and time	12 January 2021; 12:30 UTC.
Wind	Speed 4 knots. Angle of incidence predominantly 80°.
Visibility	Visibility greater than 10 km and no clouds below the reference height.
Temperature	0 °C.
QNH	1,030 hPA.
Dew point	-4 °C.

1.8. Aids to navigation

N/A.

1.9. Communications

Salamanca Airport is a controlled airport. It uses the 118.100 MHz frequency for communications with TWR and 121.850 MHz for ground movement control (GMC).

The investigation collected and analysed the communications between Salamanca TWR, the student pilot of aircraft involved in the incident and the witness, as well as the communications between GMC and the emergency services.

They were provided by the Spanish Air Force through CITAAM.

The most relevant extracts are shown below:

- TWR communications:

- 13:40:05: The student pilot reported that he was on final.
- 13:41:58: The controller cleared the student pilot to make a U-turn on the runway and proceed to exit taxiway C5.
- 13:45:30: The student pilot witness alerted the controller to the fire. In the alert communication, he said he could see fire coming out of the left wing of the aircraft that had just exited the runway to the side of runway head 03.
- 13:46:18: The controller acknowledged the above and advised the student pilot witness that they were proceeding to activate the SSEI (Fire and Rescue Service).

- GMC communications:

- 13:47:36: The controller instructs the SSEI to proceed to the head of runway 03 for an aircraft with one wheel on fire, instantly receiving confirmation from the SSEI.
- 13:53:54: The SSEI reports fire extinguished and situation under control to TWR.

The communications made by the student pilot, the student pilot witness, and the SSEI to Adventia Operations were not recorded.

1.10. Aerodrome information

Salamanca Airport is located approximately 15 km to the east of Salamanca, 2,595 ft (791 m) above sea level.

It has a paved 2,513 m-long by 60 m-wide runway designated 03-21. It also has an intersecting runway, designated 08-26, reserved for military use only.

The airport has one civil and one military apron.

The SSEI protection level for civil aircraft at Salamanca Airport is protection level 5, with the possibility of SSEI protection levels 6 and 7 on request.

The SSEI civil base is located to the south of the airport, near the head of runway 03.

On the day of the accident, several NOTAMs were in force due to work being carried out at the airport that necessitated the closure of some of the taxiways.

The following image shows the airport and the areas closed for construction work on the day of the accident:

Figure 4: Salamanca Airport.

1.11. Flight recorders

The aircraft was not equipped with a flight data or cockpit voice recorder because they are not a regulatory requirement for this type of aircraft.

However, the investigation was given access to data from a GPS that recorded the flight made by the student pilot. The data was processed in the laboratory, obtaining the results shown below.

The aircraft took off at 12:56 h from Salamanca Airport on runway 03, made a flight over neighbouring towns and then landed on the same runway at Salamanca Airport at 13:40 h.

The aircraft's GPS trace was used to detail its movements from the time it landed to the arrival of the SSEI at the accident site.

The following image shows the route followed by the aircraft after it landed at the airport:

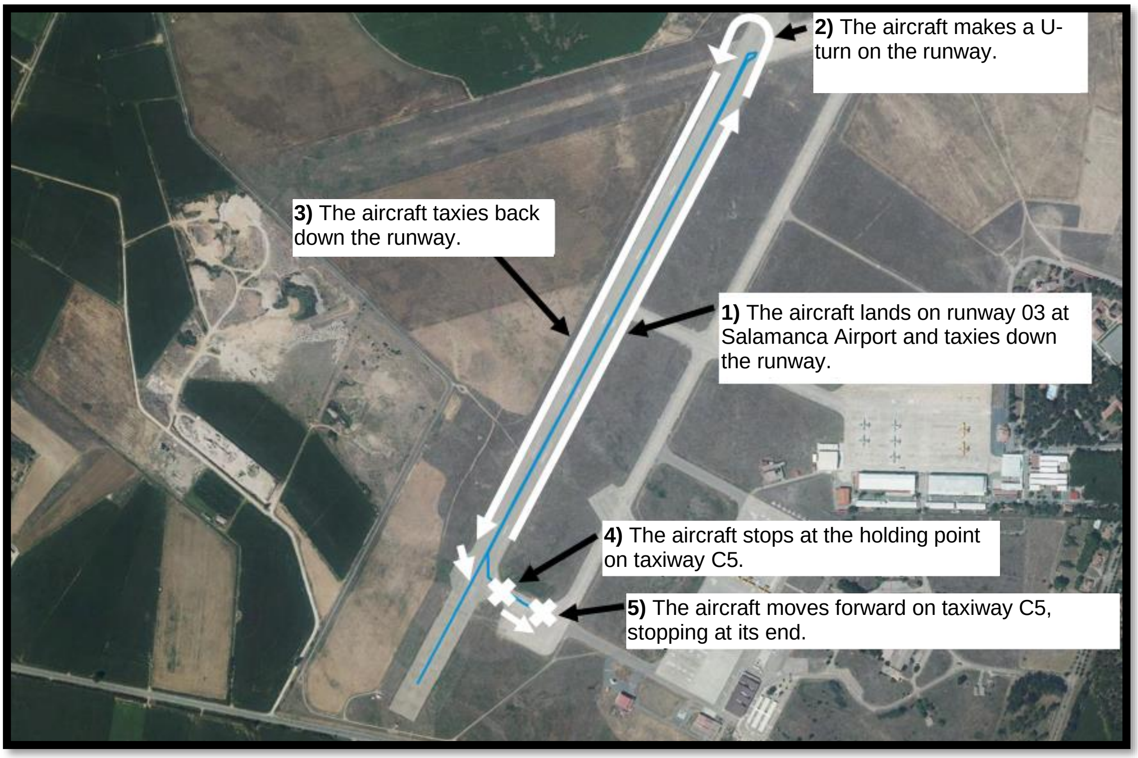


Figure 5: GPS plot of the landing and subsequent taxi.

A detailed explanation of each of the phases is provided below:

1- <u>The aircraft lands on runway 03 at Salamanca Airport and taxies along the runway:</u>

Once on the ground, the GPS trace shows it taxied along the runway for 1 minute and 10 seconds, covering approximately 987 metres.

In his interview, the student pilot stated that because the first exit taxiway from runway 03 was closed due to construction work, instead of using the brakes, he allowed the aircraft to slow down naturally during the landing roll-out.

2- The aircraft makes a U-turn on the runway:

Following TWR instructions, the student pilot made a U-turn on the runway. According to the GPS trace, he made a tight turn to the left, as can be in the following figure:

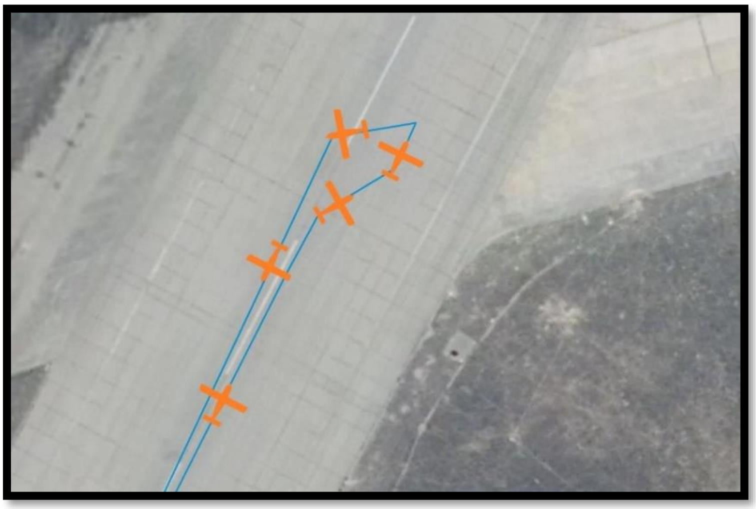
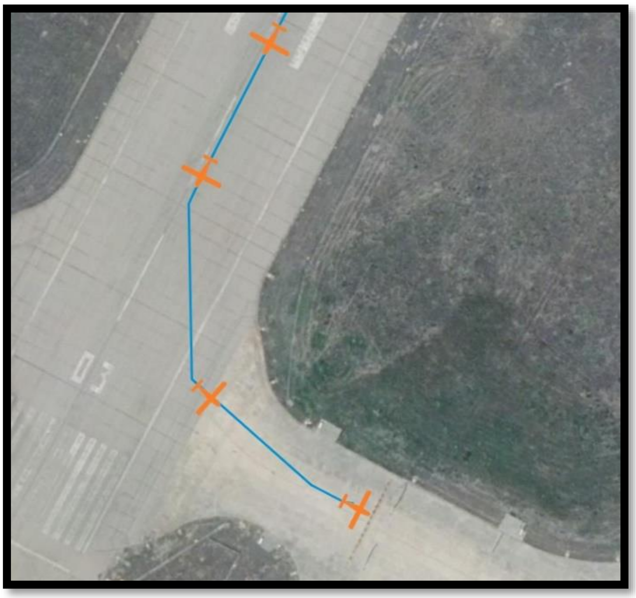


Figure 6: U-turn.

3- The aircraft taxies back down the runway:



According to the GPS trace, the aircraft taxied back along the runway for 1 minute and 40 seconds, covering approximately 1,150 metres, until it reached the holding point for taxiway C5, as can be seen in the figure. Based on the above, the average speed during the taxi was approximately 40 km/h.

It should be noted that, in the interview, the student pilot stated that when he reached the holding point for taxiway C5, he stopped and applied the brakes to report that he had left the runway.

Figure 7: Arrival at C5.

4- Wait at holding point C5:

According to the GPS trace, the aircraft was stationary at the holding point for taxiway C5 for approximately 1 minute and 15 seconds.

In the interview, the student pilot stated that he had kept the brakes applied while waiting without noticing any malfunction.

While waiting at the C5 holding point with the brakes applied, the student pilot stated that he heard a message over the radio indicating that the EC-FTJ aircraft was on fire. This message came from the student pilot of an aircraft waiting in the C5 taxiway holding bay for the student pilot of the EC-FTJ aircraft to leave the runway so he could take off.

Figure 8: Wait at C5.

5- <u>The aircraft rolls in an uncontrolled taxi along C5, eventually stopping at its end:</u>

According to the GPS trace, approximately 1 minute and 15 seconds after the aircraft came to a stop at the holding point for taxiway C5, it moved about 80 metres in a straight line before coming to a complete stop at the end of said taxiway, where moments later it was attended to by the SSEI.

It should be noted that, in the interview, the student pilot stated that while he was managing the emergency, the brakes suddenly released, and when he tried to apply them, they did not respond. As a result, the aircraft began to roll forward in an uncontrolled taxi before stopping on its own.

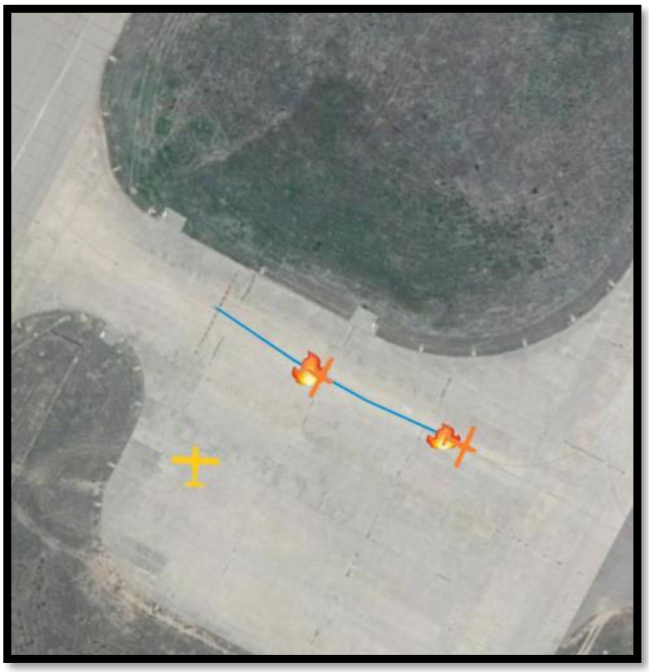


Figure 9: Uncontrolled taxi on C5.

1.12. Wreckage and impact information

When the firefighters arrived on the scene to extinguish the fire, the aircraft was stationary at the end of taxiway C5, approximately 80 metres from the holding point.

Once the firefighters had extinguished the fire, the left wheel fairing was removed as part of it was stuck to the wheel, preventing the aircraft from being towed.

Figure 10: Position of the aircraft after the accident.

The aircraft was towed to a hangar for safekeeping until the investigation team arrived.

The fire caused significant damage to the brakes, the tyre, and the left main landing gear leg and fairing.

The left intrados wing skin and the ventral skin were also affected.

The structure and characteristics of the rest of the aircraft remained intact, with no apparent damage.

Figure 11: Aircraft EC-FTJ after the accident.

A more detailed description of the damage is included in section 1.16.

1.13. Medical and pathological information

No evidence was found to suggest the student pilot's performance was affected by physiological or disabling factors.

1.14. Fire

At some point during the landing roll-out and taxi to the airport's civilian apron, the brake on the left main landing gear caught fire. This fire then spread to other parts of the aircraft, causing significant damage.

The first indication of the fire came at around 13:45 h when the incident aircraft was stationary at the holding point for taxiway C5 and the student pilot witness contacted TWR to report, according to the recordings, fire coming from the left wing of the EC-FTJ aircraft.

Furthermore, the student pilot witness stated in the interview that while the aircraft was stopped at the C5 holding point, he saw the fire get bigger and the aircraft began to move forward in a straight line, at which point he could see that the fire was coming from the left brake.

When the firefighters arrived at the accident scene, the aircraft was stationary with the left gear in flames and the fire moving towards the wing.

The first vehicle to arrive at the aircraft began to spray water and foam from the main monitor. Once the flames had been reduced, they proceeded to extinguish the fire with the hose reel. As some areas were still smouldering after the fire had been put out, they continued to cool the wing, the leg, the wheel, and its fairing with the hose reel.

At 13:53 h, the firefighters informed TWR that the fire had been extinguished and the situation was under control.

According to the SSEI report, four SSEI units were sent to deal with the emergency (RED 6, RED 7, RED 9 and RED 10), but only two acted to extinguish the fire (RED 9 and RED 10), operated by a crew chief and two firefighters.

In relation to the fire, it should be noted that neither the student pilot nor the firefighters in their respective interviews identified the smell of burning as being characteristic of an electrical or fuel fire.

1.15. Survival aspects

As soon as the student pilot witness became aware of the fire on the EC-FTJ aircraft, he tried to contact TWR but was unsuccessful as another pilot was on the frequency, so he called Adventia Operations instead.

After informing Adventia Operations, he tried again to contact TWR, this time successfully, reporting in accordance with 1.9 above.

As a result, the controller activated the SSEI, giving them the appropriate instructions at around 13:46 h.

After the student pilot witness alerted Adventia Operations, they also contacted the SSEI at around 13:46 h to inform them of the situation. According to the SSEI report, the caller told them an Adventia aircraft at the holding point on runway 03 was reporting smoke in the engine but had not declared an emergency.

When the firefighters arrived at the scene, they saw the student pilot evacuating the aircraft and running away from it.

According to the intervention report, the SSEI's response time was 1 minute and 10 seconds.

With regard to the student pilot's management of the emergency, as soon as he heard on the radio that his aircraft was on fire, he called Adventia Operations for instructions on how to proceed because, as he stated in the interview, he did not have an emergency procedure to follow for a landing gear fire while taxiing.

He said that Adventia Operations' first instruction was to shut off the mixture.

Seconds later, when black smoke entered the cockpit, he called Adventia Operations again and was instructed to shut down the engine, pump and alternator.

After complying with their instructions to secure the aircraft, the student pilot evacuated while it was still moving. He was not injured. A few seconds later, he saw the aircraft stop on its own.

In the interview, the student pilot claimed that he was trained and had memorised the emergency procedures but did not have the resources to handle this particular situation.

1.16. Tests and research

Several parts of the aircraft's brake system were disassembled and inspected, both on the left side (where the fire originated) and the right side (for comparison).

The most relevant findings are set out below:

1. Parts on the left side of the aircraft:

    a) The brake pads and the plates that hold them:

Figure 12: Moving pad after the accident.

Figure 13: Fixed pad after the accident.

- The LH brake pads were extremely worn and deteriorated throughout. They were badly damaged and partially charred, with material loss and additional adhered materials, evidenced by traces of orange.
- Some difficulty was encountered when removing the pressure plate (which contains the moving pad) from the brake calliper because it was stuck on the calliper anchor bolts.
- The back plate (which holds the fixed pad) was considerably deformed, while the pressure plate was slightly deformed.

    b) The brake calliper:

Figure 14: Brake calliper after the accident.

- No obstructions were found in the hydraulic line running inside the brake calliper to the actuator piston.
- The actuator piston was not seized inside the cylinder and moved freely.
- No trace of the actuating brake piston O-Ring was found.
- On removing the calliper, some resistance was encountered when sliding the calliper anchor bolts through the torque plate bushings.

Due to the above, a calibre was used to measure the distance between the two anchor bolts at their base and ends. There was a significant difference between the two measurements, which means the anchor bolts were not entirely parallel, and there was some conicity between them.

c) The brake disc:

- Deep grooves and traces of adhered melted orange material were found on both sides of the LH brake disc.

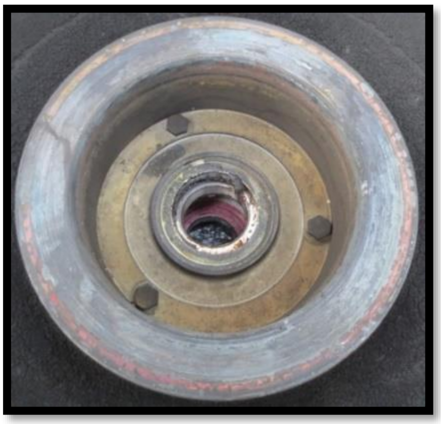


Figure 15: Brake disc after the accident.

d) The master actuator pistons:

- The master actuator pistons on the co-pilot's side of the aircraft were found as shown in the image. On the left side, the coils of the return spring are slightly closer together than on the right side.

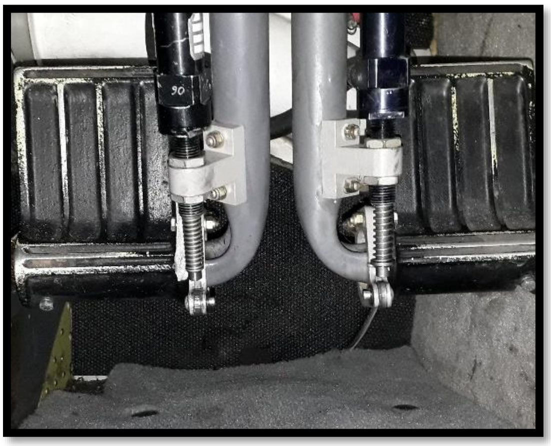


Figure 16: Master actuator pistons of the co-pilot's brake pedal.

- The master actuator pistons of both the pilot's and co-pilot's left pedal were disassembled and inspected, confirming that, while a little stiff, they returned to their natural position and functioned correctly.

e) The tyre:

- The LH tyre displayed uniform deterioration on its inner side. There were no breakages, and it had pressure. No scuffing was observed on the tread.

Figure 17: Tyre after the accident.

f) The brake hose:

- Only the following remained of the hose that connects the brake calliper to the hydraulic circuit:
  · At the end that connects it to the brake, the connecting fitting,
  · At the other end, a small fragment of the hose and its respective fitting.

  The rest of the hose had burned. Both fittings were checked for tightness. Traces of rubber were observed on the inside of the fitting attached to the brake.

g) The wheel fairing:

- The inner-rear part of the fairing was the most severely burnt, while the outer-forward part remained intact.

h) Torque plate bushings through which the anchor bolts of the brake calliper slide:

- Staggered grooves and corrosion could be seen inside the torque plate bushings.

Figure 18: Detail of a guide pin hole.

2. <u>Parts on the right side of the aircraft:</u>

   a) The brake pads:

      - The RH brake pads were in an acceptable condition (approximately 25% wear).

   b) The brake disc:

      - The RH brake disc had wear within normal working limits.

   c) The brake hose:

      - The RH hose connecting the brake calliper to the hydraulic circuit was undamaged and contained hydraulic fluid.

   d) The brake calliper:

      - There was hydraulic fluid inside the calliper.
      - The RH calliper anchor bolts slid smoothly through the RH landing gear torque plate bushings.

Several other inspections considered relevant to the investigation were also carried out:

- The brake system’s hydraulic fluid reservoir was found to be empty.
- The fuel tank on the left-hand wing was not leaking.

1.17. Organisational and management information

a) The operator:

Adventia European Aviation College, S.A. is an EASA-approved training organisation with authorisation E-ATO-230 signed on 08 November 2018 (Rev. No. 6).

The organisation's document *TB 10 - emergency procedures* outlines the following fire-related emergency procedures (which are identical to those in the aircraft flight manual):

- Fire in the engine during start-up.
- Fire on the wing.
- In-flight engine fire.
- Cockpit fire.
- In-flight electrical fire.

The document details the actions necessary to protect the aircraft and its occupants from potential danger in each situation.

Furthermore, the training manual stipulates that prior to a solo flight, the student must have reached a satisfactory level of performance in emergency procedures and that, in order to remain familiar with these procedures, after completing the training prior to the solo flight, the student must perform simulated emergency procedures during the pre or post-flight briefings of all the specified dual-control instruction flights.

These instruction flights correspond to missions 9, 11, 13, 16, 22 and 25.

With regard to the aforementioned training manual, the following should also be noted:

- Mission 11 provides for the execution of emergency drills in the event of a fire on the ground and in flight.

- In mission 13 (first solo flight progress check), one of the objectives is to check that the student pilot has memorised the emergency procedures.

- In mission 14, the first solo flight takes place.

Also, according to information provided by Adventia, for a student to be allowed to fly solo, no more than 6 months should have passed since their last flight. However, in practice, students never fly solo more than two weeks after their last flight.

b) The owner and maintainer of the aircraft:

The owner of the aircraft is Servicios y Estudios para la Navegación Aérea y la Seguridad Aeronáutica S.A. (Services and Studies for Air Navigation and Aeronautical Safety - SENASA S.A.). SENASA is also responsible for the aircraft's airworthiness management and maintenance (EASA-approved CAMO organisation ES.MG.121, and PART 145 organisation ES.145.074).

1.18. Additional information

a) <u>Obtained from the maintenance centre:</u>

The following information was obtained about the brake maintenance carried out by the aircraft maintainer:

- The brake calliper, pads and disc are inspected at every scheduled maintenance inspection (50 hours, 100 hours and 2,000 hours).

- During the 50-hour and 100-hour inspections, the brake calliper, pads and disc do not have to be disassembled from the aircraft unless they need to be replaced.

- During the 2,000-hour inspection, the brake calliper is removed and inspected as per the instructions in the aircraft manufacturer's maintenance manual. This is the most thorough inspection of the brake system (overhaul).

- No lubricant of any kind is applied to the torque plate bushings or the brake calliper anchor bolts.

- When the brake calliper is fitted to the aircraft after removal, the mechanics check to make sure there is some play between the brake calliper anchor bolts and the torque plate bushings.

b) <u>Obtained from the aircraft's manufacturer:</u>

The following information was extracted from the aircraft manufacturer's maintenance instructions:

- Lubricating the brake calliper anchor bolts or the holes through which they slide to facilitate the movement is not a prescribed maintenance task.

c) <u>Obtained from the brake manufacturer:</u>

The following information of interest was obtained from the brake manufacturer after the photo in figure 18 was sent to them:

The torque plate bushing I.D. (anchor bolt holes) are corroded. The surface finish also looks to be have been compromised in addition to the lack of cadmium plating. It is important that the anchor bolts are lubricated with a dry film lube and that the torque plate bushings are free of corrosion.

Based on the photos, there is a strong chance anchor bolts will not slide freely in the torque plate bushing I.D.

1.19. Useful or effective investigation techniques

N/A.

2. ANALYSIS

As stated in Section 1 (factual information), the aircraft's left brake caught fire at some point during the landing roll-out and subsequent taxi to the apron. This section will evaluate the following aspects:

- Cause of the fire.
- Maintenance of the aircraft.
- Emergency management by the student pilot.

2.1. Cause of the fire

According to the information outlined in point 1.16, the fire appears to have originated in the area around the left brake. The following sections will try to offer an explanation of how, why and when the fire started, followed by a possible sequence of events:

2.1.1. How did the fire start?

The fire triangle model will be used to work out how the fire started.

Based on this model, three requirements are necessary to ignite a fire:

- A fuel.
- An oxidant (an oxidising agent such as oxygen).
- An activation energy that generates a high temperature (e.g. heat or a spark).

When these three ingredients combine in the right proportion, a fire ignites.

Fuel

In this case, the fuel could have been the hydraulic fluid in the brake system (type MIL-H-5606F) or the petrol (AVGAS100LL).

In regard to petrol, although there is a vent hole in each wing (about 30 cm from where the leg meets the wing) through which, in certain circumstances, a small amount of fuel can escape, it is considered unlikely that fuel could have got through the wheel fairing into the brake area, even with possible assistance from the wind, because the fairing practically covers the entire leg. Therefore, we believe it unlikely that petrol acted as the fuel in this fire.

In addition, the post-accident inspection confirmed the absence of any fuel leak that could have found its way into the brake area.

As a result, we believe hydraulic fluid probably provided the fuel for the fire. However, the possibility that the brake system's synthetic materials could have started to burn due to high temperatures, with the hydraulic fluid simply contributing to the fire, cannot be ruled out.

Oxidant

Atmospheric oxygen typically serves as the oxidising agent in most fires. Since the fire started as the aircraft was taxiing in the open air, it is safe to say that there was a constant flow of air, and therefore oxygen, which fed the flames.

Activation energy

As explained in point 1.16, the inspection of the aircraft's left brake components found that the surfaces of the LH brake pads were extremely worn and deteriorated. In addition, deep grooves and adhered melted material were observed on both sides of the LH disc surface. The evidence, therefore, suggests that there was considerable friction between these components, which generated a large amount of heat and exposed the brakes to very high temperatures.

This high temperature in the area of the brakes would have:

1- Served as the activation energy for the fire, either in the form of heat or sparks generated by continuous and prolonged friction between the pads and the disc.

2- Led to the deterioration not only of the pads and disc, as explained above, but also the rubber of the brake hose close to the fitting and/or the brake actuator piston O-Ring, causing hydraulic fluid to leak into the brake.

Once this initial quantity of hydraulic fluid seeped out, either from the brake actuator piston O-Ring or from the rubber close to the fitting of the hose, it presumably began to burn when it came into contact with the highly overheated brakes or sparks generated by the pads rubbing against the disc.

The possibility that the hose came loose and caused a hydraulic leak has been ruled out, based on the condition in which the hoses were found (with the fittings tightened and in position and remains of rubber inside the hose, as explained in point 1.16.1.f) and the student pilot's statement (the left brake was working after the fire started).

Once the fire started, it spread to different parts of the aircraft, including the hose, which leaked more hydraulic fluid as it deteriorated, contributing to the spread of the fire.

2.1.2. Why did the fire start?

Next, we must consider what caused the excessive heat in the brake area that served as the activation energy for the fire.

Firstly, as explained in point 1.6, when the brake pedal is pressed, it generates friction between the brake pads and the brake disc, slowing the aircraft. This friction between the brake pads and disc generates great heat.

As soon as the brake pedal is released, the brake calliper's actuator piston stops applying pressure to the moving brake pad, and the brake pads move away from the brake disc. Consequently, the heat begins to dissipate, aided by the considerable cooling effect of air moving around the aircraft.

If something were to cause the brake pads to remain in contact with the brake disc after the brake was released, the aircraft would roll with the brake pads partially in contact with the brake disc without locking the wheel. This would mean that rather than dissipating, the heat generated while braking would increase due to the continuing pads-to-disc contact. The high heat level would result in wear to the brake pads, disc and adjacent parts, such as the brake actuator piston O-Ring and the rubber from the brake hoses, and cause the metal brake components to expand and deform.

Therefore, on the day of the accident, something must have caused the brake pads and disc to remain in contact after the brake was released.

Secondly, the fact that the student pilot indicated in the interview that he had not noticed anything unusual during the initial taxi, the take-off, the landing roll-out, or the first phases of the taxi after landing (and the GPS trace corroborates this) suggests that the excessive wear found on the pads and disc was not produced solely on the day of the accident nor during any previous isolated operation. Therefore, we believe it likely that the excessive wear to the brake pads and disc accumulated gradually over time as a result of the aircraft being subjected to prolonged "brake drag[4]".

Although the "brake drag" phenomenon would have also been present on other days, we believe that fire broke out on the day of the accident because hydraulic fluid leaked onto

[4] A phenomenon whereby the brake pads remain in contact with the brake disc with no actuation from the cockpit by the pilot or co-pilot

the overheated brakes. This, in turn, happened because the brake actuator piston O-Ring and/or the rubber of brake hose finally lost their integrity after progressively eroding for some time due to the brake drag phenomenon.

Based on the brake manufacturer's troubleshooting guide and the inspection of the brake system in paragraph 1.16, we believe the brake drag was caused by the calliper not returning to its resting position after the brakes were released due to:

- A seizure of the brake calliper actuator piston, which would prevent the moving pad from ceasing to apply pressure to the disc, even though hydraulic pressure was no longer present.
- Unintentional hydraulic pressure due to a blockage of the brake pedal's master actuator piston.
- Impeded sliding of the brake calliper anchor bolts through the torque plate bushings, which would cause the brake calliper to jam on its way back to its resting position after the brake pedal was released.

The investigation has not been able to definitively determine why or when the calliper stopped returning to its resting position after the brakes were released.

However, based on the information provided in point 1.16, in particular:

- The conicity observed in the brake calliper anchor bolts and the corroded grooves found in the torque plate bushings through which they slide suggest the calliper anchor bolts were meeting resistance during the movement (based on the information in points 1.6.3 on "off-aircraft" maintenance guidelines and 1.18 on the brake manufacturer's instructions). However, it has not been possible to determine to what extent the fire that broke out and the subsequent removal of the brake from its housing in the aircraft leg contributed to these damages and deformities.
- The acceptable condition of the other brake system components that could have prevented the calliper from returning to its resting position, such as the brake master actuator pistons for the left-hand brake pedals and the brake calliper actuator piston.

We have concluded the most likely explanation for the calliper failing to return to its resting position is that the calliper anchor bolts were not sliding smoothly through the torque plate bushings. Furthermore, we believe this phenomenon could occur randomly; in other words, it may not have happened every time the brakes were applied, depending, for example, on the extent to which the calliper inclined when the brakes were applied.

It should be noted that, although it was considered possible that the condition of the brake master actuator piston of the left-hand pedal in the co-pilot's seat (shown in figure 16) could be responsible for the calliper not returning to its resting position, this hypothesis was deemed less likely than the previous due to the following factors:

- We could not confirm that the brake pads and brake disc were in contact with the brake master actuator piston in this position.
- The brake master actuator piston was disassembled, tested and found to be working correctly.
- The master actuator piston in question corresponded to the co-pilot's seat, which would imply that the brake pads and the brake disc had been in permanent contact since 15-12-2020 (the last time the aircraft was flown with a co-pilot, two flights before the accident flight). If this was the case, we believe it highly likely that either one of the crews of the two previous flights (one of them with an instructor), or the student pilot himself, would have noticed something unusual during one of the phases of their respective operations, particularly while taxiing at a low speed.

Based on the information in point 1.6.4, we do not believe the student pilot could have detected the anomalies in the pre-flight inspection because the only aspect checked at that time is whether there are any signs of hydraulic leaks and, given the wheel fairings, they would be challenging to detect.

2.1.3. When did the fire start?

Having analysed how and why the fire started, the next step is to work out when the fire may have started.

Chronologically, the first factual evidence of the fire is the sighting by the student pilot witness, who, according to the interview, first noticed it when the aircraft was at the C5 holding point but could not say whether it was already on fire when it approached it. Thus, we can deduce that the fire started when the aircraft was at the C5 taxiway holding point, at the latest.

However, as can be seen in figure 17, the entire interior of the fairing was burnt, which suggests the fire most likely originated in the brake when the aircraft was moving.

In order to produce the high temperatures and/or sparks necessary to start the fire, there must have been friction between the pads and disc for enough time and at a considerable relative speed for the brakes to reach a temperature sufficient to serve as the activation energy for the fire.

Taking into account the student pilot's testimony that he did not apply the brakes during the first phase of the landing roll-out (point 1.11.1), leaving the aircraft to slow on its own, and the information outlined in point 1.11.2, the most likely scenario is that brake calliper did not return to its resting position after the student pilot applied the left brake to make the U-turn and then disengaged it to continue taxiing, leaving the brake pads partially in contact with the disc as the aircraft travelled back down the runway to taxiway C5 (point 1.11.3).

Therefore, we believe the fire started sometime between the U-turn and stopping at the C5 holding point.

2.1.4. Possible sequence of events:

Having analysed how, why and when the fire started, a possible sequence of events is provided below:

1) The student pilot carried out the pre-flight inspection, taxied along the apron and taxiways and took off from runway 03. He did not notice anything unusual in the aircraft's performance, completed the scheduled flight, and returned to the airport to land.
2) The student pilot landed on runway 03.
3) During the first phase of the landing roll-out, the student pilot taxied down the runway without applying the brakes, leaving the aircraft to slow itself.
4) TWR instructed the student pilot to make a U-turn and taxi back to exit the runway via taxiway C5.
5) The student pilot made the U-turn. Since he made a full, tight turn to the left, he probably applied the left brake fully to execute the manoeuvre. When he had completed the U-turn, the student pilot released the left brake. However, the brake calliper did not return to its resting position and the left brake pads remained partially in contact with the left brake disc.
6) The student pilot taxied back down the runway with the brake pads and brake disc partially in contact. Consequently, throughout this return run (lasting approximately 1 minute and 40 seconds at an average speed of 40 km/h until reaching the holding point for C5), heat and/or sparks were generated in the aircraft's left brake and

spread to all the brake components. As the student pilot was taxiing down the runway at a higher speed than usual, he had to apply more power, which could have prevented him from noticing that the brake remained slightly applied.

7) The student pilot reached the holding point for C5 and stopped the aircraft, which means the brakes were operational up to this point.

As explained previously, it is highly likely the fire in the brake area originated during the taxi back down the runway after the U-turn, so by the time the student pilot stopped the aircraft at the C5 holding point, the brake was on fire.

8) The student pilot witness saw the fire on the aircraft and notified Adventia Operations by radio in the first instance and then TWR.
9) Thanks to the radio communication between the student pilot witness and TWR, the student pilot became aware that his aircraft was on fire and began to manage the emergency by radioing Adventia Operations.
10) While the student pilot was stationary at the C5 holding point, with the left brake on fire and both brakes applied, the rubber of left brake hose and/or the brake actuator piston O-Ring, which had been badly damaged by the fire at that point, could not withstand the pressure of the brake system (as the brakes were applied) and ruptured, releasing hydraulic fluid and worsening the existing flames.
11) As a result, the student pilot lost control of the brakes, and the aircraft began to move slowly forward in an almost completely straight line.

The fact that the aircraft rolled in a straight line and that the student pilot stated in the interview that the brakes released, suggests that the right brake also lost effectiveness (note that this model of aircraft has differential brakes). However, no evidence has been found to support this claim because, as indicated in point 1.16., traces of hydraulic fluid were found in both the right brake hoses and the right brake calliper.

12) The student pilot followed the emergency management guidelines provided by Adventia Operations and abandoned the aircraft while it was in motion.
13) The aircraft stopped on its own at the end of taxiway C5.
14) The SSEI approached the burning aircraft and proceeded to extinguish the fire.

2.2. Aircraft maintenance analysis/aircraft maintenance guidelines.

Based on the maintenance information collected, some of which has been outlined in section 1.6.3, it can be stated that:

- The aircraft was up-to-date in terms of scheduled maintenance.
- All the life-limited parts were within the manufacturer’s specified date and/or number of hours.
- The maintenance tasks prescribed by the aircraft maintainer in the scheduled maintenance programme are identical to those prescribed by the aircraft manufacturer in its maintenance manual.
- The corrective maintenance carried out in recent maintenance inspections is typical of the type of maintenance generated by the normal operation of the aircraft.
- The aircraft did not have any brake-related anomalies noted in the aircraft flight and maintenance logbook in the month prior to the incident.

Although it is believed, as indicated in point 2.1.2, that the deterioration of the various brake components and hoses occurred progressively, no signs of any brake-related anomalies were found during the removal of the calliper to replace the brake pads on 05-10-2020 nor the last scheduled inspection (of 50 hours, on 20-11-2020). This was probably because neither of these two scheduled inspections found that the discs, pads or other elements were noticeably damaged or that the calliper anchor bolts were meeting resistance when sliding through the torque plate bushings.

This would suggest that the brake calliper problem originated or worsened (given that, up to that time, if it existed, it was not sufficiently noticeable to be perceived during maintenance or operation) sometime between 20-11-2020 (the last scheduled maintenance inspection) and 12-01-2021 (the day of the accident), during which the aircraft flew 33 hours and 15 minutes and competed 46 landings and 46 take-offs.

In addition, in regard to the 2,000-hour brake overhaul guidelines (callipers, pads and disc) provided by the aircraft manufacturer and the brake manufacturer, set out in point 1.6.3, the following is observed:

- that the aircraft manufacturer only prescribes checking the general condition and attachment and inspecting for wear and cracks in the brake system.

- that the brake manufacturer seems to consider it critical to check that the brake calliper anchor bolts slide smoothly through the torque plate bushings and to lubricate the assembly to facilitate that movement (as reiterated in point 1.18, in the information obtained from the brake manufacturer); tasks not prescribed by the aircraft manufacturer.

However, we cannot conclude that this contributed to the failure of the calliper to return to its resting position after the brakes were released because to date, after many years of operating and maintaining a fleet containing several aircraft of this model, no evidence of brake problems due to a lack of lubrication between the anchor bolts and the torque plate bushings has been found on any of the aircraft.

2.3. Analysis of the emergency management by the student pilot

On the one hand, based on the communications outlined in point 1.9, the student pilot witness informed TWR that the aircraft was on fire at 13:45:30. Therefore, we can deduce that this was when the student pilot became aware that his aircraft was on fire, given that, as stated above, the student pilot learned of the fire from the aforementioned communication.

On the other hand, according to the GPS trace, the aircraft began to move in an uncontrolled manner from the holding point for taxiway C5 at 13:46:25.

Therefore, at the very least, the student pilot was inside the aircraft when it was on fire (and aware of that fact) for at least 55 seconds.

3. CONCLUSION

3.1. Findings

- There was a considerable transfer of heat and material between the brake pads and the brake disc, resulting in a high brake temperature.

- The left brake calliper anchor bolts displayed conicity and were not parallel, compromising their ability to slide through the torque plate bushings.

- Material loss in the form of grooves and corrosion was observed on the inner surfaces of the torque plate bushings of the left leg, through which the brake calliper anchor bolts slide. In the opinion of the brake manufacturer, the torque plate bushings were sufficiently deteriorated to prevent the brake calliper anchor bolts from sliding freely.

- After comparing the failures of the EC-FTJ aircraft with the failures of other aircraft in the fleet, it was established that it had suffered no failures other than those associated with the normal operation of the aircraft in the months prior to the accident.

- The aircraft manufacturer’s maintenance instructions for the brake inspection do not, at any point, include checking the brake calliper slides smoothly through the torque plate bushings, nor is it mentioned as a possible cause of brake drag in the troubleshooting guide.

- The brake manufacturer’s maintenance instructions for inspecting the brakes do include checking the brake calliper slides smoothly through the torque plate bushings. It is also included as a possible cause of brake drag in the troubleshooting guide.

3.2. Causes/contributing factors

The investigation has not been able to determine the cause of the accident.

4. SAFETY RECOMMENDATIONS

No operational safety recommendations are proposed.

5. APPENDIX: BRAKE SYSTEM COMPONENTS AND OPERATION

This appendix provides a detailed explanation of each of the brake system's components and how the system works.

The most important components of the brake system (shown in Figure 2) are described below:

- Brake fluid reservoir: Holds and supplies the brake fluid necessary for the operation of the brake system. The fluid used is MIL-H-5606F.

- Pedals: Operated from the cockpit by the pilot or co-pilot, transmits pressure to move the brake master actuator piston.

- Brake master actuator piston: Actuated by the pedal, it introduces pressure into the hydraulic circuit, which is transmitted through the brake system via the brake hoses.

- Hose: A nitrile conduit reinforced with two high-strength steel wire braids and coated with neoprene. It connects the various parts of the brake system to form a hydraulic circuit. The hoses are connected to the various parts of the brake system by means of threaded metal endings, called fittings. The working temperature range is from -40 °C to 100 °C.

- Parking brake valve: When operated from the cockpit by means of a rotary knob, the valve closes to prevent hydraulic fluid from flowing through it.

- Parking brake light in the cockpit: Light that illuminates when the parking brake valve is closed.

- Brake: When this component receives hydraulic pressure through the hoses, it reduces the aircraft's speed. It consists of the calliper, two pads and a disc:

    - Brake calliper: The brake calliper is installed by inserting two anchor bolts into the holes in a plate welded to the aircraft's leg. Mounted onto the calliper are a pressure plate and a back plate, each with a brake pad attached. It also has a hydraulic fluid inlet, a drainage outlet and an actuating piston.

    - Brake pads: When the brakes are applied, the brake pads come into contact with the brake disc. The friction between the brake pads and the brake disc causes the aircraft to slow down. One of the pads is fixed to the calliper with two bolts. The other pad is mobile and moves with the calliper via two anchor bolts.

    - Brake disc: The brake disc is installed on the aircraft and rotates with the wheel.

    - Brake actuator piston: This component receives hydraulic pressure through the hose and transmits it to the pressure plate (which holds the moving pad), moving it towards the brake disc. This actuating piston has a nitrile butadiene O-Ring (NBR) that can withstand temperatures up to 135 °C.

The following images show the brake structure and its attachment to the aircraft's landing gear leg:

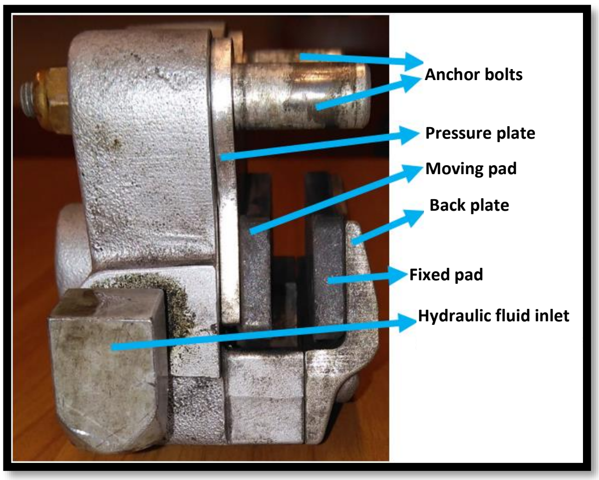


Figure 19: Brake (side view).

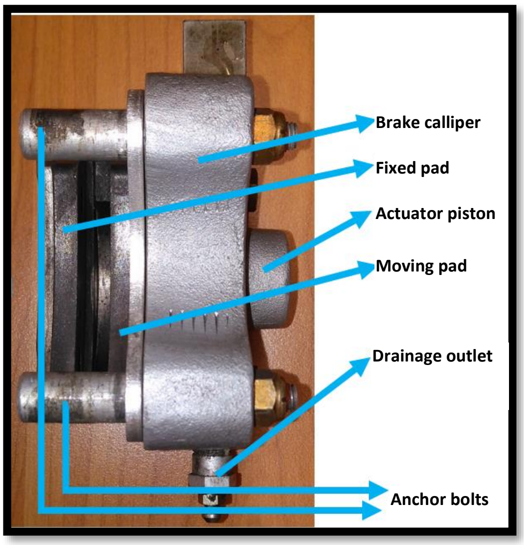


Figure 20: Brake (plan view).

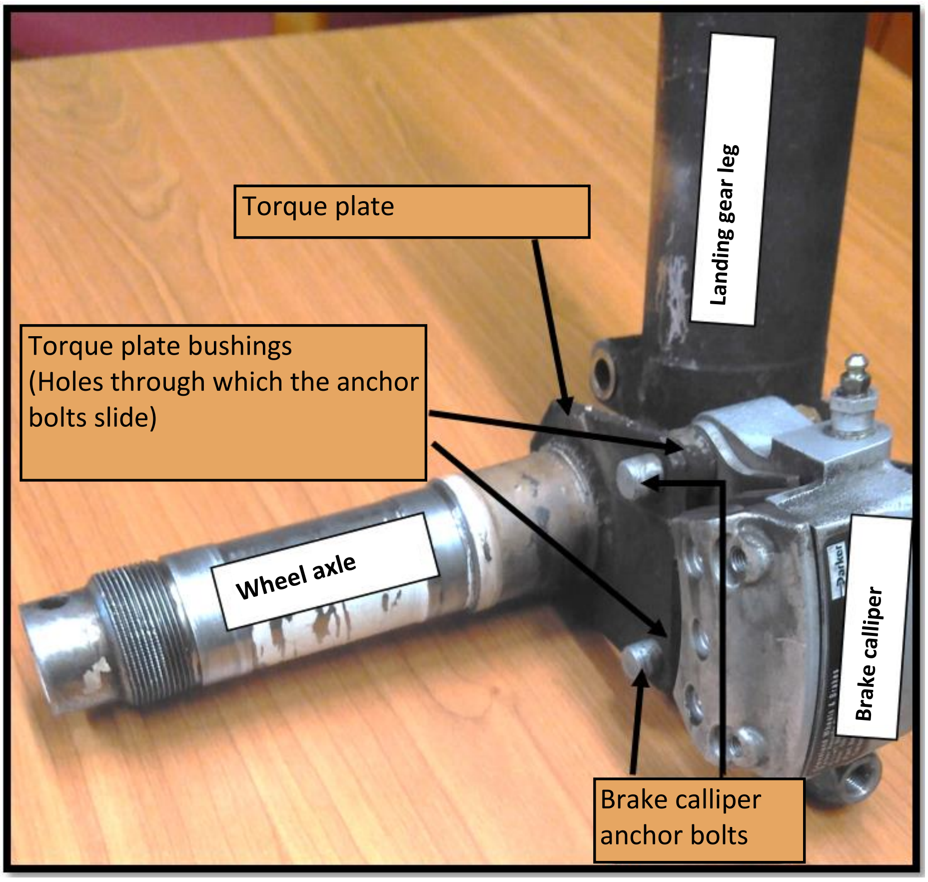
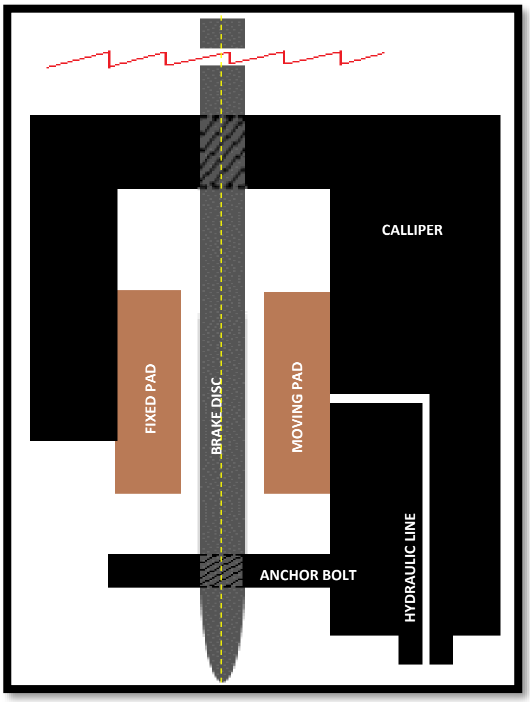


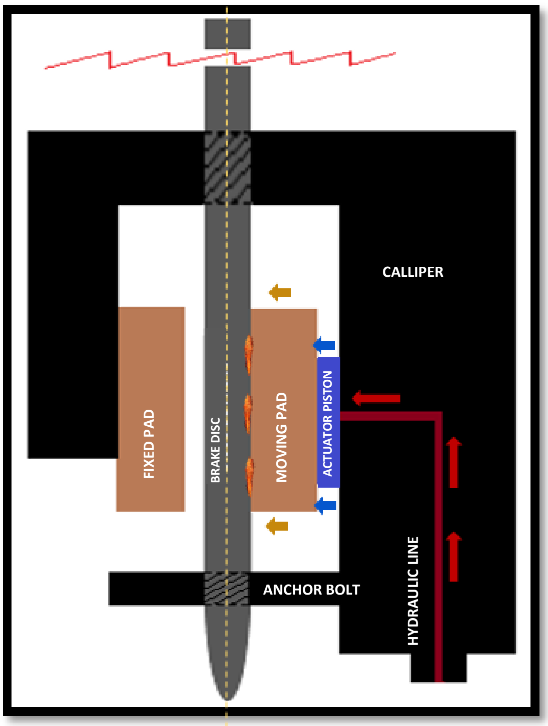
Figure 21: Brake and landing gear leg coupling.

Lastly, a schematic explanation of how the brake system works is provided below:



This is the position of the brake at rest.

Figure 22: Operation of the brake (1).



When the brake pedal is pressed, pressure is transmitted by hydraulic fluid through a line running inside the brake calliper.

The hydraulic fluid moves the actuator piston, which, in turn, moves the moving pad until it makes contact with the brake disc.

Figure 23: Operation of the brake (2).

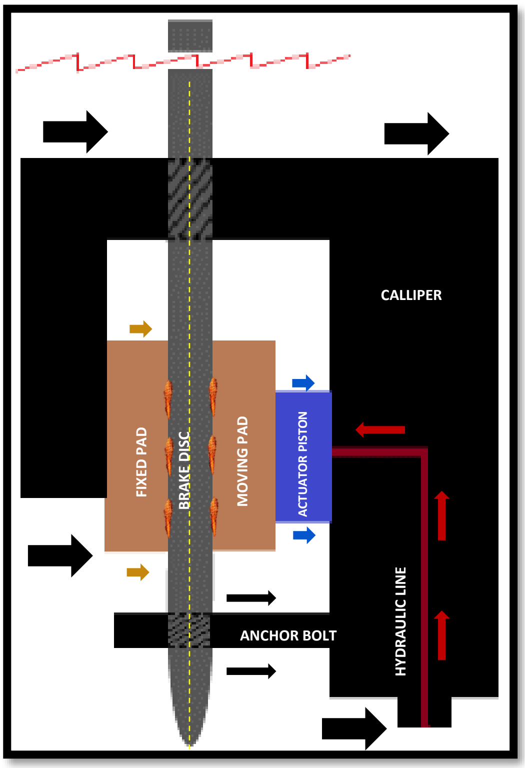


Figure 24: Operation of the brake (3).

As the moving pad cannot continue forward after making contact with the brake disc, the entire calliper moves sideways, sliding the anchor bolts through the holes in the landing gear leg plate (torque plate bushings). It then uses the moving pad, which is already pressing on the brake disc, as a support point to drag the fixed pad forward until it makes contact with the other side of the disc, braking the aircraft.

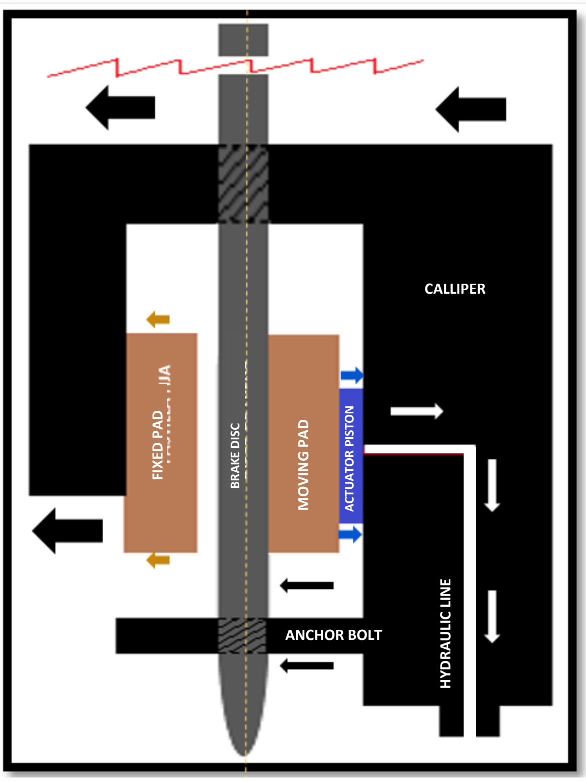


Figure 25: Operation of the brake (4).

When the brake pedal is released, the hydraulic pressure is removed from the system, allowing it to return to its resting position gradually.

When the hydraulic pressure is released, the actuator piston retracts. This causes the calliper and its fixed pad to slide away from the disc.

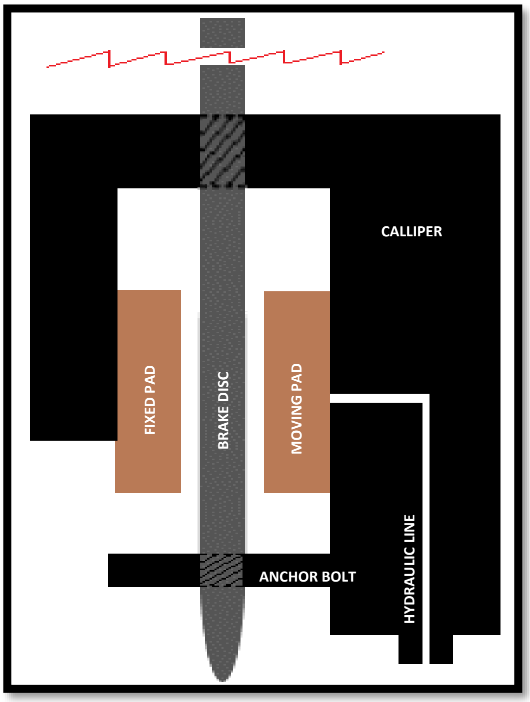


Figure 26: Operation of the brake (5).

Lastly, as the actuator piston is no longer pushing the moving pad toward the disc, it moves away, freeing the disc and returning the system to its resting position (in this particular brake model, there is no retraction element as such).