

REAR DOOR SEPARATED DURING FLIGHT

The aim in the Netherlands is to reduce the risk of accidents and incidents as much as possible. If accidents or near-accidents nevertheless occur, a thorough investigation into the causes of the problem, irrespective of who is to blame for it, may help to prevent similar problems from occurring in the future. It is important to ensure that the investigation is carried out independently from the parties involved. This is why the Dutch Safety Board itself selects the issues it wishes to investigate, mindful of citizens' position of dependence with respect to public authorities and businesses. In some cases, the Dutch Safety Board is required by law to conduct an investigation.

GENERAL INFORMATION

Identification number:	2011051
Classification:	Incident
Date, time ¹ of occurrence:	29 June 2011, 15.43 hours
Location of occurrence:	North-east of the village Biddinghuizen
Aircraft registration:	PH-TIN
Aircraft model:	Diamond DA 40 D
Type of aircraft:	Single engine piston
Type of flight:	Private
Phase of operation:	En route
Damage to aircraft:	Door hinge brackets broken and rear door separated
Cockpit crew:	One
Number of passengers:	None
Injuries:	None
Other damage:	None
Lighting conditions:	Daylight

SUMMARY

During the flight the rear passenger door separated from the aircraft and passed over the aircraft tail section. The pilot returned to the airfield of departure and made a safe landing. There was no damage to the aircraft. Only the door hinges brackets were broken. The separated door was found later.

¹ All times in this report are local unless otherwise specified.

FACTUAL INFORMATION

1 History of the flight

The pilot intended to make a local flight from Lelystad Airport with PH-TIN, a Diamond DA 40 D. He stated that he performed the pre-flight exterior check of the aircraft in accordance with the pre-flight exterior checklist items. This checklist includes among others the item 'Left fuselage, rear door'. The pilot stated he verified the rear door was closed and locked. In the cockpit he performed the 'check before engine start' checklist, which includes the item 'Rear door ... CLOSED and LATCHED'. After the checks were completed he started the engine and taxied towards the holding point of runway 23. The pilot was the sole occupant. At this point he performed the 'before take-off check' checklist items, which includes again the item 'Rear door ... CLOSED and LATCHED', and subsequently lined up on runway 23 for take-off. The aircraft took off at 15.30 hours. At 200 feet the pilot executed the after take-off checklist items, left the circuit and continued the climb to 1000 feet. He set course in the direction of the city Harderwijk. During flight the radio onboard PH-TIN was tuned to the frequency of Lelystad Radio.

After thirteen minutes, when the aircraft was flying at 1000 feet with a speed of approximately 120 knots and a power setting of 80%, the pilot observed a 'door open' alert on the primary flight display. The pilot stated that he looked over his left shoulder and saw the door handle slowly moving out of the closed position. He noticed that the safety latch was closed (see figure 1). Within seconds the rear door separated from the aircraft and passed over the aircraft tail section. The position of the aircraft at this time was north-east of the village Biddinghuizen. The pilot reduced the speed of the aircraft to approximately 100 knots and contacted Lelystad Radio to report the occurrence. He also stated he was returning immediately to the airfield. The pilot was not able to hear the response from Lelystad Radio properly due to the wind noise. He returned to Lelystad Airport and performed a normal circuit and landed on runway 23. Thereafter the pilot taxied back to the hangar where he switched off the engine.



Figure 1: safety latch and door handle on the inside of the rear door

During the thirteen minutes flight after take-off until the door separated, the pilot did not observe any unusual vibration or noise. The pilot used an aviation headset with active noise reduction.

After the incident a search operation was performed on the ground and by air to find the door. However, it was not found. On 27 August, approximately two months after the incident had occurred, the door was found in a field north-east of the village Biddinghuizen. There was no

damage to properties on the ground. The door was picked up by the police and was obtained by the Dutch Safety Board; see figure 3.

As more similar incidents had occurred before, it was decided in consultation with the Austrian Aircraft Accident Investigation Branch, on behalf of the state of design and manufacture of the aircraft, to send the door to their office for examination. After this had been completed, the door was sent back to the Dutch Safety Board who returned it to the owner of the aircraft.



Figure 2: rear door missing after flight (source: W.L. Nijdam)



Figure 3: separated rear door

2 Damage to aircraft

The rear hinge bracket was broken from the door. A part of the bracket was still attached to the hinge pin in the fuselage; see figure 5. The forward hinge bracket was torn. The emergency door pin was still in place; see figure 4.

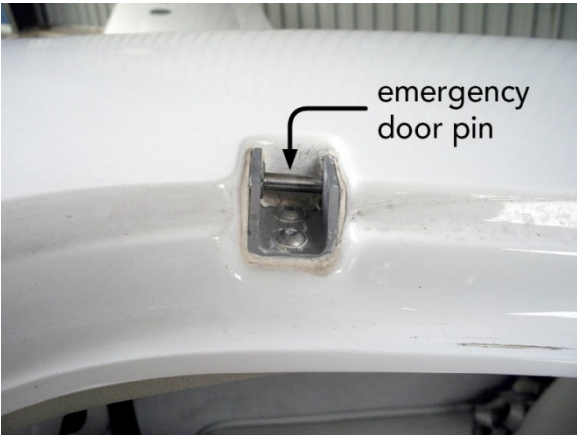


Figure 4: emergency door pin and missing forward hinge bracket (source: Wings over Holland)

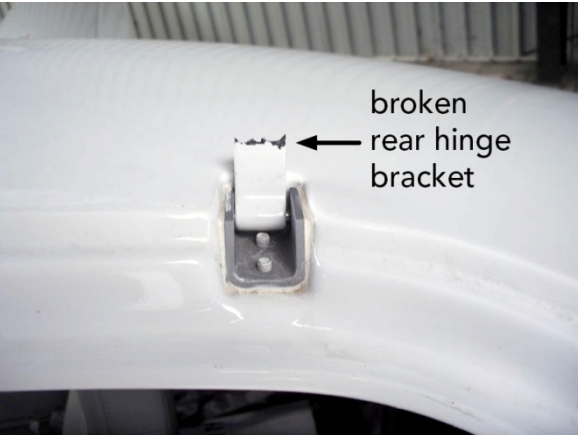


Figure 5: broken rear hinge bracket (source: Wings over Holland)

3 Personnel information

The pilot was a 55-year-old man who possessed a Private Pilot Licence (PPL(A)) and was qualified to operate the flight. His licence contained a valid single-engine piston and a valid multi-engine piston rating. The pilot held a valid medical certificate, class II.

Number of hours total	190 hours pilot in command 82 hours dual
Number of hours on DA 40 D	92

Table 1: flying experience pilot

4 Aircraft information

The Diamond DA 40 D Diamond Star is a four seat low wing single engine piston light aircraft constructed from composite materials. The aircraft has a front canopy for access in the cockpit and a rear door for the passengers on the left-hand side.

PH-TIN is powered by a Thielert TAE 125-02-99 (Centurion 2.0) diesel engine of 135 hp. It has a constant speed propeller and a full authority digital engine control unit. The first flight of the DA 40 D was made on 28 November 2002. PH-TIN is equipped with Garmin G1000 all-glass avionics.

PH-TIN had a valid certificate of registration and airworthiness. The aircraft, built in 2006, had flown a total of 404.8 hours. The aircraft serial number is D4.205.

Rear door

The rear door is a carbon-fibre-reinforced plastic molding with inner and outer frames. The door has an acrylic glass window. A flexible filler seals the small gap between the edge of the window and the frame.

Two hinge brackets attach the door to the top of the fuselage; see figure 6. The hinge brackets are bolted to the door frame. In an emergency the forward hinge bracket can be released by pulling the emergency door pin (see figure 4) forward by means of a lever in the cabin. With this bracket released, the passenger door can be forced open from the top. In the normal position the emergency door pin is placed in a blind hole in the fuselage on the rear side of the forward door hinge bracket.



Figure 6: rear door

The Airplane Flight Manual² states that the rear door is closed by pulling down on the frame and locking it with the handle. A gas pressure damper prevents the door from dropping; in strong winds the assembly must be held. The rear door is protected against unintentional opening by a safety latch. The safety latch must be lifted before the handle can be operated from inside the passenger compartment; see figure 1. To operate the handle from the outside a button on top of the handle (see figure 7) must be pushed to release the inner safety latch. The door mechanism is locked by an over centre device.

The door handle operates two locking pins (see figure 8). The locking pins are at the bottom forward and rear corners of the door. If the door is closed and locked the pins should be in the forward and aft guide plates in the aircraft fuselage (see figures 11 and 12). If the door handle is pulled outward, the rear locking pin will be pulled forward and the front locking pin will be pulled aft. The aft movement of the front locking pin operates a micro switch for a 'door open' alert message on the primary flight display.

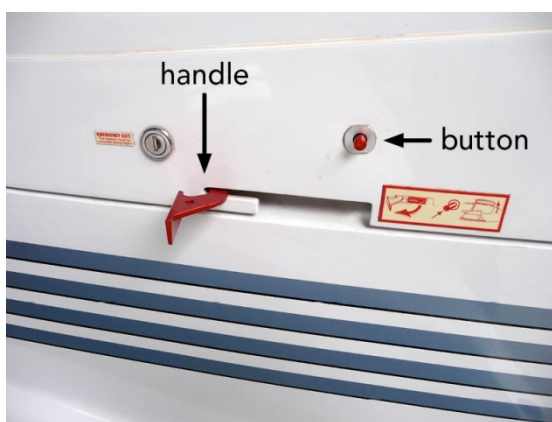


Figure 7: outside of rear door



Figure 8: one of the two locking pins

5 Meteorological information

At the time of the occurrence visual meteorological conditions prevailed. Visibility was more than 10 kilometres and there was no precipitation. According to a weather report of the Royal Netherlands Meteorological Institute the wind came from a northwest direction and the wind speed was 20 knots at an altitude of 1000 feet. There was no turbulence.

6 Additional information

On 14 July 2010 Diamond Aircraft Industries issued Mandatory Service Bulletin 40-067, D4-074 and F4-021. The aircraft affected were DA 40, DA 40 D and DA 40 F.³ The subject was the check of the emergency exit lever. During maintenance action on some aircraft it was found that the emergency exit lever was sitting so tight that smooth operation of the door release was not guaranteed. In order to ensure an instant and smooth door release on every aircraft possibly affected, a check of the emergency release and corrective actions if required, are prescribed for these aircraft.

² DA 40 D AFM, Doc. # 6.01.05-E, Revision 5, 01-Jun-2008, Page 7-15.

³ Among others serial numbers D4.001 through D4.417.

On 10 November 2010 the European Aviation Safety Agency (EASA) issued Airworthiness Directive 2010-0235⁴ mandating accomplishment with Diamond Aircraft Industries Mandatory Service Bulletin MSB 40-070, MSB D4-079 or MSB F4-024 which prescribe the identification of the part number of the passenger door retaining bracket (see figure 9) and if necessary its replacement. As reason for Airworthiness Directive 2010-0235 is given that since 2004, more than 30 reports have been received of in-flight losses of a rear passenger door on Diamond aircraft, the majority of which were DA 40. In addition, at least 18 doors have been replaced due to damage found on the hinge brackets.

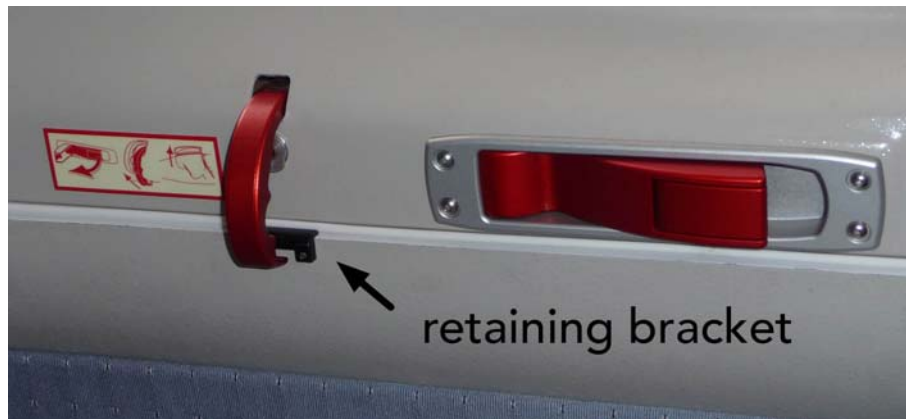


Figure 9: retaining bracket

The Airworthiness Directive states that Diamond Aircraft Industries performed analyses and structural tests to determine the root cause of the door opening in flight. The conclusions were that:

- The primary locking mechanism provided adequate strength to react to the loads in flight.
- The root cause was the crew not properly securing the rear passenger door by the main locking mechanism, prior to flight.
- Damage to the hinge brackets has been caused primarily by external loads (wind gust conditions) while the aeroplane was parked.

Furthermore the Airworthiness Directives states that all DA 40 and DA 42⁵ aircraft have a system installed that provides a warning if the rear door is not fully closed. In addition they have a safety latch (with retaining bracket). The initial intended design function of this safety latch was to hold the rear passenger door in the "near closed" position while on the ground, protecting the door from wind gusts. However, the original retaining bracket might not hold the door in this "near closed" position while in flight.

On 17 January 2011 Mandatory Service Bulletin 40-070/1, D4-079/1 and F4-024/1 was issued by Diamond Aircraft Industries.⁶ The airplanes affected were DA 40, DA 40 D and DA 40 F.⁷ The subject was the replacement of the passenger door retaining bracket. An improved retaining

⁴ Applicability: DA 40, DA 40 D and DA 40 F aeroplanes, all serial numbers, and DA 42, DA 42 M, DA 42 NG and DA 42 M-NG aeroplanes, all serial numbers.

⁵ The Diamond DA 42 Twin Star is a four seat, twin engine, propeller-driven airplane.

⁶ Supersedes MSB 40-070, MSB D4-079 and MSB F4-024/1 which prescribe the identification of the part number of the passenger door retaining bracket and if necessary its replacement.

⁷ Among others serial numbers D4.001 through D4.249.

bracket (see figure 10) for the door safety latch had been designed to, together with an amended emergency procedure, prevent opening and separation of the door during flight with an unlatched door. The Service Bulletin describes the retrofit installation of the retaining bracket on aircraft already in operation.



Figure 10: improved rear door retaining bracket of PH-TIN
(source: W.L. Nijdam)

INVESTIGATION AND ANALYSIS

On 1 July 2011 the Dutch Safety Board notified the Aircraft Accident Investigation Branch in Austria about the incident as the state of design and manufacture of the aircraft.

According to the company who performed maintenance on the aircraft and the owner of the aircraft, PH-TIN had not encountered problems with the rear door before. AD 2010-0235 had been complied with for PH-TIN on 20 May 2011. An improved retaining bracket was installed on PH-TIN; see figure 10.

Although, according AD 2010-0235, more than 30 reports have been received of in-flight losses of a rear passenger door on Diamond aeroplanes, the Austrian Aircraft Accident Investigation Branch stated that the door of PH-TIN was the first door they received and examined. According to Diamond Aircraft Industries GmbH the root cause of in-flight losses of a rear passenger door was the crew not properly securing the rear passenger door by the main locking mechanism, prior to the flight.

The separated passenger door was investigated by the aircraft manufacturer Diamond Aircraft Industries GmbH in the presence of an investigator of the Austrian Aircraft Accident Investigation Branch. The corresponding investigation report of Diamond Aircraft Industries GmbH was received by the Dutch Safety Board. It concluded that no evidence was found to support a malfunction of any component of the passenger door.

Besides, the following inspections and tests were accomplished together by the Austrian Aircraft Accident Investigation Branch, the national authority Austro Control GmbH and the aircraft manufacturer Diamond Aircraft Industries GmbH:

- Detailed visual inspection of the rear passenger door.
- Microscope analyses/inspections of the forward door hinge bracket.

- *High speed taxi tests with an identical constructed DA 40 with the emergency lever pin removed, to simulate a damaged forward hinge, and the passenger door handle locked. The goal was to evaluate the possibility of the handle to unlatch uncommanded. The result was that no uncommanded unlatching occurred because of a 'soft' forward hinge.*
- *Tests with the emergency pin not in its fully engaged position and the door unlocked and held by the safety latch. Strong sideward and up/down hand power was applied. For additional information, see appendix A.*

The manufacturer stated that they did not carry out high speed taxi test with the emergency lever pin removed and the passenger door handle opened and the door held by the safety latch only, because regular maintenance prescribes the inspection of the passenger door and its locking mechanism during every scheduled 100 flight hours maintenance inspection. For additional information, see appendix A.

The Dutch Safety Board did not receive a report of these inspections, but was informed about the findings via e-mail by the Austrian Aircraft Accident Investigation Branch.

It was concluded that:

- *The rear door was not closed and secured properly during flight.*
- *The forward door hinge bracket showed damage marks which were caused by an excessive free play of the component itself.*
- *The emergency lever was not in its designated (stowed/closed) position. The emergency pin was out of the rear blind hole. This did not significantly contribute to the free play of the forward hinge. It might have contributed to damage of the hinge, but this is covered by the airplane maintenance manual procedure which prescribes the inspection of the passenger door and its locking mechanism during every scheduled 100 flight hours maintenance inspection.*
- *It is not known if the forward door hinge bracket was broken or damaged before the said flight. However, a movement mark of the emergency pin on the forward door hinge bracket was visible and indicates that the door was moving in this area for a longer period of time.*
- *The excessive free play on the forward door hinge bracket combined with an unlatched door could move the door up at the top front position. This was causing a de-activation of the safety latch and the door separated from the aircraft.*

Among others the following finding was made:

The basic idea of AD 2010-0235R1 was to ensure that the passenger door is held by the safety latch, in case that the passenger door is not closed and locked. The intention of the manufacturer was to offer additional safety, also during flight. However, this will not work if the door is not closed or locked and if the forward door hinge bracket is damaged and/or has an excessive free play. The door can move up at the top forward side and can de-activate the safety latch and the door will separate from the aircraft.

Check flights

Diamond Aircraft Industries has conducted flights with the passenger door handle opened (undamaged forward hinge) to check the safety latch function as part of a compliance demonstration of the revised emergency procedure and retrofit latch. The corresponding reports have been reviewed by EASA and were communicated to the Federal Aviation Administration prior they issued the Airworthiness Directive 2010-0235. The door showed a tendency to open slightly but was always successfully restrained by the safety latch.

Emergency lever

Although the emergency lever of the rear door is secured by a locking wire, it may be possible that the emergency pin moves out of the blind hole as the whole panel, where the lever is secured, is moveable because of a seal. Under several circumstances, it is possible that the emergency door lever is not fully in the closed (latched) position and causes free play and/or damage to the door hinge bracket. Due to the manufacturing process, a tolerance from aircraft to aircraft is given for the length of the emergency pin. Even if the emergency door lever is visually (inside cabin, looking up on the panel) in the closed/stowed position on the ceiling panel, it may happen that the pin is not fully inside the hole. Also the Aircraft Maintenance Manual does not include any inspections of the correct position of the emergency lever. It describes only the visual inspection of the door hinge brackets.

Maintenance company

The aircraft maintenance mechanic who had performed maintenance on PH-TIN stated that the emergency pin had not moved out of the rear blind hole. He had checked the emergency exit lever in accordance with Mandatory Service Bulletin D4-074 on 20 May 2011. This check had not shown excessive free play of the forward door hinge bracket, caused by the emergency pin.

The mechanic also mentioned that the locking wire which secures the emergency lever of the rear door was undamaged after the door had separated.

Scenario

The pilot stated that it is physically impossible to close the door when sitting in the left front seat. Therefore his practice was to close the door and latch it before boarding the aircraft. Subsequently the item 'Rear door ... CLOSED and LATCHED' was checked twice when performing checklists.

The statement of the pilot that the rear door was closed correctly prior to the flight is in contrast with the results of the examinations and tests that were carried out. The scenario that the rear door was closed properly and subsequently opened and separated could not be reproduced. If the door had been properly closed, damage marks should have been present on the guide plates in the fuselage, caused by the locking pins. See figures 11 and 12. No damage marks were present on both plates. The locking pins move into the fuselage when the door is locked by using the handle.

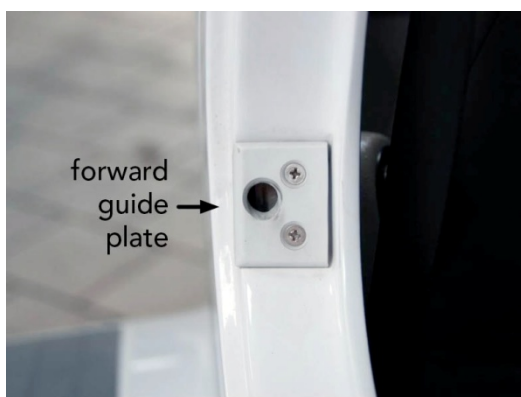


Figure 11: forward guide plate in fuselage
(source: W.L. Nijdam)

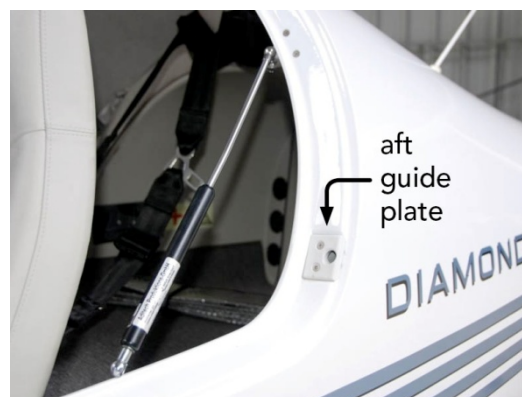


Figure 12: aft guide plate in fuselage
(source: W.L. Nijdam)

Therefore it is concluded that the two locking pins of the rear door closing mechanism were not in the guide plates in the aircraft fuselage at the moment the door separated. This can be explained by the scenario that the door handle was not in the locked position. As a result of this the door

moved up at the top forward side and the safety latch was deactivated. Subsequently the door separated from the aircraft.

Based on the results of the check flights that were conducted by the manufacturer, which showed that the safety latch was able to restrain the door from opening during flight, it is concluded that the most likely contribution to the door separation was excessive free play on the forward door hinge. This free play in combination with the door not being locked, caused a de-activation of the safety latch. Under those conditions the improved retaining bracket did not prevent opening and separation of the door.

It has not been investigated why it took thirteen minutes before a 'door open' alert was displayed on the primary flight display. With the door handle not being in the locked position the alert should have been displayed already in the beginning of the flight.

CONCLUSIONS

The most probable cause of the door separation was the door handle not being in the locked position in combination with excessive free play in the forward door hinge. As a result of this, the door moved up at the top forward side and the safety latch was deactivated. Subsequently the door separated from the aircraft.

This report is published in the Dutch and English languages. In the event of conflict in interpretation, the Dutch text will be deemed binding.

APPENDIX A: ADDITIONAL INFORMATION OF DIAMOND AIRCRAFT INDUSTRIES GMBH

Additional information regarding tests with the emergency pin not in its fully engaged position and the door unlocked and held by the safety latch. Strong sideward and up/down hand power was applied.

Test 1: The emergency lever bolt was moved in flight direction so that the pin had disengaged from the rear part of the aluminium bracket. The pin engaged still the carbon fibre hinge over its full length. Strong side-wards and up/down hand-force was applied to the unlocked door held by the safety latch. The increased play was hardly noticeable.

Test 2: The emergency lever bolt was moved further forward so that approximately one third (6 mm) of the full length of the carbon fibre hinge were engaged. The side play increased to approximately +/- 0,5 mm when using strong side-wards and up/down hand-force to the unlocked door which was held by the safety latch. There was still sufficient clearance (approximately 1,5 mm) between the door carbon hinge and the fuselage composite structure.

Additional information regarding the maintenance procedure which prescribes the inspection of the passenger door and its locking mechanism during every scheduled 100 flight hours maintenance inspection.

The detection of hinge damages is part of regular maintenance and is covered by the Temporary Revision of the Airplane Maintenance Manual AMM-TR-MÄM 42-334 for DA 42 series aircraft, the DA 40 /D/F Airplane Maintenance Manual and the DA 40 NG Airplane Maintenance Manual which prescribe the inspection of the passenger door and its locking mechanism during every scheduled 100 flight hours maintenance inspection. Damaged door hinges can be repaired via repair instruction RÄM 42-131/a or RÄM 40-127/a.

The airplane flight manual instructs the pilot twice to ensure that the passenger door is closed: First in chapter 4A.3.2 - before starting the engine checklist: "rear door closed & locked", and then again in chapter 4A.3.6 – before take-off: "rear door check closed & locked"