Airworthiness Bulletin

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Preventing Carbon Monoxide Poisoning in Aircraft

An Airworthiness Bulletin is an advisory document that alerts, educates and makes recommendations about airworthiness matters. Recommendations in this bulletin are not mandatory.

1. Effectivity

Operators, pilots, passengers, maintenance personnel and organisations that operate or maintain internal combustion aircraft engines.

2. Purpose

To highlight the potential for aircraft occupants to potentially suffer from Carbon Monoxide (CO) poisoning due to unsealed penetrations through engine firewalls, fuselage penetrations and other openings. Draw attention to on sources of CO such as damaged or leaking exhaust components and unserviceable heat exchange assemblies.

Also, advice relating CO detection systems within aircraft that use an internal combustion engine. Whilst audible/visual CO detectors are not mandated, they are highly recommended and easily available to assist in the detection of CO. Emphasize that CO detectors should not be used as the primary protection method against CO emissions into aircraft.

3. Background

CO is a colourless and odorless gas produced by the incomplete combustion of fuel. CO is undetectable to the human senses which means that dangerous concentrations can build up inside aircraft and operating crews, passengers or maintenance personnel have no natural way to detect the CO.

Following an incident investigation of a DHC-2 Beaver by the Australian Transport Safety Bureau (ATSB), it was revealed several occupants of the incident aircraft had elevated levels of CO within their blood samples. The investigation highlights several concerns relating to CO. Refer ATSB Report – AO-2017-118.

Exhaust components and collector assemblies on piston powered aircraft are a known source of CO. Manufacturer's instructions for continued airworthiness (ICA) require regular inspection of exhaust pipe collectors and heat exchangers. Most aircraft exhaust component service life is determined by an "on condition" maintenance inspection philosophy. As such these systems require increased vigilance and attention to detail, especially with ageing exhaust components.

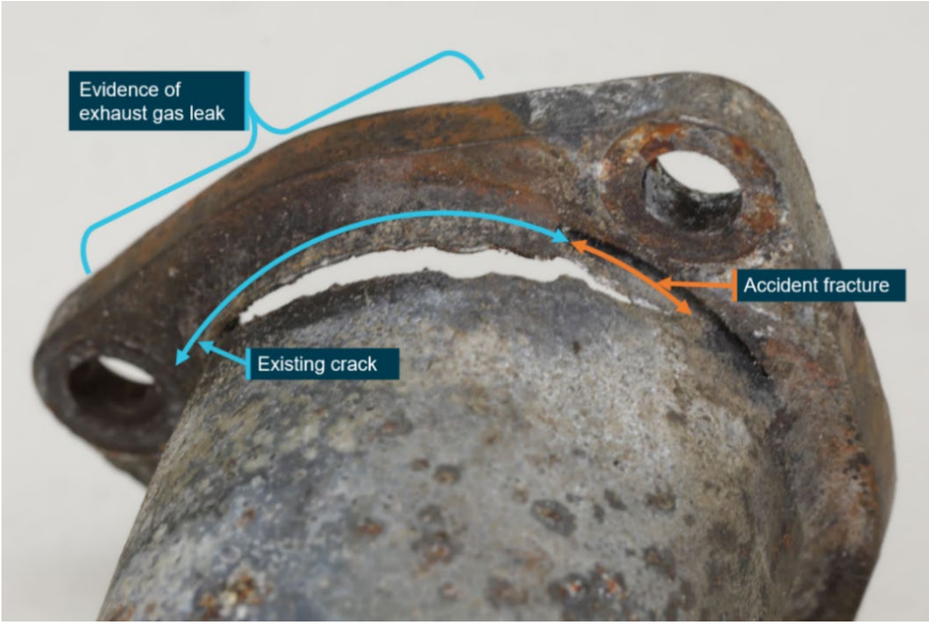

Figure 1. Engine exhaust (Image provided by Australian Transport Safety Bureau)

CO can potentially enter cockpits and cabins via heating ducts, open voids in engine firewalls or open doors, vents and windows. Whilst the latter three are unavoidable, firewall integrity, heating ducts and control valves need to be inspected to ensure correct operation and seals remain serviceable and effective. Firewall access panels or wire and cable penetration covers, boots, grommets etc. can all be avenues of CO ingress into cabins and cockpits. Aircraft window and door seals that are deteriorated or deformed could also become an ingress point.

Figure 2. Firewall penetrations, openings and access panels.

Some aircraft have boots or covers on components that do not penetrate a firewall but other areas of the fuselage, for instance, steering components.

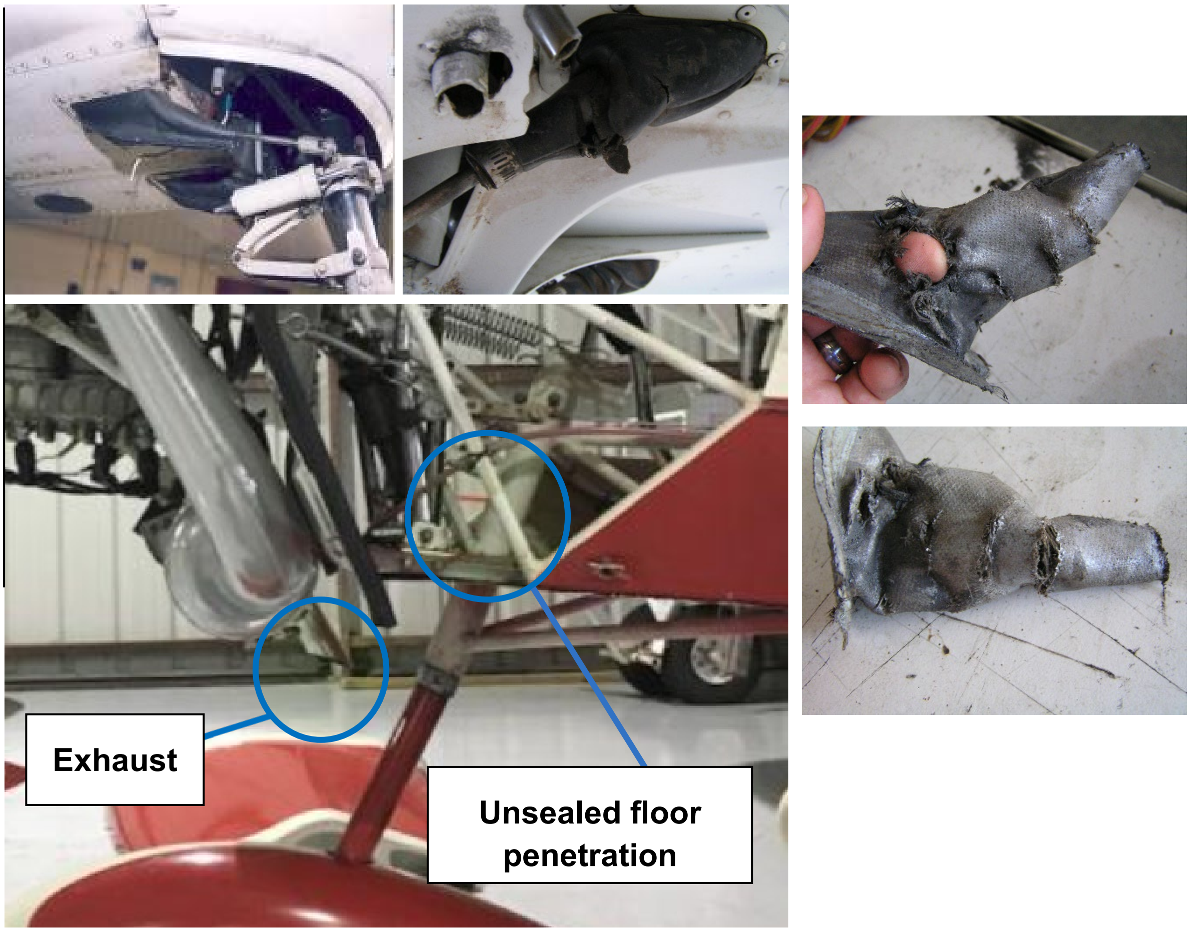

Figure 3. Boots or covers on components that may not penetrate a firewall but other areas. Some aircraft may also have unsealed openings.

CO detection systems have significantly improved beyond placard style detectors that change colour in the presence of CO.

Older methods may not provide adequate or timely warnings of rising CO concentrations to the pilots, passengers or maintenance personnel.

Modern, affordable devices now offer enhanced features such as audible alarms and clearer visual warnings, making them more effective in alerting occupants to elevated CO levels.

4. Recommendations

Aircraft systems, maintenance and modifications

The Civil Aviation Safety Authority (CASA) suggests conducting a carbon monoxide check at each annual or 100 hours-time in service, whichever occurs first, and each time the exhaust system or related components are disturbed. Registered operators, maintenance repair organisation or CAMOs can instigate periodic CO detection functional tests, during which, the CO level in the cabin can be measured.

The CO concentration may not exceed one part in 20,000 parts of air within a cockpit or cabin (equivalent to 50 parts per million), derived from FAA FAR 23.831.

CASA recommends that when LAME/AMEs conduct visual inspections of exhaust collectors and heat exchange units, a thorough inspection is conducted with the view of finding potential CO leak points. All shrouding and shields should be removed to allow for a detailed inspection.

Whilst the internal condition and thickness of exhaust components is difficult to determine visually, if the component exhibits signs of thinning, cracking, bulging or any exhaust leakage (soot deposits or discolouring) the section should be removed and replaced with a serviceable item. Gaskets, brackets and clamps should also form part of these inspections. Pressure tests or other appropriate leak checks on exhaust components may help diagnose defects that are too small to be detected by visual inspections.

An ideal maintenance program would involve exhaust system replacement at engine change or at a predetermined interval gained from operating experience. To operate these items to a point of failure is not considered appropriate

Exhaust tail pipes are designed for forward flight with the dispersion of exhaust gases rearwards. Lengthy engine run ups and taxi periods with tail or cross winds can draw the exhaust into the cabin. Pilots should ensure adequate fresh air ventilation is available to them and that the aircraft is directed into the wind.

Additionally, any modification or reduction in the length of the tail pipe/exhaust system must be conducted with original equipment manufacturer approval or local Australian CASR Part 21 approval.

Heating ducts and ON/OFF valves should function and seal properly, especially in the OFF position, to prevent the flow of contaminated air.

Maintaining the integrity of cabin penetrations and firewalls provides a secondary barrier to CO, other gases or flammable fluids from entering the cockpit or cabin. Exposure to heat, contact with fuels, oils, lubricants, mechanical movement and flexing during maintenance or normal operations can cause degradation or components over time.

Regular inspections, maintenance or modifications that disturb the below components will require special attention to ensure all components are serviceable and correctly installed.

- access panels
- seals
- gaskets
- wiring and cable covers
- boots
- grommets and
- hardware.

Carbon monoxide detectors

CASA strongly recommends pilots wear or carry personal active CO detectors. Another option is to have an approved/certified CO detection system fitted to aircraft.

CO detectors should not serve or be relied upon as the primary method for preventing carbon monoxide poisoning. The first line of defence should be the design and proactive maintenance of internal combustion engine exhaust system components and airframe penetrations.

Use of and reliance on visual CO detection placards that change colour in the presence of carbon monoxide (CO), is considered among the less effective options. CO detection placards have the following limitations:

- Are passive - No audio alarm - reliant on constant monitoring.
- Require frequent replacement every 3-12 months.
- Effected by direct sunlight.
- May revert to their original colour when exposed to fresh air.
- Degradation due to chemicals (fuels, oils, lubricants and cleaning products).
- Do not show or record the level of CO present.

If an aircraft is fitted with a placard type CO indicator, the operator should ensure the placard is placed in the field of view of the pilot and regularly checked to ensure it is not time expired nor damaged from ultraviolet exposure or contamination.

There are many small electronic personal devices readily available at affordable prices. These devices allow for continual monitoring of CO levels with audible and/or visual warnings when escalated CO levels are detected.

Figure 4. Examples of portable CO detectors, USB power and headset systems with integrated CO detectors.

Keep in mind that non-certified equipment is not necessarily tested to nor required to meet rigorous requirements for aviation vehicles like certified equipment is.

Aircraft certified products are available that can be installed by approved maintenance organisation.

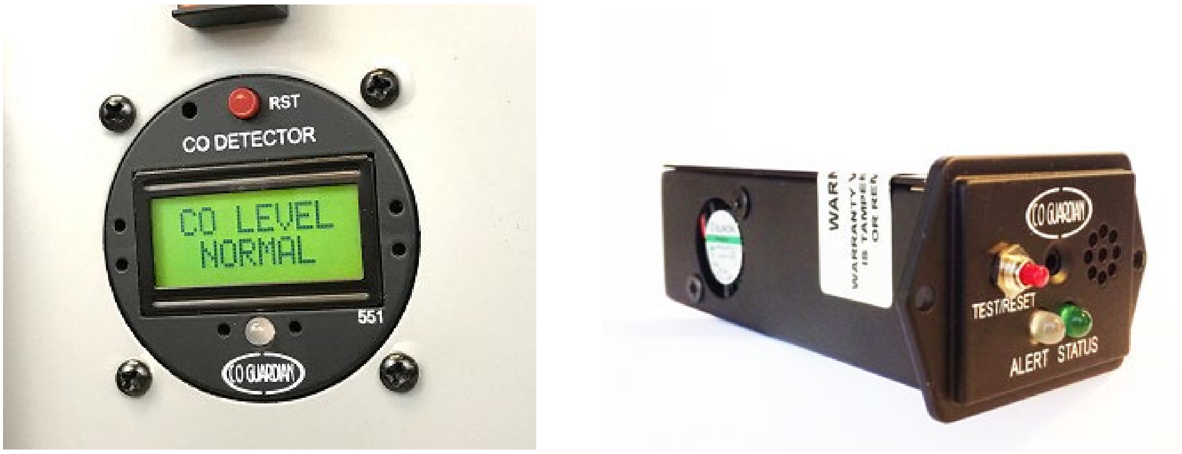

Figure 5. TSO approved panel mounted CO detectors.

An example of how TSO systems can improve safety is illustrated by the alarm trigger times shown below.

- TSO-C48a systems (SAE International Standard (AS) 412B) - Alarm circuit triggered at 75 PPM after 5 minutes.
- European Standard - EN50291-1 (non-TSO, sold in Australia) – Alarm circuit triggered at approximately 75 PPM after 35 minutes.
- United States standard - UL 2034 (non-TSO, sold in Australia)– Alarm circuit triggered at 70 PPM, must not activate before 60 minutes but must activate before 240 minutes.

Users of CO detectors should be aware that there have been reports of defects related to unreliable or false indications. However, operating crew should always take system warnings seriously and never ignore them.

Finally, operators and passengers of internal combustion engine aircraft should be aware of the cumulative effect of CO. Commonly reported symptoms of acute (short term) exposure to high levels of CO include:

- headaches, dizziness, nausea
- metallic taste
- darkened vision
- muscular weakness, incoordination and impaired judgement
- numbed reflexes and reaction times
- sleepiness, collapse and unconsciousness
- increased pulse and breathing
- convulsions
- heart attack or stroke.

Ongoing chronic exposure to high levels of CO may result in:

- recurring headaches
- irritability
- insomnia
- foetal changes in pregnant women (including miscarriage)
- personality changes
- impaired judgement.

5. Other information from National Airworthiness Authorities

UK CAA

- Carbon monoxide in general aviation - Carbon monoxide – prevention and protection strategies
- Safety Directive: SD–2024/001V2 - Active Carbon Monoxide Detectors for Piston Engine Aircraft Operations
- YOUR SAFETY SENSE LEAFLET FOR: CARBON MONOXIDE SAFETY

Transport Canada

- CASA 2019-07 – Reducing the risk of carbon monoxide poisoning in general aviation aircraft

FAA

- DOT/FAA/AR-09/49 - Detection and Prevention of Carbon Monoxide Exposure in General Aviation Aircraft
- SAIB CE-10-19 R1 - Engine Exhaust and Carbon Monoxide Detectors
- Carbon Monoxide Hazards and Mitigations in Aircraft Exhaust Systems

The FAA have produced an interactive on-line presentation Aircraft Exhaust Systems as part of their FAA AMT Course. An overview of exhaust systems and examines many of the components, issues and techniques used in inspecting and maintaining exhaust systems.

6. Reporting

All defects found within any of the following, should be submitted to CASA via the Defect Reporting System.

- exhaust sections
- ducting
- heat exchangers
- firewall assemblies and
- CO detection equipment.

7. Enquiries

Enquiries with regard to the content of this Airworthiness Bulletin should be made via the direct link email address:

AirworthinessBulletin@casa.gov.au

or in writing, to:

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