SAFETY INVESTIGATION REPORT

Accident to the PIPER PA-28RT - 201T registered **HB-PNP** on Thursday 23 July 2020 on Bâle-Mulhouse airport

Time	Around 13:40[1]
Operator	Private
Type of flight	Local
Persons on board	Pilot, two passengers
Consequences and damage	One passenger fatally injured, one passenger injured, aeroplane destroyed
This is a courtesy translation by the BEA of the Final Report on the Safety Investigation. As accurate as the translation may be, the original text in French is the work of reference.	

In-flight fire, emergency landing

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[1] Except where otherwise indicated, the times in this report are in local time.

1 HISTORY OF THE FLIGHT

Note: the following information is principally based on statements, radio-communication recordings and radar data.

The accident flight was the first flight with the aeroplane following the installation of new avionics and an autopilot. The purpose of this flight was to test the correct operation of these new equipment items and for the owner of the aeroplane to familiarize himself with their use. Taking part in the flight were the owner of the aeroplane, an electronics technician who had participated in the work and the pilot who was an instructor and had already carried out a check flight on this type of aeroplane after similar work. The flight programme drawn up by the pilot included:

- take-off from Bâle-Mulhouse airport under VFR[2] before changing to IFR overhead waypoint ALTIK (see Figure 1);
- an RNP approach to runway 15, rejected on final;
- an ILS approach to runway 33.

The pilot had previously informed the airport controllers of the flight programme.

The pilot took off at 15:17 from runway 15. The first minutes into the flight were normal and the various tests of the autopilot and flight director were satisfactory. After a flight time of around 15 minutes, between waypoint ALTIK and the final for runway 15, the pilot observed an ammeter charge indication close to 70 A which corresponds to the needle being close to the indicator's limit. This charge value was a lot higher than the values expected for such a flight phase, which are normally between 10 and 30 A (see Figure 1,point 1).

The pilot cut off the alternator (using the Master ALT switch) and observed that the ammeter then indicated zero. When he switched the alternator back on, the ammeter again indicated a constant value of around 70 A. The pilot and his passengers presumed that the battery was discharged and that its recharge called on the alternator. They decided to continue with the planned flight programme. The pilot joined the final for runway 15, carried out a missed approach at around 3,000 ft and then continued with an ILS approach for runway 33.

While climbing to 7,000 ft, the pilot and his passengers perceived a smell in the cabin (point 2) that the pilot described as an electrical smell. The pilot suspected an incipient fire and decided to carry out an emergency landing on runway 33. He announced to the controller, "*We have to abort the exercise actually we have an electrical problem. Request from position short approach 3 3 and land*." The controller cleared him to land on runway 33. In the seconds that followed, smoke from the luggage hold and then flames spread into the cabin (points 3 and 4). The pilot started a quick descent and isolated the battery and alternator by setting the Master BAT and Master ALT switches to OFF.[3] He managed to land on runway 33.

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[2] The glossary of abbreviations and acronyms frequently used by the BEA can be found on its website.

[3] The Master ALT switch controls the excitation and thus operation of the alternator. The Master BAT switch connects/disconnects the battery with the power system. This set of two switches is also called the Master Switch.

While the aeroplane was still running on the runway at a speed which the pilot estimated as being between 30 and 40 kt, the three occupants evacuated the aeroplane. The owner of the aeroplane who was in the front right seat was the first to evacuate[4] the aircraft. He was fatally injured on hitting the runway. The passenger in the rear seat was severely burnt.

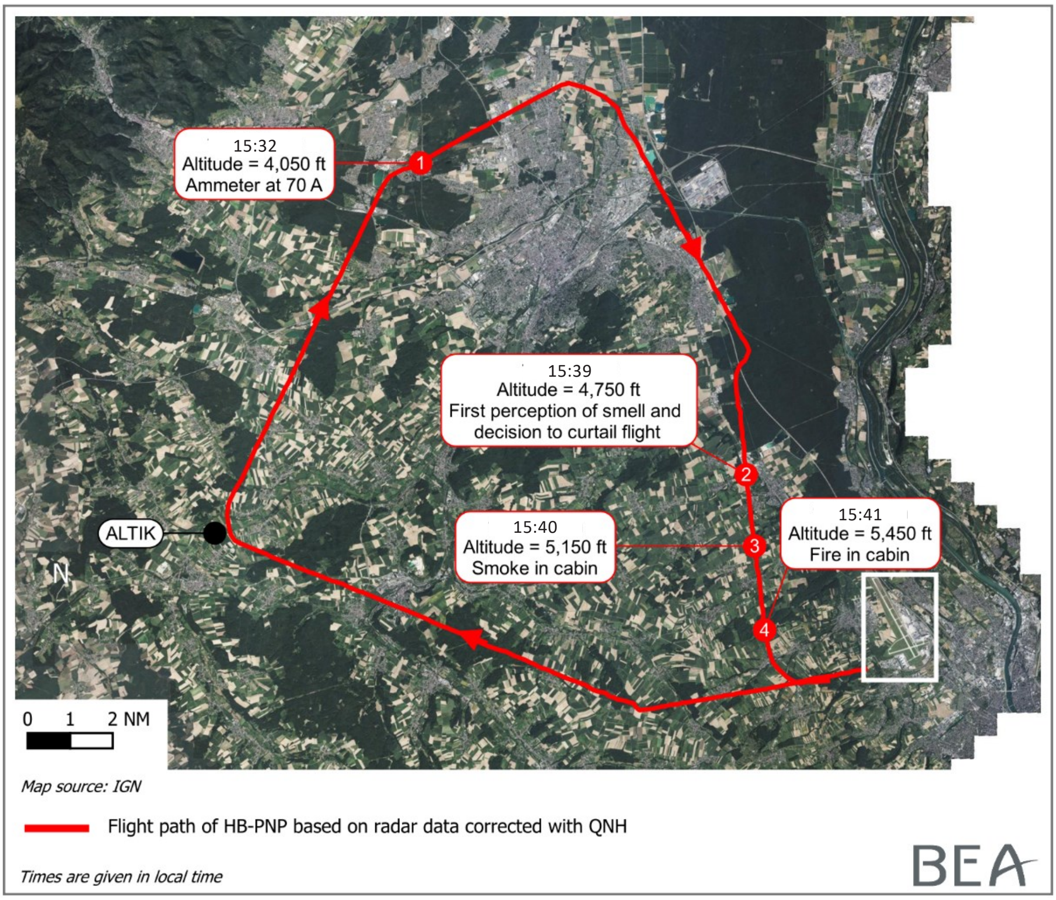


Figure 1: flight path of HB-PNP based on radar data and the pilot's statement. The positions of the red circles on the flight path are approximate as solely based on the pilot's statement.

2 ADDITIONAL INFORMATION

2.1 Aircraft information

The aeroplane registered HB-PNP was a Piper PA-28RT-201T Arrow IV manufactured in 1981. There are two types of this PA-28 model: one with a conventional tail unit known as the PA-28R-201T and the other with a T-shaped tail unit known as the PA-28RT-201T.

The aeroplane had logged 5,386 flight hours and 5,560 cycles. Its airworthiness review certificate issued on 3 October 2019 was valid. The aeroplane was equipped with a hand-held halon fire extinguisher located under the passenger's front right seat.

[4] The Piper PA-28 is equipped with a single door situated on the front right side.

This aeroplane was based at Bâle-Mulhouse airport and was maintained by FLUGSCHULE BASEL (an organisation with Part-CAO approval[5]). The last 100-h annual inspection had been carried out in October 2019 and had not brought to light any particular problem.

Several electrical equipment items covered by various STC[6] were installed on the aeroplane (see the BEA's technical document available on the accident to HB-PNP page on the BEA's website):

- STC SA01147W concerning the installation of a battery RG-35AXC manufactured by CONCORDE BATTERY CORPORATION. The battery was installed in October 2017.
- STC SA3531NM concerning the installation of cables manufactured by BOGERT AVIATION INC, between the battery and the starter. They were installed in November 2019. The aeroplane had flown around eight hours between this modification and the accident.

The modifications made to the aeroplane before the accident flight were also covered by an STC (GARMIN AML STC SA01866WI). These modifications concerned the installation of two Garmin G5 EFIS (EASA STC 10060846 issue 2) and a Garmin GFC500 autopilot (EASA STC 100694439 issue 1). The work took place from 19 June to 16 July 2020.

AVIONITEC (organisation with Part-145 approval) carried out the "avionics" work. The company specified that it complied with the procedure provided by Garmin for this STC. The work comprised the electrical wiring of the aeroplane and replacing the old instruments with the new ones provided by Garmin. It specified that when carrying out the wiring, the old avionic cables were removed and the new cables installed using the same route.

FLUGSCHULE BASEL workshop carried out all the "mechanical" work which consisted of:

- disassembling the seats and interior trimmings;
- removing the old servo-motors and installing the new ones;
- installing the adapters for the new instruments which were not the same size as the old instruments, and then reassembling the trimmings and seats.

At the end of the work, an electrical power consumption test was carried out during the ground tests on 16 July 2020. These ground tests showed that the total electrical power consumption of the new equipment was around 5 A less than that of the old equipment. The total electrical power consumption of all the equipment in operation was less than 60 A, i.e. 85% of the capacity of the alternator (70 A). These tests were carried out with a GPU to electrically power the aeroplane. The alternator was thus not used.

[5] It is suitable for small structures, organisations carrying out maintenance and/or airworthiness management activities for aircraft which are not in the complex aircraft group, and which are not used for the commercial carriage of passengers or freight.

[6] When substantial aircraft or aircraft equipment modifications are not designed by the type certificate holder for the aircraft concerned, an authorisation from the authorities must be obtained. These modifications called Supplemental Type Certificates (STC) are approved by a document issued in this present case, by the American civil aviation authorities, the Federal Aviation Administration (FAA) confirming the authorisation to modify an aircraft or aircraft equipment. EASA had also approved these STC.

The Garmin STC does not require a flight test before the aircraft is returned to service. The Approval for Return to Service (ARS) was issued on 16 July 2020 by the AVIONITEC electronics technician who was the rear passenger during the accident flight.

The day before the accident, the battery had been removed and fully charged by FLUGSCHULE BASEL workshop personnel who then carried out ground tests for around two hours the day of the accident, with the engine running on a GPU. These tests were used to check the operation of all the instruments and to calibrate them.

FLUGSCHULE BASEL had two other Piper PA-28 types, embodying since 2017, like HB-PNP, battery and cable related STCs (Bogert cables, Concorde battery and original battery tray). In January 2024, each aeroplane had totalled around 2,000 flight hours since the embodiment of these STCs without having known any electrical failure.

The company also owned another PA-28 of the same type as HB-PNP. It also embodied battery-related STCs and the Garmin avionics STC. This STC had been embodied on the aircraft two months before it was embodied on HB-PNP, without the aircraft experiencing an electrical failure.

2.2 Technical examinations

The visual examination of the damage observed on the wreckage (see Figure 2) and the assessment of its severity made it possible to determine that the source of the fire was located in the compartment situated behind the luggage hold. This zone holds the ventilation system, the hydraulic pump for the landing gear, the battery and numerous components of the general electrical system supplying the aeroplane equipment (see Figure 3).

Figure 2: general view of damaged area (source: BEA)

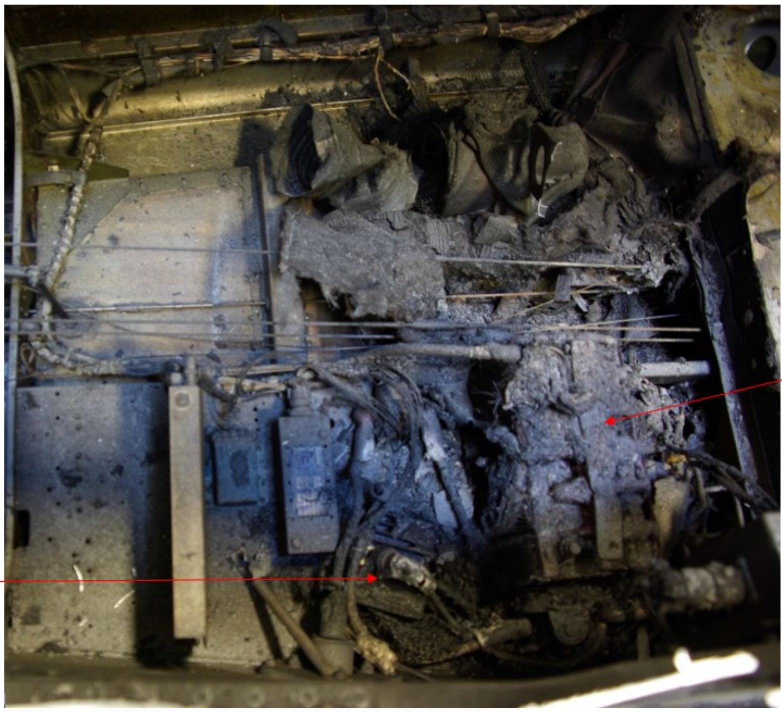


Figure 3: site of the fire (source: BEA)

The damage observed on the ventilation system and the hydraulic pump did not indicate prior damage on this equipment. The work therefore concentrated on the aeroplane's electrical power system.

Due to the numerous STCs embodied on HB-PNP, the BEA, in coordination with the NTSB, its American counterpart, asked Piper and the equipment manufacturers of the STCs for their help. The later informed the BEA that they were not aware of any similar occurrences.

The BEA also asked the following entities for their assistance:

- the ENAC workshop at Castelnaudary;
- a fire fighter specialist;
- the Institut National de l'Energie Solaire (INES) situated at Chambéry. This is a laboratory of the French Atomic Energy Commission (CEA) with specific expertise in electrical systems.

The BEA endeavoured to identify which component could have experienced an electrical fault creating an extended electrical over-consumption of a value close to the maximum capacity of the alternator (70 A).

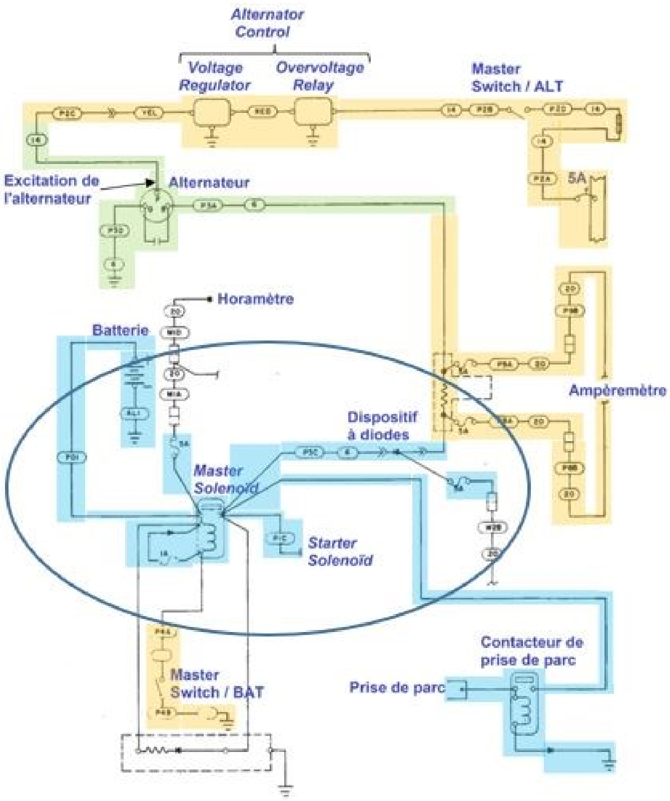
All of the examinations are described in detail in the technical document available on the accident to HB-PNP page on the BEA website.

The damage observed, the examinations carried out on all the components of the aeroplane's electrical system (battery, alternator, contactors, equipment linked to the embodiment of the Garmin STC, etc.) and the information gathered led to the most likely hypothesis of an electrical fault level with the diode device. In this report, only information regarding the diode device is given in detail.

2.2.1 Diode device

2.2.1.1 General

In the electrical power system of the PA-28, the diode device (Piper equipment P/N 79412-011) is located between the battery and the alternator. It participates in rectifying the voltage at the alternator output to recharge the battery. This device also prevents the current from the battery returning to the alternator (see Figure 4).



Areas of the system located aft of the luggage hold
Areas of the system located in the engine compartment
Areas of the system located level with the instrument panel

Figure 4: aircraft's electrical power system (source: Piper, annotations BEA)

This equipment is composed of a four-diode device attached to a metal cooler (heat sink). This aluminium alloy cooler has an outer protective coating formed by electrolytic anodisation.

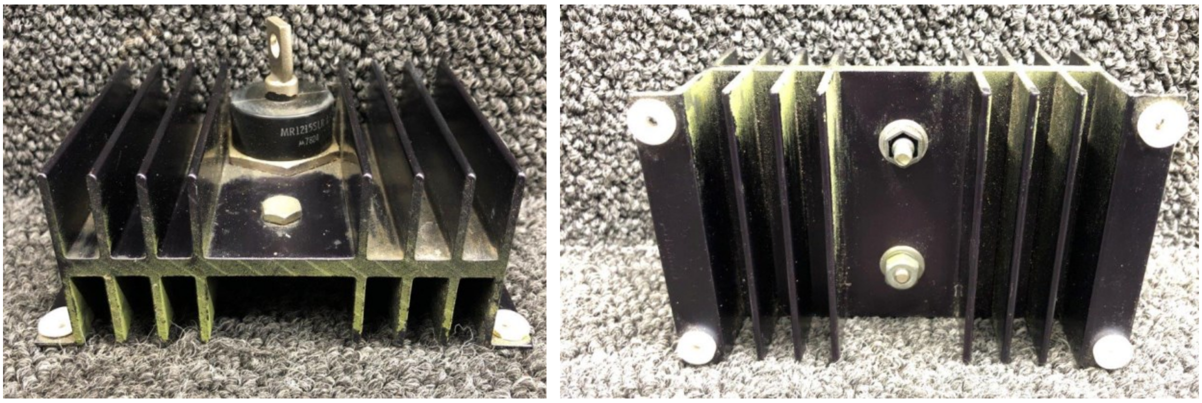


Figure 5: undamaged diode device (source: Piper spare parts on-line store)

This device is located in the compartment situated behind the luggage hold, close to the battery. The metal cooler is attached to the aeroplane floor by means of four carbon steel screws. It is electrically insulated from the floor by a phenolic shield and electrically insulated from the attaching items by isolating washers. The cooler has an outer protection composed of a plastic (ABS[7]) cover.

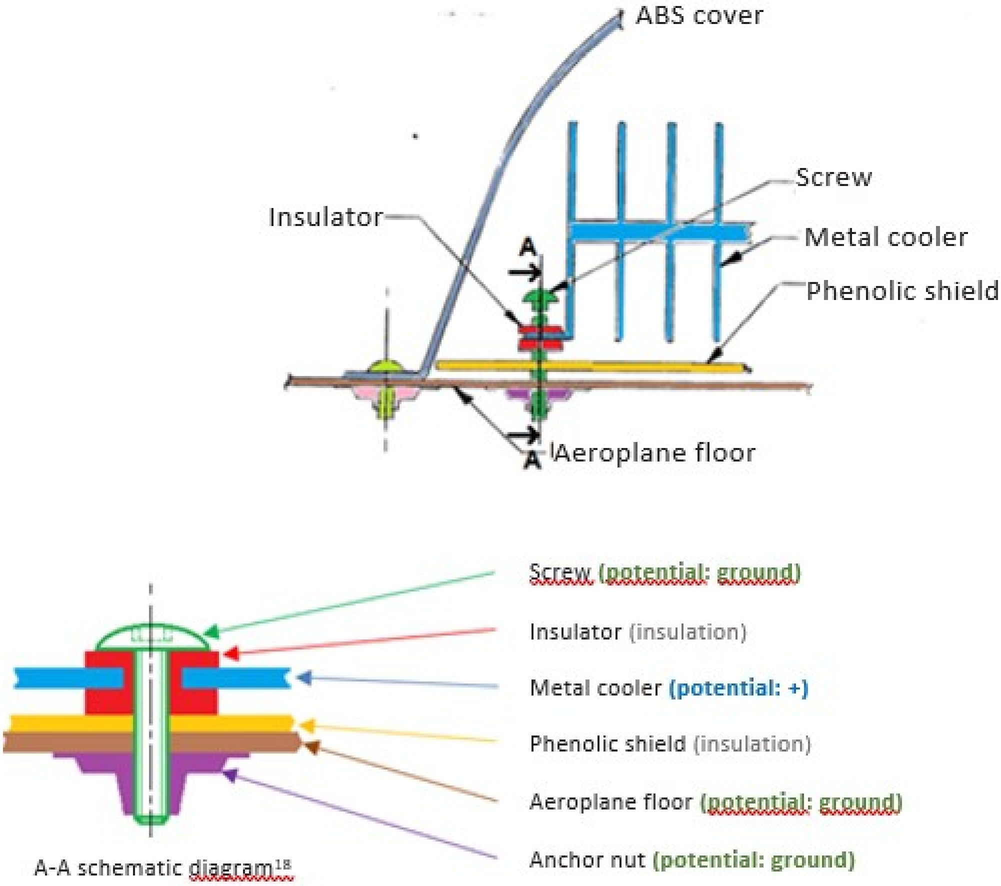


Figure 6: diagram of diode device installation (source: Piper, annotations BEA)

[7] Acrylonitrile butadiene styrene, or ABS, is a thermoplastic and amorphous industrial polymer.

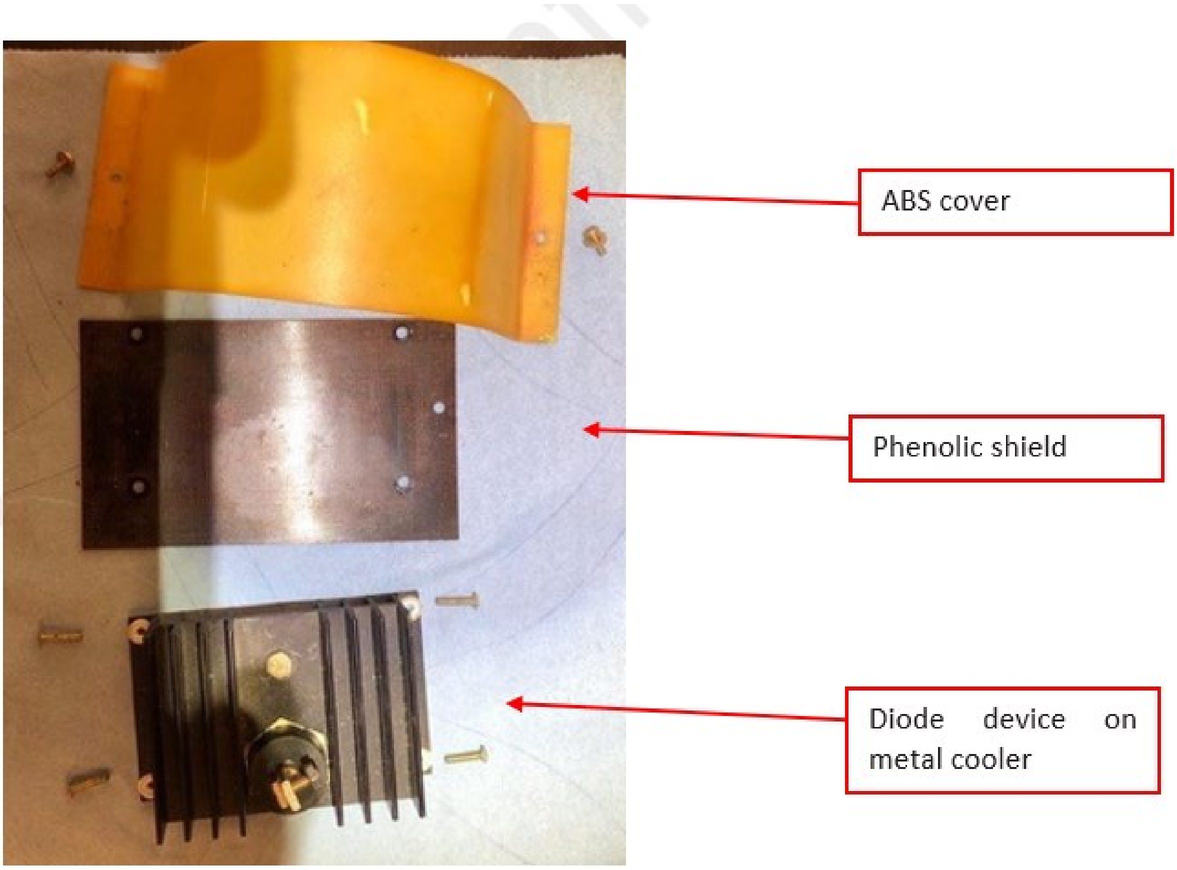


Figure 7: photo of device from a PA-28RT-201T
(source: FLUGSCHULE BASEL flying club)

The electrical terminal of the diode device, in contact with the cooler, is connected to the alternator. Consequently, if the insulation is incorrect between the cooler and the aeroplane floor, the alternator is directly connected to the structure of the aeroplane. This could create a short-circuit and the alternator would supply its maximum power.

2.2.1.2 Diode device maintenance

The review of Piper maintenance documents found no action linked to the diode device. Specifically, no inspection of this equipment is specified to check for its insulation from the aeroplane floor.

Piper published service bulletin SB 623 on 1 November 1978 to warn maintenance workshops that the incorrect installation of the items attaching the cooler to the floor could cause a short-circuit and demand maximum output from the alternator.

This service bulletin provided a sketch indicating the correct installation of the equipment and included instructions to remove any insulating washer incorrectly installed to prevent a possible malfunction of the electrical system.

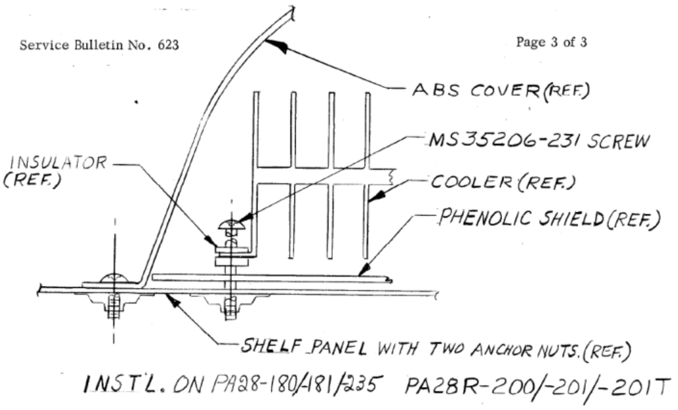


Figure 8: excerpt from Piper service bulletin SB 623

This SB applies to the various Piper PA-28 models manufactured between 1975 and 1978 which includes the PA-28R-201T (model with a conventional tail unit). It was not referenced as being applicable to the PA-28RT-201Ts which were manufactured between 1979 and 1988, i.e. after the publication of the SB which has not been updated since.

The maintenance documents for HB-PNP indicated that no maintenance action on the diode device had been carried out. The FLUGSCHULE BASEL workshop mechanics and the Avionitec avionics specialists explained that they had not disassembled this device when carrying out the avionics installation work.

2.2.1.3 Observations of HB-PNP diode device

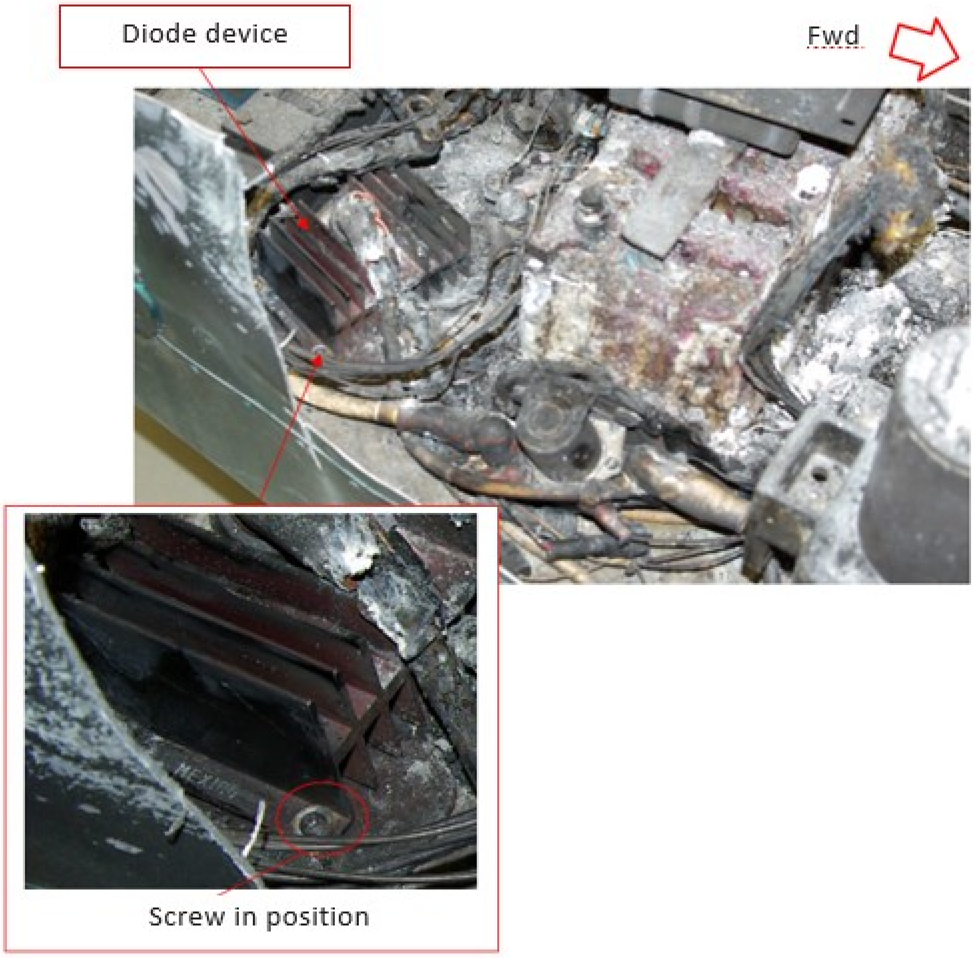


Figure 9: diode device in HB-PNP (source: BEA)

The diode device showed the following damage:

- The ABS cover was destroyed. Only the flanges of this cover were still partially present with their attaching screws in position and tightened. The melting point of the material composing the cover is 349°C.
- One of the four corners of the metal cooler was very damaged (thermal effect which had caused the aluminium alloy of which it is made to melt). The associated attaching screw and insulating washer were no longer present. The three other attaching screws and insulating washers in the three other attachment corners were in position (see Figure 10) and showed little damage. The melting point of aluminium is 660°C.
- The cooler also had a brown/purple discolouration. Initially, this cooler was black. This discolouration indicates that the cooler was exposed to a very high temperature.

Figure 10: metal cooler of diode device after disassembly (source: BEA)

- The phenolic shield was in position under the metal cooler. It had a blackened appearance around the attaching point where the corner of the metal cooler had melted. It was also partially burnt in line with the front left corner situated the closest to the positive terminal of the battery (see Figure 11).

Figure 11: phenolic shield on aeroplane floor (source: BEA)

- The aluminium alloy plate making up the aeroplane floor had a blackened appearance around the attaching point where the cooler had melted. The anchor nut holding the attaching screw also had a dark appearance. This dark appearance was not observed around the three other attaching points (see Figure 12).

Figure 12: floor on which the cooler was fixed (source: BEA)

- The diode device had separated from the metal cooler after the area of the brazed assembly had melted.
- The conductor coming from the alternator was correctly connected to the diode device. However, the core of the conductor was oxidised and showed "swelling" level with the lug fixed to the cooler.
- The 5A fuse, connected to the diode device, was in position and whole. The associated fuse holder was intact and undamaged.

These observations on the diode device indicate that the latter had been subject to a very high temperature in line with one of the four cooler attaching points that was sufficient to melt the aluminium alloy of the cooler. The distribution of this very localised damage does not seem to be the consequence of an external fire.

2.2.1.4 Detailed examination of metal cooler

The corner of the cooler with thermal-effect damage was examined by the BEA laboratory. Sliced samples of the damaged area (see Figure 13) were taken, coated and then polished in order to carry out analyses of the chemical composition in the melted area using Energy Dispersive Spectrometry (EDS).

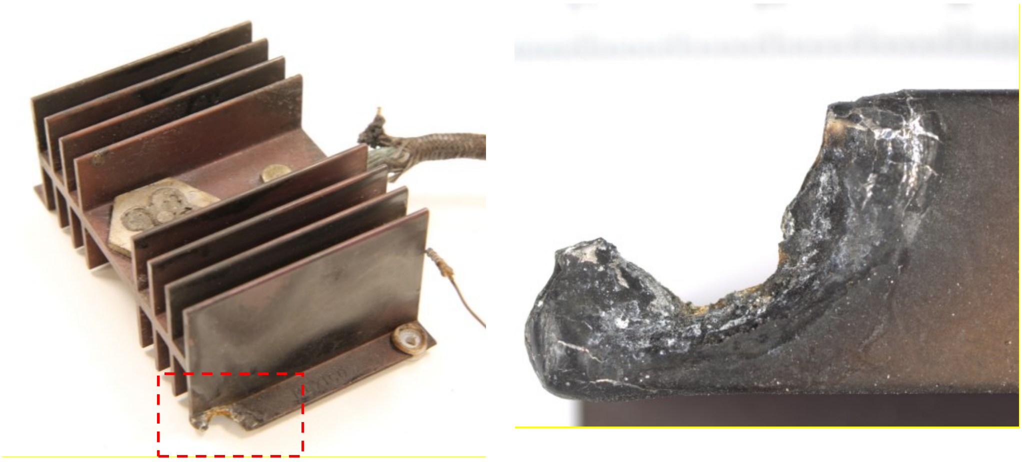


Figure 13: metal cooler of HB-PNP and detail view of damaged area (source: BEA)

Beforehand, an EDS analysis was carried out on a similar screw and washer, normally in place on the fixing lug of the metal cooler. The screw was found to be made of galvanised unalloyed steel (Fe in the core and Zn on the surface). The washer showed a fluorine (F) peak.

The EDS analysis of the successive sections found the presence of iron (Fe) and fluorine (F) in significant quantities in the melted area of the cooler of HB-PNP. The aluminium (Al) is the material making up the metal cooler.

These EDS analyses of the melted area of the cooler show that the steel screw and fluorine washer were present when the overheating occurred and led to them melting.

2.2.1.5 Observation of insulating washers of a diode device installed on an identical aeroplane

The Piper PA-28RT-201T registered HB-PPB is maintained by the same workshop as HB-PNP. Its electrical system is similar. The diode device of this aeroplane was removed and the four insulating washers examined. The upper flange of two of the four washers was cracked (see Figure 14).

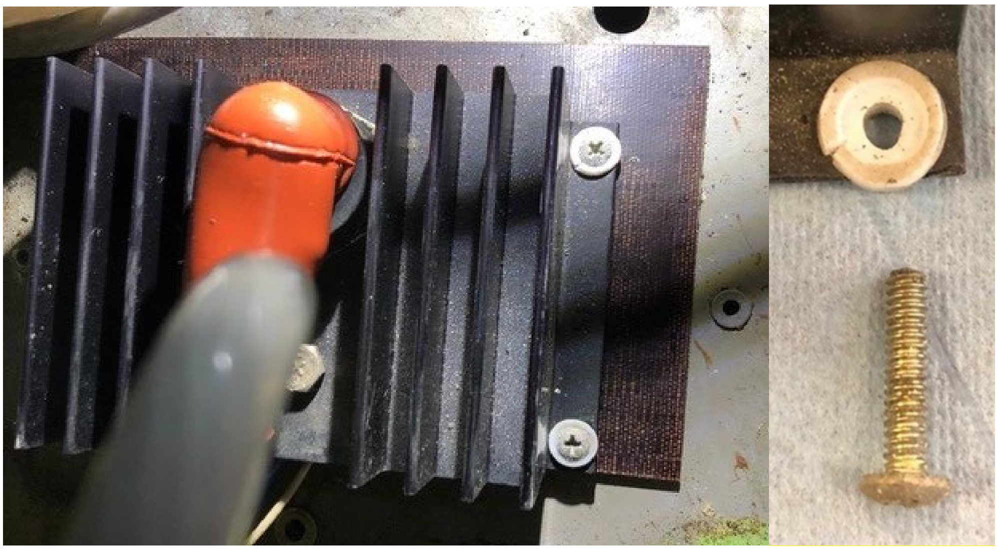


Figure 14: diode device installed on floor of HB-PPB and cracked upper flange of one of the insulating washers (source: BEA)

A detailed visual and tomographic examination of these cracked washers found the presence of permanent deformations.

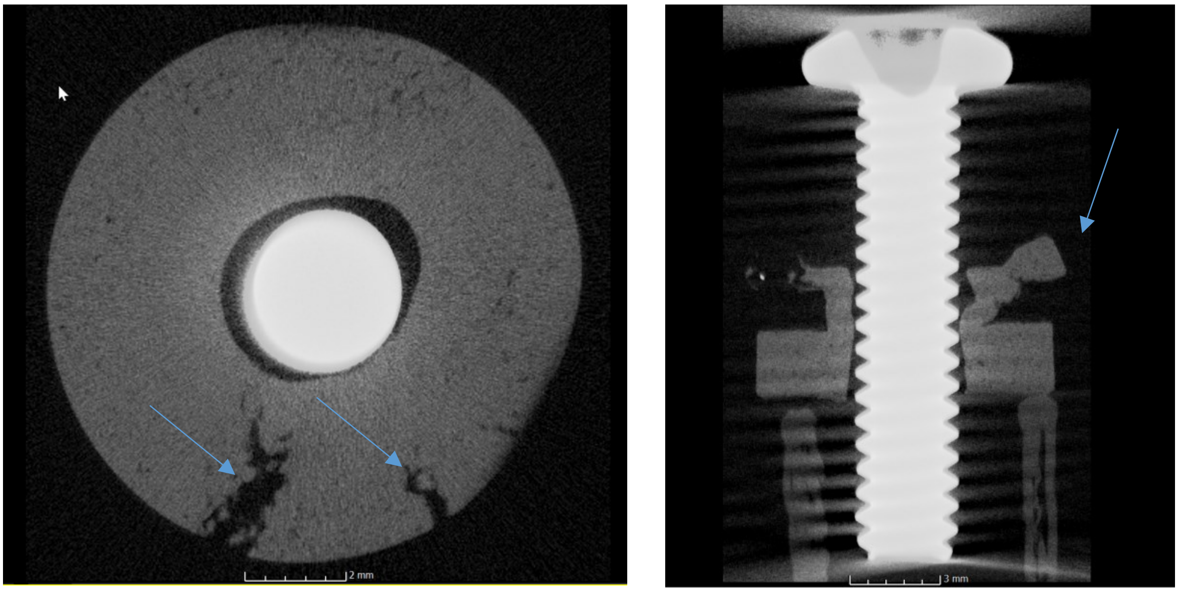


Figure 15: example of screw and washer observed – the washer shows cracks (LH side) and plastic deformations (RH side) (source: BEA)

2.2.1.6 Examinations carried out on similar diode device to that equipping accident aeroplane

In coordination with the BEA, CONCORDE BATTERY CORPORATION, the battery manufacturer, carried out tests on a similar diode device to that equipping HB-PNP.

- **Test series No. 1:**

These tests consisted of checking that the diode device was capable of bearing the maximum alternator power for several tens of minutes (thirty minutes which corresponds to the approximate time of the accident flight and then sixty minutes). After these tests, the diode device was still functional.

- **Test series No. 2:**

These tests consisted of simulating a short-circuit between the metal cooler and the structure of the aeroplane. These tests were prompted by the existence of the Piper service bulletin informing of the possibility of a short-circuit occurring on this equipment and the damage observed at one of the attaching points of the cooler on HB-PNP.

The insulating washer between the metal cooler and an attaching screw were removed and the washer was replaced by a slightly bent metal washer with the idea that it would penetrate the oxide coating which protects the outer surface of the metal cooler (see Figure 16). The test was repeated three times.

For the duration of two tests, the current was 77 A (nominal value of alternator with an overcurrent of 10%). For the duration of the last test, the current was 70 A.

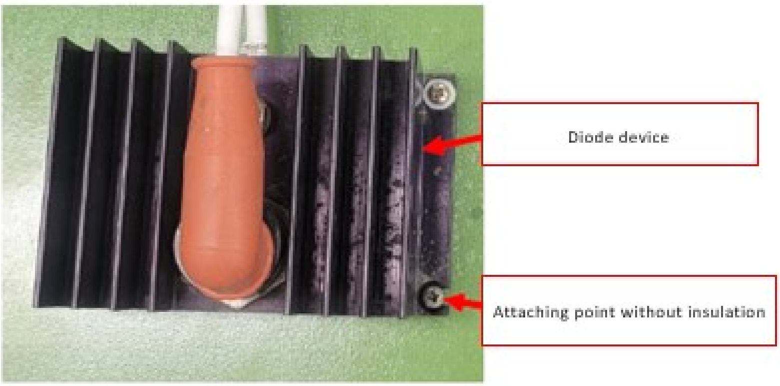


Figure 16: installation for tests (source: CONCORDE BATTERY CORPORATION)

It was observed that the cooler attaching point without the insulating washer melted during the three tests. This melting occurred after different time periods of between 9 and 35 min. The results of these three tests show cooler damage similar to the damage observed on the HB-PNP cooler (see Figure 17)

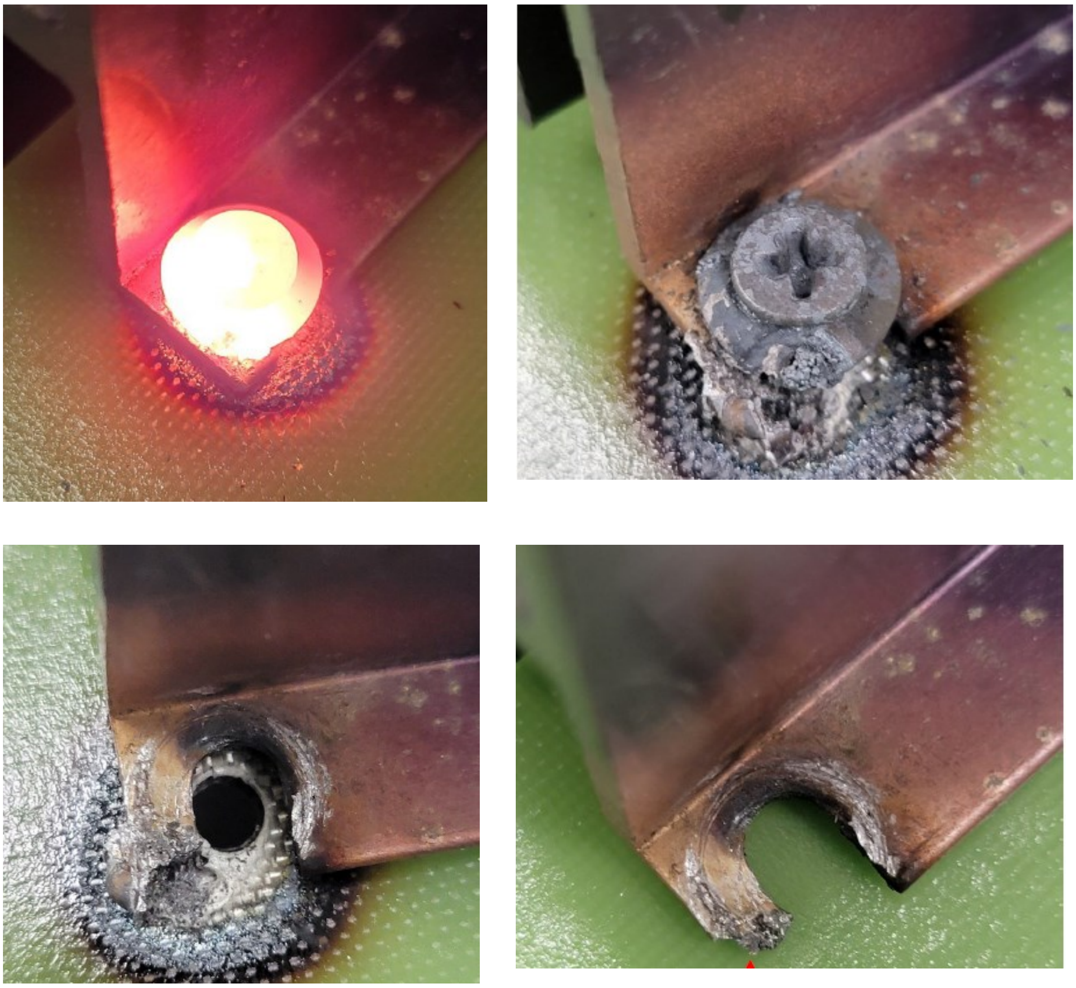


Figure 17: short-circuit test at one of the diode device attaching points
(Source: CONCORDE BATTERY CORPORATION)

- **Test No. 3**

This test consisted of reproducing one of the previous tests with the ABS cover in position. The cover was positioned when the colour of the attaching point indicated intense heat. The ABS cover burst into flames around 20 s after it had been put in position. The cover completely burnt in around 13 min.

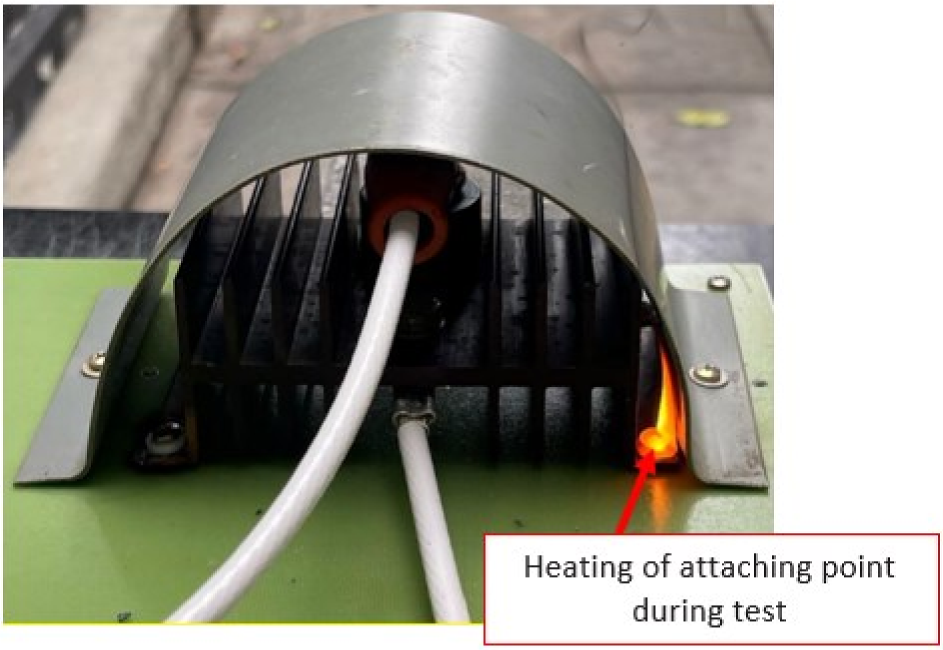


Figure 18: ABS cover in position with attaching point subject to intense heat (source: CONCORDE BATTERY CORPORATION)

Figure 19: burning ABS cover (source: CONCORDE BATTERY CORPORATION)

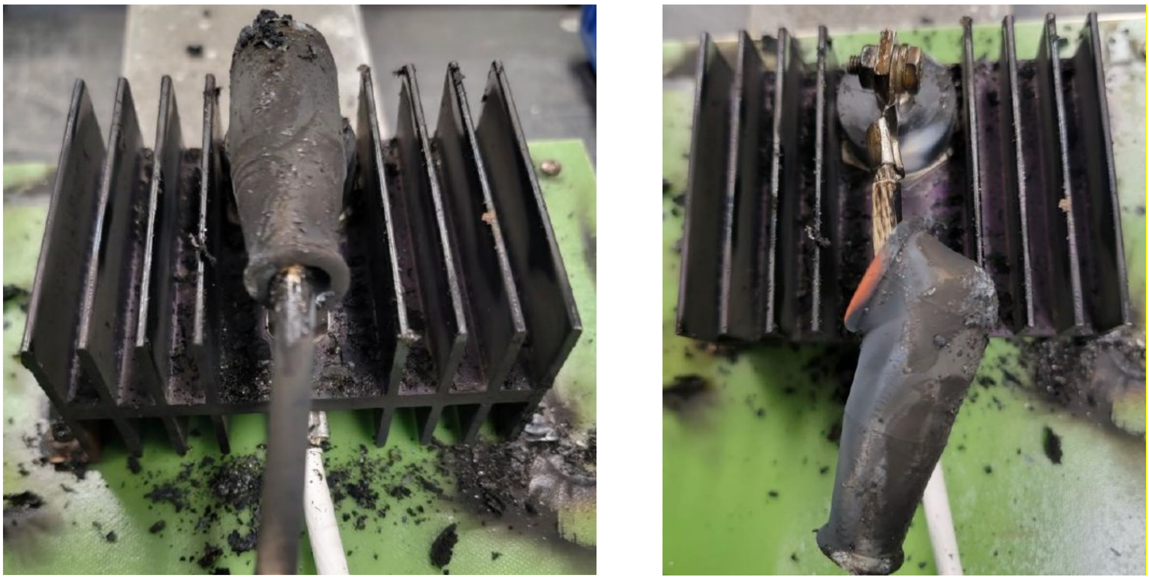


Figure 20: condition of diode device after test (source: CONCORDE BATTERY CORPORATION)

- **Test No. 4**

This test consisted of exposing the diode device to a hydrogen/oxygen flame. The diode device separated from the metal cooler after around 8 min of exposure to the flame. This separation was identical to that observed on HB-PNP. After this separation, the diodes were in a short-circuit as was the case on HB-PNP.

Figure 21: separation of diode bridge from metal cooler
(Source: CONCORDE BATTERY CORPORATION)

2.2.1.7 Incorrect insulation of diode device

The examination of washers from another diode device equipping another PA28 found that the latter can be damaged and allow the screw head to come into direct contact with the cooler or lead to a reduction in the distance between these two components and the appearance of electric arcs.

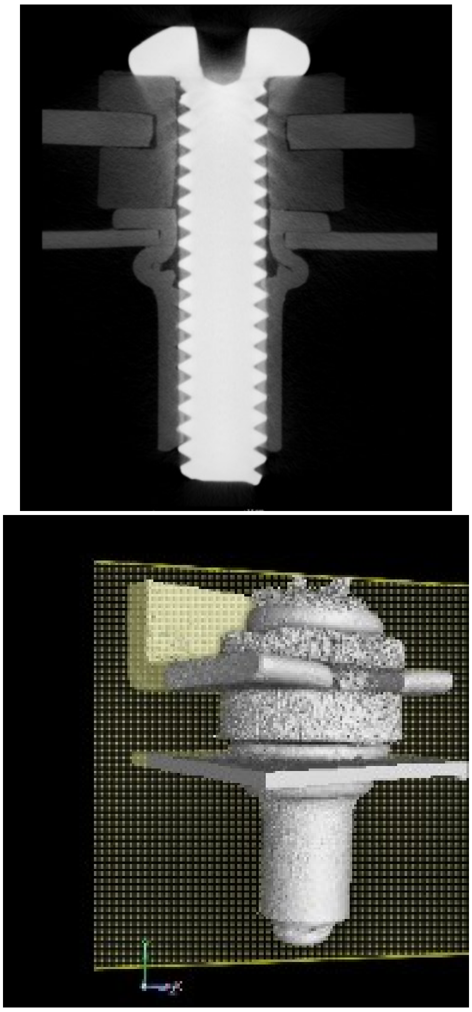


Figure 22: tomographic view of assembly with an insulating washer in good condition (source: BEA)

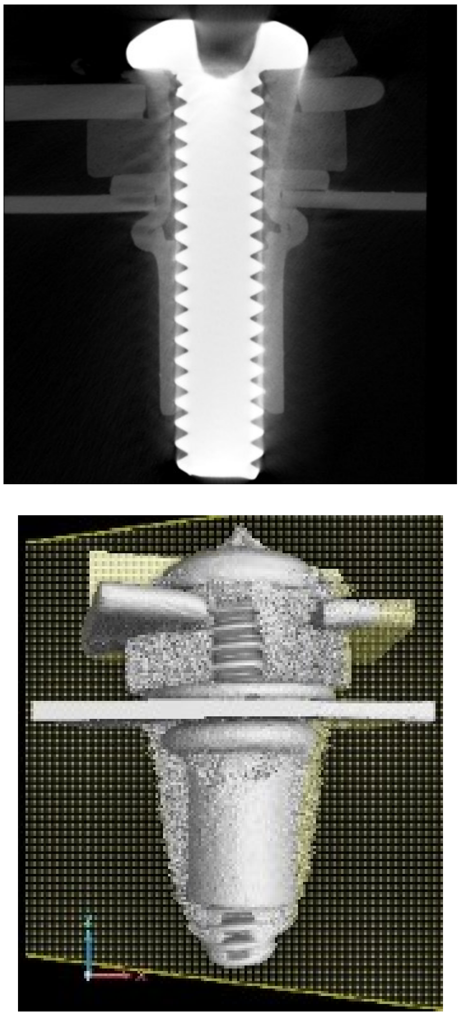


Figure 23: tomographic view of an assembly with one of the washers cracked equipping an identical aeroplane (source: BEA)

For the above assemblies, the distance between the lower face of the screw head and the cooler was of around 1.5 mm when a washer in good condition was used and of around 0.5 mm when a partially cracked washer was used.

2.3 Flight manual emergency procedures

2.3.1 Emergency procedure in event of electrical overload

The flight manual defines an electrical overload as an ammeter indication of 20 A more than the normal electrical load.

The procedure presented below, requires the pilot to leave the Master ALT switch in the ON position and to set the Master BAT switch to OFF. This first step in the procedure tests whether the current overload from the alternator is the result of a fault in the system powered by the battery. If the pilot does not observe a reduction in the electrical load, he must then set the Master ALT switch to OFF and decide on the position of the Master BAT switch according to the situation.

The pilot must then land as soon as possible and anticipate a complete electrical failure.

ELECTRICAL OVERLOAD (alternator over 20 amps above known electrical load)

ALT switch .... ON
BAT switch .... OFF

If alternator loads are reduced
Electrical load .... reduce to minimum

Land as soon as practical.

NOTE

Due to increased system voltage and radio frequency noise, operation with ALT switch ON and BAT switch OFF should be made only when required by an electrical system failure.

REPORT: VB-940 ISSUED: NOVEMBER 30, 1978
3-6 REVISED: JUNE 30, 1981

PIPER AIRCRAFT CORPORATION SECTION 3
PA-28RT-201T, TURBO ARROW IV EMERGENCY PROCEDURES

If alternator loads are not reduced
ALT switch .... OFF
BAT switch .... as required

Land as soon as possible. Anticipate complete electrical failure.

NOTE

If the battery is depleted, the landing gear must be lowered using the emergency extension procedure. The gear position lights will be inoperative.

Figure 24: emergency procedure in event of electrical overload (source: Piper Aircraft)

2.3.2 Emergency procedure in event of in-flight electrical fire

The procedure steps include setting the Master Switch to OFF. The Master Switch corresponds to the two switches Master ALT and Master BAT.

SECTION 3 PIPER AIRCRAFT CORPORATION
EMERGENCY PROCEDURES PA-28RT-201T, TURBO ARROW IV

FIRE IN FLIGHT

Source of fire....................check

Electrical fire (smoke in cabin):
Master switch .... OFF
Vents .... open
Cabin heat .... OFF
Land as soon as practicable.

Engine fire:
Fuel selector .... OFF
Throttle .... CLOSED
Mixture .... idle cut-off
Auxiliary fuel pump ....check OFF
Heater and defroster .... OFF
Proceed with power off landing procedure.

Figure 25: excerpt from "Fire in flight" emergency procedure (source: Piper Aircraft)

2.4 Pilot information

The 36-year-old pilot held:

- an ATPL(A) and an Airbus A320 type rating;
- a PPL(A) with aeroplane flight instructor (FI(A)), single-engine piston (SEP) and multi-engine piston (MEP) ratings.

He had logged on the day of the accident, approximately 4,500 flight hours, including around 100 hours on type. He had flown around 140 hours in the previous 3 months.

Pilot's statement

The pilot explained that he started up the aeroplane at 15:08 after several unsuccessful attempts to start the engine. He indicated that they were not worried by this as the plane had not flown for several weeks. He specified that he had not been aware that the battery had been recharged the day before.

The pilot reported that halfway between waypoint ALTIK and the start of the final for runway 15, he observed that the ammeter indicated a charge of around 70 A whereas the normal value is between 20 and 30 A. He cut off the alternator (Master ALT) and observed that the ammeter then indicated zero. On switching the alternator back on, the ammeter again indicated a value of around 70 A and this indication stayed constant. The pilot then questioned the passengers to find out if they had an explanation for this increase in charge. They deduced that the battery might have been discharged due to the attempted start-ups and the fact that the aeroplane had been on the ground for several weeks.

The pilot continued the approach to runway 15 to 3,000 ft and then flew a missed approach by changing the heading and climbing back up to 5,500 ft. He specified that all the equipment items were operating nominally. The purpose of this manoeuvre was to carry out an ILS approach on runway 33.

While climbing to 5,500 ft, the pilot indicated that he smelt an "electrical" smell, confirmed by the two passengers. The pilot thought it could be an incipient fire and decided to carry out an emergency landing. He reduced the engine speed to idle and started a high speed descent. He specified that he set the Master ALT and the Master BAT switches to OFF. He added that the smoke started to spread into the cabin from the rear. During the descent, the pilot handed the controls to the owner in order to carry out the radio failure procedure[8]. He tried to contact the controllers with his mobile phone, but the Bluetooth connection between the phone and his headset took too much time. He then took back the controls. He indicated that the flames started to enter the cabin when they were on the axis of runway 08, on a long left-hand base leg for runway 33. On final for runway 33, he fully extended the flaps and asked the owner to open the door and stand by to evacuate. The pilot landed at a high speed of around 90 kt and started to brake as soon as the wheels touched down. At around 30 or 40 kt, they evacuated the aeroplane which continued to run over several hundred metres before coming to a stop in the grass.

The pilot indicated that he did not think to use the fire extinguisher nor to ask the passenger in the front right seat to use it. He could not remember where the fire extinguisher was installed. Its possible use had not been discussed before the flight.

The pilot specified that the owner had probably asked him to carry out this flight because he was an instructor in FLUGSCHULE BASEL school and knew the PA-28 well. He had already carried out a check flight on a PA-28 modified with the same STC. He had also been a flight test engineer at Pilatus before becoming an airline transport pilot.

He had drawn up this check flight programme based on that carried out for the previously modified PA-28. This programme included various procedures to test the new automated systems which had been installed. He specified that he chose a day where the weather conditions were such that all of the flight could be carried out in VMC. He had also coordinated with the air traffic control services in order to be able to carry out approaches on the reciprocal QFU (in particular the RNP procedure for runway 15) to enable him to check the correct operation of all of the aeroplane's systems. Lastly, he specified that he had carried out a risk analysis concerning a fault on the autopilot.

2.5 Passenger and owner of aeroplane information

The 65-year-old passenger and owner held a commercial pilot licence (CPL(A)) and a single engine piston (SEP) rating.

He had purchased HB-PNP in August 2007. On the day of the accident, he had logged approximately 350 flight hours on HB-PNP. In 2020, the pilot carried out four flights on HB-PNP in January, February, March and June, for a total flight time of less than five hours.

[8] With the Master Switch set to OFF, the aeroplane's electrical equipment items which include the radio were no longer powered.

3 CONCLUSIONS

The conclusions are solely based on the information which came to the knowledge of the BEA during the investigation.

Scenario

At the end of the work to install a new GARMIN avionics suite and an autopilot, the ground tests took place normally. The GARMIN STC did not require a check flight; the Approval for Return to Service (ARS) was signed by a technician from the maintenance workshop.

The owner of the aeroplane wanted to check that the newly installed systems were operating correctly and to familiarize himself with their use. He therefore asked an instructor pilot who was acquainted with the avionics suite installed, to carry out a first flight with him. They were accompanied by an electronics technician who had taken part in the work.

During the flight, the ammeter's abnormally high indication of around 70 A (corresponding to the maximum mark of the ammeter) and more than 30 A higher than the normal values was not interpreted by the pilot and passengers as a sign of an electrical failure (overload). They thought that it was the consequence of the battery charging, believing that the latter was partially discharged.

The electrical overload procedure was therefore not considered and the flight was continued. The persons on board did not know that the battery had been totally recharged the day before. This lack of information may have contributed to their erroneous interpretation of the electrical overload situation indicated by the ammeter.

All of the damage observed and the information collected during the various examinations and tests indicate that incorrect insulation at the attaching point of the diode device cooler very probably resulted in an electrical continuity between this cooler and the aeroplane floor. As a result of this short-circuit, the aeroplane's alternator delivered its maximum power, explaining the excessive current observed by the pilot and his passengers during the event.

This excessive current very probably led to intense overheating of the diode device in the area of the short-circuit followed by the ignition of the ABS plastic protective cover. The flames then spread inside the compartment and the luggage hold. The tests showed that the ABS cover was an aggravating factor in the spread of the fire.

As soon as the persons on board smelt the "electrical" smell, the pilot complied with the in-flight fire emergency procedure and decided to land as quickly as possible. The flames moved into the cabin a short time later. The pilot and passengers evacuated the aeroplane during the landing run carried out at a high speed. The fire extinguisher located under the front right seat was not used. It is, however, very probable that its use would not have reached the source of the fire. There is a possibility that it might have slowed down the speed at which it spread.

Based on the elements collected during the investigation, it is not possible to say at what exact point in time the diode device cover ignited. As a consequence, the investigation cannot affirm that

compliance with the overload emergency procedure after the pilot observed the ammeter indication would have prevented the fire. The latter might have started before the overload was observed around fifteen minutes after taking off.
The electrical consumption tests carried out at the end of the work and the ground tests carried out before the accident flight had proceeded without any malfunction. The latter, carried out with the GPU connected, would not have shown such a short-circuit as the alternator was not used.

The personnel who carried out the work to install the new avionics suite stated that the diode device was not disassembled nor was it checked. The review of the aeroplane's maintenance documentation indicated that no maintenance action (checks or disassembly) had been carried out on this diode device. Piper does not require any maintenance action on this equipment during the aeroplane's service life. The examinations carried out found that the four insulating washers and four screws attaching the device to the floor of the aeroplane were present when the overheating occurred. Observations on another aeroplane of the same type equipped with a similar diode device found cracks and deformations of the insulating washer.

The investigation was not able to determine the exact cause of the incorrect insulation between the diode device cooler and the aeroplane floor which led to the short-circuit. It might be explained by a combination of the following:

- wear of the insulating washers and,
- indirect consequence of the work carried out during the installation of the new avionics (device being accidentally knocked, introduction of ferrous residue during drilling operations, etc.).

Safety lessons

Preparing a flight after a maintenance operation on numerous equipment items
The flight programme planned by the pilot was complete with respect to the manoeuvres and procedures to be carried out to check the correct operation of all the new systems installed and to present them to the passenger who was the owner of the aeroplane.

The flight was undertaken with the idea that only a failure with an impact on navigation might occur. As a consequence, the planned programme did not include a part relating to actions to be performed on the occurrence of failures linked to the electrical work carried out given that this was the first flight after the maintenance operations.

It was not a regulatory requirement to carry out a post-maintenance check flight (MCF) as defined in the AIR-OPS regulations as this was not specified in the Garmin STC, and it had not been requested by the client.

After a maintenance operation involving substantial work, it may be worthwhile for the client to consider adding a check flight.

In the AIR-OPS, a MCF flight is defined as *"... a flight of an aircraft with an airworthiness certificate or with a permit to fly <u>which is carried out</u> for troubleshooting purposes or to check the functioning of one or more systems, parts or appliances after maintenance, if the functioning of the systems,* *parts or appliances cannot be established during ground checks and which is carried out in any of the following situations:*

> *(a) as required by the aircraft maintenance manual ("AMM") or any other maintenance data issued by a design approval holder being responsible for the continuing airworthiness of the aircraft;*
> *(b) after maintenance, as required by the operator or proposed by the organisation responsible for the continuing airworthiness of the aircraft;*
> *(c) as requested by the maintenance organisation for verification of a successful defect rectification;*
> *(d) to assist with fault isolation or troubleshooting."*

When the MCF are carried out in a non-commercial capacity on a non-complex aircraft, they must be carried out in compliance with Part NCO of the AIR-OPS, and in particular its subpart NCO.SPEC.MCF (see paragraph 7.11.4 of the DSAC guide regarding specialized operation - Part SPO. In particular, it is indicated for all MCF type flights, that when a maintenance check flight is intended to check the proper functioning of a system or equipment, that system or equipment shall be identified as potentially unreliable and appropriate mitigation measures (in compliance with the risk management process of the operator's management system) shall be agreed prior to the flight in order to minimise risks to flight safety.

In the case of the accident, these mitigation measures could have included the following:
- review of emergency procedures associated with an electrical failure;
- briefing on the use of the fire extinguisher;
- limiting the number of persons on board to what was strictly necessary.

There is no guarantee that the use of the on-board fire extinguisher would have extinguished the fire, but it would have possibly limited its consequences and the speed at which it spread. The pilot's statement indicated that no one on board thought to use the fire extinguisher.

4 SAFETY RECOMMENDATIONS

Note: in accordance with the provisions of Article 17.3 of Regulation 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, a safety recommendation in no case creates a presumption of fault or liability in an accident, serious incident or incident. The recipients of safety recommendations shall report to the safety investigation authority which issued them, on the measures taken or being studied for their implementation, as provided for in Article 18 of the aforementioned regulation.

Checking insulation of diode device

Incorrect insulation in line with one of the attaching points of the diode device metal cooler led to electrical continuity between this cooler and the aeroplane floor. Due to this short-circuit, the aeroplane's alternator delivered its maximum power for a continuous period, causing intense overheating and then the ignition of the ABS plastic cover. The flames then spread to the interior of the aircraft's luggage hold and airframe.

The examinations carried out found that the four insulating washers and four screws attaching the device to the floor of the aeroplane were present when the overheating occurred. The observations on another aeroplane of the same type, also equipped with a similar diode device found evidence of cracks and deformations of the insulating washer compatible with the appearance of the same phenomena as on HB-PNP. These observations seem to indicate that in-service wear of the insulating washers may contribute to the creation of an incorrect insulation. In the absence of any specific maintenance action on the diode bridge in the manufacturer's maintenance documentation, this incorrect insulation may not be detected.

Consequently, the BEA recommends that:

- ***Whereas Piper's publication of service bulletin SB No 623 in November 1978 indicates that it had come to this manufacturer's attention that there had been cases of short-circuits generated by the absence or incorrect positioning of one of the insulating washers between the diode device metal cooler and the floor of the aeroplane;***
- ***Whereas this SB was applicable to all the aeroplanes manufactured by Piper before November 1978 and equipped with this type of diode device. The Piper PA-28RT-201T manufactured from 1979 onwards was not concerned by this SB, which had not been updated since;***
- ***Whereas Piper's maintenance documentation does not require a check of the condition of the insulation between the diode device cooler and the floor of the aeroplane;***
- ***Whereas PA-28RT-201Ts were built between 1979 and 1992 and that some of these aeroplanes are therefore equipped with insulating washers that are more than 40 years old;***
- ***Whereas the examination of this device on another PA-28RT-201T found the presence of wear on these washers in the form of cracks. These cracks could lead to the cooler coming into contact with the floor, thus creating a short-circuit and potentially causing a fire by igniting the ABS cover;***

Piper implement a maintenance procedure to ensure that the diode device insulating washers on aeroplanes equipped with such a device perform their insulating role throughout their life cycle [FRAN-2024-0015].

Piper assess the need to replace the ABS cover with another system made of a material that limits the risk of a fire spreading [FRAN-2024-0016].

EASA, in coordination with the FAA, ensure that the risk of fire following a short-circuit at the diode device attaching points is controlled by aircraft manufacturers using a diode device similar to that on HB-PNP [FRAN-2024-0017].

The BEA investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liabilities.