Serious incident to the Vulcanair / Partenavia P68
TC Observer
registered F-HVEY
on 10 April 2018
at Orléans (Loiret)

Time: Around 17:10
Operator: Geofit-Expert
Type of flight: Ferry flight
Persons on board: Pilot
Consequences and damage: Pilot poisoned by carbon monoxide (CO)

This is a courtesy translation by the BEA of the Final Report on the Safety Investigation published in May 2020. As accurate as the translation may be, the original text in French is the work of reference.

Carbon monoxide poisoning in cruise, diversion for landing

1 - HISTORY OF THE FLIGHT

The pilot took off under VFR from Châteauroux-Déols (Indre) aerodrome bound for Pontoise Cormeilles-en-Vexin (Val-D’Oise) aerodrome, where the aircraft was based. The aircraft had undergone a scheduled fifty-hour periodic technical inspection at the workshops of the maintenance company located at Châteauroux.

While cruising at 2,000 ft, and after turning on the heater, the pilot reported that he experienced nausea, headaches and stomach pains. He noted that the colour of the carbon monoxide (CO) detection disc installed in the cockpit was midnight blue. He turned off the heating, opened the small lateral windows to take in as much outside air as possible and then diverted to the aerodrome at Orléans-Bricy Air Base, which was close to his position at that time. After a normal landing, the pilot was taken to the regional hospital where he was placed on oxygen and monitored for two hours.

2 - ADDITIONAL INFORMATION

2.1 Meteorological conditions

The pilot reported visibility greater than 10 km and a cloud base of more than 3,000 ft. The wind was 240°, 15 kt, the temperature was 15 °C.
2.2 Pilot information and statement

The pilot, who held a commercial pilot licence (CPL (A)) issued in 2013, IRME and FI (A) ratings, an Airbus A320 type rating since 2017 and a category-1 medical certificate issued on 6 April 2018, had logged 1,110 flight hours, 220 of which were on this type of aircraft and 40 in the previous three months.

He indicated that, at Châteauroux, he made a post-maintenance test flight with the maintenance workshop mechanic, which did not give rise to any particular observations. He then asked for a CO detection system\(^{(5)}\) to be fitted for the flight to Pontoise Cormeilles-en-Vexin aerodrome.

2.3 Research into the aircraft

The aircraft is a twin-engine, high-winged aircraft equipped with two turbocharged Lycoming IO 360-A1B6 piston engines. In a passenger-carrying model, it can accommodate six people on board in three rows.

\(^{(5)}\) The pilot did not recall what prompted this request.

The aircraft involved in the incident parked on the tarmac

Source: Alexandre Février - [http://spottingaviation.forumactif.com](http://spottingaviation.forumactif.com)

The aircraft was purchased by the company Geofit Expert in November 2016. The aircraft’s documentation does not mention any report of an incident involving CO poisoning (see §2.4).

The cockpit/cabin air conditioning system is a standalone electrical system consisting of two fans equipped with a heating resistor, one of which is positioned at the front behind the dashboard and the other at the rear of the cabin. No bleed air extraction on the aircraft uses heat exchanges with the engines.
On 12 April 2018, a 40-minute power run was conducted with a new CO detection system. After twenty minutes, without any specific observations having been made, the heating was switched on. Twenty minutes later, the detector turned green and the test was immediately stopped.

A visual examination of the central sections of the wings between the engines and the fuselage showed slightly greasy marks on the left more than on the right.

On 18 April 2018, the aircraft was ferried from Orléans-Bricy to the Châteauroux maintenance workshop by a test pilot accompanied by a mechanic, both of whom were wearing individual respiratory assistance equipment. The flight was undertaken with the heating system switched off and with a mobile electronic CO measuring device (Testo 317-3) in order to take readings of the level of CO\(^6\).

The ppm (parts per million) readings were as follows:

<table>
<thead>
<tr>
<th>Phases</th>
<th>Configurations</th>
<th>Rate in ppm without heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>After start-up</td>
<td>14</td>
</tr>
<tr>
<td>1</td>
<td>Initial climb</td>
<td>156</td>
</tr>
<tr>
<td>2</td>
<td>Level flight</td>
<td>181/173</td>
</tr>
<tr>
<td>3</td>
<td>Level flight with reduced left engine</td>
<td>65</td>
</tr>
<tr>
<td>4</td>
<td>During descent</td>
<td>65</td>
</tr>
</tbody>
</table>

After landing at Châteauroux, another flight was made to take CO level readings with the same detector and in similar configurations to the ferry flight, but with the heating system switched on. The readings indicated generally similar levels, which meant that the heating system could be ruled out as the potential source of the issue.

On 4 May 2018, at Châteauroux, in the presence of representatives of the manufacturer, the operator, the maintenance workshop and the BEA, an examination of the aircraft revealed the following faults:

- A gasket around a duct passing through the outer casing of the left engine compartment was missing. The same gasket was present on the casing of the right engine compartment.
- Two air vents in the upper part of the rear bulkhead of the passenger compartment were obstructed. The aircraft was purchased by the company in this configuration in 2016.
- An air vent in the bottom part of the same bulkhead was permanently covered by a bag containing the aircraft documents.
- During the occurrence flight, the aircraft was flying with a metal plate that was fitted and taped to the cabin floor to close the hole used to install an optical camera system and its gyro-stabilized plate for use by a photogrammetry operator. This metal plate is perforated with holes at regular distances, screwed to the floor, then taped and covered with the cabin floor carpet. As the operation of the aircraft is completely dedicated to photographic work, this «passenger» cabin configuration is very uncommon.

\[^6\] The World Health Organization (WHO) has defined reference values that are considered harmless based on the exposure time: 26 ppm for 1 h; 52 ppm for 30 min; 90 ppm for 15 min. Headaches, dizziness and nausea occur as of 200 ppm. An exposure of 1,000 ppm kills within one hour.
In addition, this exterior hole in the cabin floor should normally be closed with two flaps that open and close like a window and are flush with the outer fuselage skin under the aircraft. These flaps were not fitted.

The test flights that followed revealed that the faults observed on 4 May 2018 at Châteauroux did not contribute to the cabin contamination.

On 11 May 2018, a series of test flights was conducted with a test pilot and a person whose role was to take readings using the same CO meter and the same flight configurations. The results were as follows:

- The resealing of the hoses and interstices on the engine compartment casings and of the lower shutters on the engine covers near the exhausts and the camera hatch blanking plate did not lead to a decrease in the CO readings noted regardless of the flap position during the three test flights.
- The fluctuations in the readings may be indicative of the intermittent nature of the air contamination in the cabin and therefore of the difficulty in characterising the presence of CO and identifying its source.
- Restoring the functionality of the air extraction vents on the rear cabin bulkhead did not lead to a decrease in the CO levels on the fourth test flight.
- Blocking the potential flow of exhaust gases from the left engine through the flap control feedthrough situated aft of the exhaust outlet and then between the flap and the wing using aluminium adhesive tape led to a very marked reduction in the CO levels recorded during these two flights (12 ppm maximum during climb, between 6 and 10 ppm in level flight).

In addition, the investigation showed that on the aircraft version equipped with turbocharged engines, the exhaust is offset by 30 centimetres compared to the original certified version that is equipped with naturally aspirated engines. On the left wing, this offset means that the exhaust outlet is aligned with a flap bracket. This bracket is fastened in the aerodynamic recirculation zone and there is an interstice between the bracket that is fastened to the wing spar and the wing skin. This creates a vacuum air recirculation point that generates a suction zone towards the inside of the wing at the bottom of the bracket.

This offset of the exhaust is not addressed in SB No 257 (see § 2.5). Only two modifications proposed in this SB are really relevant to resolving this suction phenomenon, particularly on the turbocharged versions (the addition of an elastomer cap at the foot of the left flap bracket, and the addition of an air extractor at the left wing root).

### 2.4 Medical information and carbon monoxide (CO) poisoning

CO is a colourless, odourless, tasteless, non-irritating gas produced by the incomplete combustion of hydrocarbons and present in exhaust gases. When inhaled, it accumulates in the body of any exposed person and prevents the red blood cells from properly carrying oxygen to the organs, causing toxic hypoxia.

The build-up of CO in the body can reduce the amount of oxygen supplied to the brain, to the point where the victim may experience headaches, dizziness and other disorders including loss of consciousness and death.
The investigation showed that the level of sensitivity to CO poisoning depends on many criteria and can vary significantly from one person to another.

2.5 Measures taken by the manufacturer

On 23 May 2018, service letter SL No. 52 was circulated to all operators to inform them to “be aware to seal opportunely the photogrammetric hatch cover (if installed) inside the cabin, located between fuselage frames No.6 and 8, and furthermore to leave all the air vents present inside the aircraft free from obstruction, in order to avoid any possible access of carbon monoxide inside the cabin and guarantee its correct ventilation.”

On 4 June 2018, service bulletin No 257 was published.

It tells P68 operators that:

“Vulcanair has been advised of CO contaminations on a little number of aircraft of the entire flying fleet.

CO contamination into the cabin was caused by poor aircraft maintenance status related to inadequate cabin and firewall sealing conditions, and/or cracks or holes or poorly fitting components in the exhaust system, which contaminate the cabin air. Because of the above, Vulcanair recommends maintaining the aircraft always in a good condition and also recommends the embodiment of this Service Bulletin supplying the information for improving cabin CO contamination prevention by installing additional defences and air way-outs.”

Aircraft leaving the factory from 2015 onwards are fitted as standard with the modifications proposed by SB No. 257 to stop airflow interference between the exhaust gas flow and the fresh air supply to the cabin.

SB No 257 is intended only for aircraft pre-dating SN 474. This information seems to show that the risk of CO poisoning by potential airflow interference had been taken into account by the manufacturer before 2015. In addition, all aircraft equipped with Garmin 1000 have an embedded CO detection system.

3 - LESSONS AND CONCLUSION

Carbon monoxide contamination of the cabin in flight is primarily due to interference in the airflow between the left engine exhaust flow and its potential conveyance into the cabin through the wing.

The presence of a CO detector is recommended by EASA, but is not mandatory. However, the aircraft was equipped with one and its use by the pilot likely mitigated the consequences of this occurrence.

The modifications recommended by SB No. 257, combined with the presence of a CO detector in the cabin, could prevent this type of incident.

The pilot and passenger of a Vulcanair / Partenavia P68 Victor registered EC-MPP and operated by a Spanish company and temporarily leased to a French company were also affected by CO poisoning on 7 July 2018 during a ferry flight to Colmar.