Australian Government
Australian Transport Safety Bureau

Carbon monoxide indication during flight involving Piper PA-28, VH-PZG

Near Bankstown Airport, New South Wales, on 8 March 2021

ATSB Transport Safety Report
Aviation Occurrence Investigation (Short)
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Addendum

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Safety summary

What happened

On 8 March 2021, the crew of a Piper PA-28 aircraft, registered VH-PZG, were conducting a dual training flight from Bankstown Airport to the Bankstown training area, New South Wales.

At the top of climb, at about 4,000 ft near Warragamba Dam, the instructor detected a faint exhaust gas smell and recalled feeling a little more tired than when they took off and mildly lightheaded. The instructor then looked up at the carbon monoxide detector and observed a localised discolouration (indicating the likely presence of carbon monoxide in the cabin).

The instructor opened all fresh air vents and windows, and ensured the heater was off. They then advised the student of the positive indication and decided to return to Bankstown. The student continued to fly the aircraft back while the instructor monitored the situation and detector.

The aircraft landed safely at Bankstown and the crew were taken to hospital for medical examination.

What the ATSB found

The ATSB found that the disposable carbon monoxide detector had indicated elevated levels of carbon monoxide in the cabin during the flight. Positive carbon monoxide indications were also reported in two previous flights nine months prior. However, subsequent post-incident inspections and test flights were unable to replicate the conditions nor determine the source of the carbon monoxide.

Safety message

Carbon monoxide (CO) is a colourless and odourless gas, and its presence may not be detected until the development of physical symptoms and/or cognitive effects. Therefore, operators and owners of piston-engine aircraft are strongly encouraged to install a CO detector with an active warning to alert pilots to the presence of elevated levels of CO in the cabin. Should any smell or sensation of illness develop, pilots should check their CO detector, ensure cabin heat has been turned off, open all fresh air vents and windows, make prompt decisions to land as soon as possible, and use all available resources for assistance. Further information on CO poisoning and detectors can be found at the following:

Are you protected from carbon monoxide poisoning?

Carbon Monoxide: A Deadly Menace

Detection and Prevention of Carbon Monoxide Exposure in General Aviation Aircraft

The investigation

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope investigation was conducted in order to produce a short investigation report and allow for greater industry awareness of findings that affect safety and potential learning opportunities.

The occurrence

On 8 March 2021, the crew of a Piper PA-28 aircraft, registered VH-PZG, were conducting a dual training flight from Bankstown Airport to the Bankstown training area, New South Wales. The student was sitting in the left-hand seat and the instructor in the right.

At about 0800 Eastern Daylight-saving Time,[1] the crew started the engine and taxied the aircraft to the run-up bay to carry out engine run-ups,[2] with the side window open, the fresh air vents closed and the heater off. Prior to take-off, the crew closed the side window, and switched the windscreen demister and carburettor heat off. No indication of carbon monoxide (CO) was observed on the disposable CO chemical spot detector while the aircraft was on the ground. At about 0815 the aircraft departed from Bankstown heading to the training area.

During climb, between 1,500 ft and 2,000 ft, the instructor noticed warm air coming from the right floor air vent. Soon after, at the top of climb, at about 4,000 ft near Warragamba Dam, the instructor detected a faint exhaust gas smell and recalled feeling a little more tired than when they took off and mildly lightheaded. The instructor then looked up at the CO detector card, that was located on the ceiling above their head, and observed a localised discolouration (Figure 1 left).

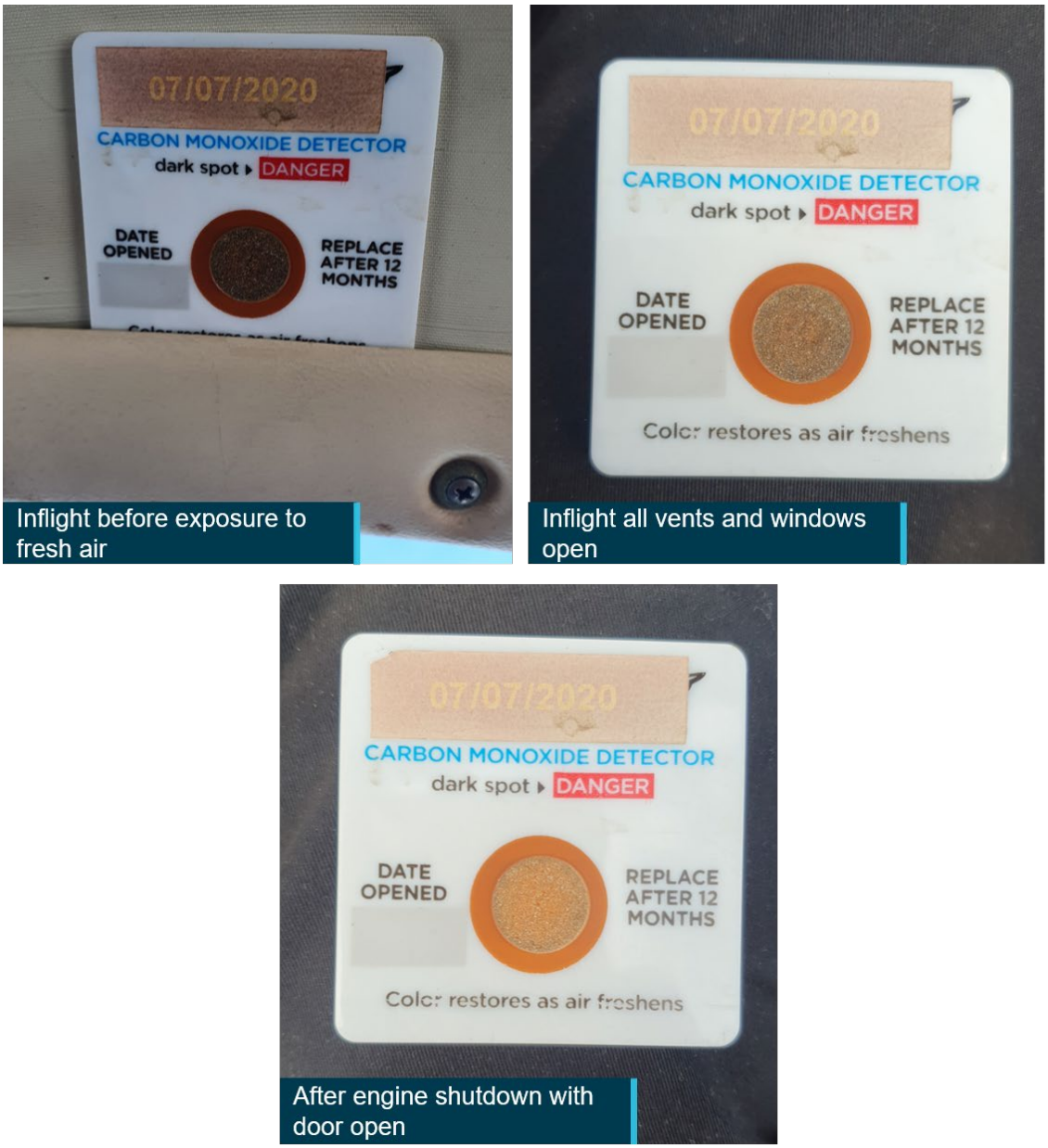
The instructor opened all fresh air vents, windows and ensured the heater was off. The instructor then advised the student of the positive indication and they both agreed to return to Bankstown. The instructor considered diverting to Camden Airport, which was closer, but they felt that their impairment was mild and could safely operate the aircraft to Bankstown. The student continued to fly the aircraft back while the instructor monitored the situation and the detector. The student recalled initially feeling normal, however, halfway back to Bankstown recalled feeling a little lightheaded and had a dry warm taste in their mouth that lasted a few of hours.

At 0845, the aircraft landed safely at Bankstown. The crew were subsequently taken to hospital for a medical examination. Both crew members reported feeling better after breathing fresh air for about half an hour before they left for the hospital.

[1] Eastern daylight-saving time: Coordinated Universal Time (UTC) + 11 hours.

[2] Run-up: a high power run-up check is carried out in a piston-engine aircraft to check the aircraft's ignition and other systems before commencing an initial take-off.

Figure 1: Discoloured carbon dioxide detector during different stages of the flight



Source: Instructor

Context

Medical information

General health and fitness

Both crew members were well rested and felt fine on the day of the incident. They were non-smokers and did not have any pre-existing medical conditions that could have contributed to the incident.

Carboxyhaemoglobin

Blood samples were taken about an hour after the aircraft had landed at Bankstown. The results of the tests indicated a carboxyhaemoglobin (COHb) level of 1.4 per cent for the instructor and 1 per cent for the student. Neither crew members were administered oxygen.

Carbon monoxide is an odourless, colourless and tasteless gas formed by the incomplete combustion of carbon-containing materials. When inhaled, it preferentially binds to haemoglobin, the oxygen carrying molecule in red blood cells. This creates COHb compounds and prevents oxygen from binding to the molecule and being transported, resulting in oxygen starvation.

Recent ATSB investigations AO-2020-026 and AO-2017-118 have shown that normal endogenous levels of COHb are generally reported to fall within the range of 0.4-0.7 per cent. Smokers, and those living in an urban area, may have higher than average levels of COHb that fall within 1-6 per cent. Carbon monoxide has a half-life of 4-5 hours at sea level, meaning the COHb will reduce to half its initial value within that time, after the source of CO has been removed. The CO half-life can be reduced to 80 minutes with the administration of pure oxygen.

The physical symptoms and cognitive effects of CO poisoning can worsen with an increasing level of COHb, however, different individuals' reactions to a given COHb level can vary (Lacefield et al., 1982). Researchers have found that a person's ability to perform complex tasks can be adversely affected at levels of 10 per cent or less (Baselt, 2014). It has also been found that the effects of CO can begin to show with the deterioration of psychomotor function at COHb levels of about 3 per cent (Hawkins, 1993).

Many studies have stated that an individual should not experience physical symptoms below 10 per cent. Such studies reference very similar tables that illustrate a specific COHb level and their associated symptoms, starting from 10 per cent up to 60-80 per cent. However, Hampson et al. (2012) discovered that the widely used tables were unreliable and, though they may differ slightly, come from a 1920's publication and are based on the symptoms experienced by three men who, between them, reached maximum COHb levels of up to 28 per cent during a total of 10 low level CO exposures.

In addition to this, various studies have found that the clinical symptoms presented by a patient can be inconsistent with their recorded COHb levels (Hampson & Hauff, 2007; Hampson et al., 2012; Widdop, 2002; Oliverio & Varlet, 2018). Curry (1972, as cited in Widdop, 2002) also found that in some forensic investigations, where the evidence strongly pointed to CO poisoning, the blood analysis indicated only low to normal COHb levels.

Post-incident aircraft inspection

After the incident, and prior to any maintenance activity, engineers conducted engine ground runs with a digital CO detector and were unable to detect CO leaking into the cabin. The engineers then inspected the aircraft and did not find any faults in the exhaust system or the heater and demister ducting.

A non-standard (improvised) gasket had been used between the cabin heat distributor box and firewall. The gasket material did not have any odour associated with it and appeared to have been in place for some time. The current maintainer could not find any record of when the gasket was installed. Due to the lack of smell, the ATSB determined that the material was unlikely to be the CO source.

The flapper valve for the heater system was also found to be out of adjustment and would not fully close. The ATSB contacted Piper Aircraft to determine if CO could leak into the cabin via the valve. They advised fresh air enters the engine compartment via the nose cowling and is vented to the heater muff through a flexible hose located on the baffling at the rear of the engine. The air is then heated and vented into the cabin area through a valve, which is controlled from the instrument panel. When the valve is completely closed off, the heated air is vented back into the engine compartment. As a result, the effect of an out of adjustment valve would act like partial heat was on. However, unless a fault was found within the exhaust system, it was unlikely that CO could leak into the cabin via the flapper valve.

Several weeks after the inspection, the operator took the aircraft for a test flight along with a digital detector. The highest concentration of CO obtained was 25 parts per million (ppm) during taxi

(with the side window and door ajar) and take-off (with all windows and doors secured), while in cruise the highest indication was 3 ppm.

The maximum exposure level, as recommended by Safe Work Australia, is 30 ppm over an 8-hour period.

Previous carbon monoxide incidents

VH-PZG was the subject of two other reported CO events in the year before this incident on 12 June and 9 July 2020. In the first incident (which involved the same instructor, but a different student), a discolouration on the detector was observed by the instructor at the runway holding point. The instructor reported feeling lightheaded, had a headache and poor cognition, the student was unsure whether they were experiencing any symptoms. The training flight was aborted, and the aircraft was returned to the apron. The instructor reported they were taken to hospital and the blood analysis indicated the instructor's COHb level was 0 per cent and the student's was 1.8 per cent, noting that the student was a smoker.

In the second incident, a discoloration on the detector was observed by the crew after the engine rpm was increased to 2,000 for engine run-ups. The run-ups were aborted, and the aircraft was taxied back to the apron. Neither the instructor nor the student reported experiencing any symptoms and were not taken to hospital.

Two days before the second incident the CO card detector was replaced with a new one. Both post-incident inspections were unable to determine the source of the CO. The exhaust and heater systems were inspected, and no faults were found. Engine ground runs and test flights were conducted with a digital CO detector and no indication of CO was detected.

Carbon monoxide detector

The aircraft was fitted with an Aviation Supplies and Academics disposable CO chemical spot detector, attached to the ceiling just above the right seat. The detector was 8 months old and within the manufacturer's 12-month replacement period. It consisted of an orange-coloured circle (spot) in the middle of the card, which was designed to change colour to grey/black following a chemical reaction with CO in the immediate vicinity. The spot then returns to normal (orange) after it has been exposed to fresh air (Figure 1, bottom). The chemical reaction depends on the concentration of CO in the air and the time of exposure. This detector was designed to react to a minimum of 50 ppm of CO within 30 minutes, 100 ppm within 10 minutes and 200 ppm within 4 minutes.

A study conducted by the United States Federal Aviation Administration (FAA) (Hossein et al., 2009) noted the useful life range of these types of detectors are between 30-60 days. The manufacturer's website advises the detector will last up to 12 months, however, they also recommend the detectors are replaced with a new one every 3-6 months depending on the environment they are being used in.

An additional limitation of this type of detector is that it does not actively alert the pilot to the presence of CO. Therefore, its effectiveness relies on the pilot regularly monitoring the detector throughout the flight. It is also dependent on the detector being easily visible and accessible, in a well-lit environment. In a low ambient light environment, the discolouration of the chemical spot, from orange to a grey/black colour, can be difficult to see.

Safety analysis

Elevated levels of carbon monoxide

The crew reported observing a discoloration of the carbon monoxide (CO) detector and experienced very mild symptoms and cognitive effects. While it was possible for CO card detectors to give an unreliable indication, the same aircraft was involved in two other incidents, nine months prior, and the detector was replaced with a new one two days before the second

incident. In addition, the crew's blood tests after this incident indicated mildly elevated carboxyhaemoglobin levels, which in conjunction with the card indication, was consistent with CO in the cabin.

Despite the above, the post-incident aircraft ground runs and subsequent flight tests were unable to detect elevated levels of CO in the aircraft cabin. While the inspection revealed a non-standard gasket and an out of adjustment flapper valve, the ATSB determined them both to be unlikely sources of CO due to the lack of smell from the foreign material and the absence of observed defects in the exhaust system. As a result, the source of the leak was not determined.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the positive carbon monoxide indication involving a Piper PA-28, registered VH-PZG that occurred near Bankstown Airport, New South Wales on 8 March 2021.

Other factors that increased risk

- The crew were exposed to elevated levels of carbon monoxide in the aircraft cabin.

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- flight crew
- aircraft operator
- maintenance organisation for VH-PZG.

References

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Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- flight crew
- aircraft operator
- maintenance organisation for VH-PZG.

No submissions were received from the directly involved parties.

General details

Occurrence details

Date and time:	8 March 2021 – 08:30 ESuT	
Occurrence category:	Incident	
Occurrence categories:	Crew and cabin safety - other	
Location:	Near Bankstown Airport, New South Wales	
	Latitude: 33° 53.860' S	Longitude: 150° 41.223' E

Aircraft details

Manufacturer and model:	Piper Aircraft Corp PA-28	
Registration:	VH-PZG	
Operator:	Aeropro Pty Ltd.	
Serial number:	28-7916193	
Type of operation:	Flying training – Training dual	
Activity:	General aviation / Recreational-Instructional flying-Instructional flying - dual	
Departure:	Bankstown, New South Wales	
Destination:	Bankstown, New South Wales	
Persons on board:	Crew – 2	Passengers – 0
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Nil	