General Aviation Unit

Carbon Monoxide Detector Trial Summary Report

CAP 2560

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Introduction

This report presents the findings from the Civil Aviation Authority (CAA) 12-month study investigating how low-cost, commercial off-the-shelf, carbon monoxide (CO) detectors with attention-getting capabilities performed in a variety of general aviation (GA) aircraft and operating conditions.

Background

Carbon monoxide poisoning is likely to have been a factor in a number of GA accidents globally. A 2020 AAIB review of accidents and incidents in the UK since 2000 identified two fatal accidents, each with two fatalities, and fifteen other events where CO may have been a causal factor. The CAA is aware of an additional non-fatal accident since that review where CO poisoning was likely a factor. The CAA recognises the importance of this issue and is actively engaged in several safety initiatives to highlight the risk posed by CO and what can be done to mitigate it.

Safety Notice SN-2020/003 is directed at GA and raises awareness of the hazards associated with CO, describes means to minimise the likelihood of encountering CO as well as what to do if CO poisoning is suspected during flight. It also includes guidance on the use of active carbon monoxide detectors in GA aircraft. The Safety Notice was first published in March 2020, was updated in April 2021, and has just recently been revised again following the completion of the CAA 12-month study, which is the focus of this report.

The CAA has also created a webpage dedicated to CO in GA, which contains general information on the topic, including how to reduce the risk of CO poisoning as well as how pilots can protect themselves by carrying a detector. In May 2022 an animation was uploaded to the webpage that included guidance for GA pilots on flying with an active CO detector. Additionally, the CAA released a podcast in May 2022 that included a segment on CO.

In July 2021, the CAA ran a survey asking pilots about their experience of flying with active CO detectors. The findings from the survey are available online as an infographic. One outcome of this survey was that it highlighted a growing number of pilots already flying with active CO detectors voluntarily who have valuable insight and experience that is worth understanding and sharing. This formed the basis for the 12-month study that launched in September 2021.

The CAA asked for volunteers to participate in the study and 98 GA pilots who currently fly with an active CO detector came forward, agreeing to complete monthly surveys over the course of a year. Four quarterly summary reports were produced during the study and this report presents the overall results from the year-long trial.

Objectives

The 12-month active CO detector trial was established to:

- qualitatively and quantitatively investigate how low-cost active detectors perform in UK GA aircraft over a full flying season;
- better understand pilot's user experience of flying with these devices;
- evaluate CO levels in a cross-section of the UK GA fleet.

Carbon Monoxide – An Overview

CO Poisoning Signs & Symptoms

Carbon monoxide is a highly poisonous colourless, odourless, and tasteless gas produced by the incomplete combustion of carbon-based fuel. When inhaled, it enters the bloodstream and mixes with haemoglobin (the part of red blood cells that carry oxygen around your body) to form carboxyhaemoglobin, causing blood to lose its ability to carry oxygen, resulting in damage to the brain, heart and nervous system. Susceptibility to CO poisoning is increased at altitude due to the lower quantity of oxygen in the atmosphere.

The physiological effects of CO poisoning are cumulative and take time to disperse. Even low-level CO ingestion, with no apparent physical symptoms, will cause a progressive reduction in blood oxygen levels over time, reducing pilot performance. Pilots should not tolerate low levels of environmental CO as the cumulative negative effects on human performance may not be noticed.

The length of time it takes to recover from CO poisoning depends on exposure time and CO concentration. Even with hospital-administered standard oxygen therapy where 100% oxygen is given (normal air contains about 21% oxygen), recovery usually takes 4-6 hours. Although mild CO poisoning does not usually require hospital treatment, it is still important that medical advice is sought.

CO poisoning symptoms are similar to hypoxia and include:

- Headache
- Dizziness
- Feeling sick and/or being sick
- Fatigue
- Confusion, degradation in performance
- Chest pain and muscle spasms
- Breathlessness
- Loss of consciousness and death

Table 1 below is extracted from the Federal Aviation Administration (FAA) report 'Detection and Prevention of Carbon Monoxide Exposure in General Aviation Aircraft' and shows how CO poisoning symptoms escalate with exposure.

CO parts per million	Time	Exposure or Symptoms
50	8 hr	Maximum exposure allowed by the US Occupational Safety and Health Administration over an 8-hour period
200	2-3 hr	Mild headache, nausea, fatigue
400	1-2 hr	Serious headache, life threatening after 3 hr

CO parts per million	Time	Exposure or Symptoms
800	45 min	Dizziness, nausea, unconscious within 2 hr, death within 2-3 hr
1600	20 min	Headache, dizziness, nausea, death within 1 hr
3200	5-10 min	Headache, dizziness, nausea, death within 1 hr
6400	1-2 min	Headache, dizziness, nausea, death within 25-30 min
12800	1-3 min	Death

Table 1: Escalation of CO Symptoms with Exposure

Causes of CO Poisoning

Many light aircraft utilise a heat exchanger to provide cabin heat by taking advantage of the hot air flowing through the exhaust system. In normal operation the exhaust gas and air for the cabin are kept separate. However, in the event of a failure in the exhaust manifold (e.g. cracks, worn seals, etc.) exhaust fumes, typically containing between 5% to 7% CO, can escape and enter the cabin via the heater vents. FAA research indicates that such contamination incidents are more prevalent in colder months when cabin heater use is high. Systems with higher operating hours are also more likely to be affected. Additionally, changes/modifications to the position and configuration of the exhaust system have been shown to notably affect the amount of CO entering the cockpit.

Another source of CO entering the cabin is due to poor sealing of the bulkhead between the engine compartment and the cabin. Additionally, CO has been known to enter the cabin from the exhaust plume flowing down the side or bottom of the fuselage and entering via poorly fitting cabin doors, access panels, fresh air vents, wing root fairings and hatches. The extent of exhaust gas ingress can vary with angle of attack.

A failure of the exhaust system may be associated with a smell of smoke/fumes in the cabin and/or a large drop in engine rpm when applying carburettor heat. The heat exchanger shroud may also show black, sooty deposits and discolouration. Vigilance from pilots and maintenance personnel to recognise these hallmarks of exhaust system failure is crucial in avoiding CO poisoning.

Actions in Case of CO Exposure

The CAA is developing a checklist to help pilots respond if their CO detector alerts during flight or if any of the symptoms described above are experienced. In the meantime, the following actions are recommended:

- Turn off the cabin heat supply
- Maximise fresh air into the cabin
- Only open windows if the flight profile and the aircraft’s operating manual permit
- Use supplemental oxygen if available
- Make a radio call to alert others (Air Traffic Control or other aircraft) to your predicament
- Land as soon as possible
- Seek medical attention once on the ground
- **Ensure the aircraft is inspected and any defects that may have caused the CO exposure are rectified before flying again**

Carbon Monoxide – Prevention and Detection

CO Prevention - Maintenance

The best way to prevent CO poisoning is to avoid exposure. Initial airworthiness requirements for UK Part 21 and UK non-Part 21 general aviation aircraft ensure newly built aircraft are safe with respect to CO by stipulating that CO concentration must not exceed one part in 20,000 parts of air (equivalent to 50 ppm). Adherence to a thorough and regular maintenance programme is key to minimising the risk of CO exposure throughout the life of the aircraft rather than just at the start. To that end, pilots and those responsible for aircraft maintenance are encouraged to:

- Ensure that aircraft exhaust and associated systems, including heating/ventilation systems are in good working condition and maintained in accordance with the relevant maintenance data. Maintenance can include physical inspection, inspection with partial dis-assembly, internal inspection, non-destructive testing (NDT) as well as pressure testing to ensure there are no leaks in the muffler/exhaust system.

- Review the guidance in CAA Publication (CAP) 562 ‘Civil Aircraft Airworthiness Information and Procedures’ (CAAIP) Leaflet B-190 ‘Carbon Monoxide Contamination’ which contains useful general maintenance-related measures to minimise the likelihood of CO contamination. The guidance emphasises the importance of routine inspections and describes a means of testing for CO contamination.

- Consider the guidance in FAA AC-43-13-1B Chapter 8, Section 3 paragraphs 8-45 to 8-52, which provide valuable information on typical exhaust system failures, hazards, descriptions and inspections including pressure checks, repairs and replacement recommendations.

- Take into consideration the CO prevention measures in EASA Safety Information Bulletin (SIB) No. 2020-01R1. UK Reg (EU) No. 1321/2014 Annex Vb (Part-ML) includes a specific CO concentration check that is in the Minimum Inspection Programme for UK Part 21 aircraft.

- Include a suitably frequent periodic inspection and test regime in the aircraft’s Maintenance Programme (Approved or Owner-Declared, including programmes based upon the UK Part 21 aircraft Minimum Inspection Programme)

- For aircraft fitted with combustion heaters, ensure compliance with CAA Publication CAP 747 ‘Mandatory Requirements for Airworthiness’ Generic Requirement (GR) 11. This covers servicing and overhaul requirements intended to prevent carbon monoxide contamination.

CO Detection

In the event that preventative maintenance fails, effective alerting of CO presence can be achieved through the use of an appropriate CO detector. The insidious nature of carbon monoxide makes it very difficult to detect unaided. For this reason, in addition to adopting best practice maintenance measures, pilots are increasingly choosing to fly with a CO detector in the aircraft.

There is a wide and ever-increasing range of CO detectors available, but they broadly fall into two categories as follows:

<u>Passive CO detectors</u>

Passive detectors are the 'spot type' devices that change colour when exposed to carbon monoxide. They are small, light, and cheap (under £10), but they have a limited declared life, often 3-6 months and therefore need to be replaced regularly for continued effectiveness. The big disadvantage of passive detectors is that they lack attention-getting capability. This is especially significant given that victims of CO often do not realise they are being poisoned. Another downside of these detectors is the fact that many revert to their original colour when exposed to fresh air again. Therefore, an intermittent CO problem may go undiagnosed if the temporary colour change is not noticed. For these reasons, some pilots prefer to fly with an active CO detector.

<u>Active CO detectors</u>

Active detectors provide audible, visible and/or vibration warnings when pre-determined carbon monoxide levels are exceeded (often 50ppm, although some can be self-adjusted to alarm at lower thresholds). These detectors have the clear advantage of actively engaging the occupant's attention and are therefore far more likely to be effective. Their effectiveness is dependent on several variables such as the alarm trigger level as well as where the device is positioned in the aircraft. Adherence to the manufacturer's installation, usage and maintenance instructions should maximise the likelihood of effective operation.

Active detectors can be either portable and 'carried on' to the aircraft or permanently 'installed' in a suitable position on the aircraft. Commercially available units meeting an appropriate standard such as EN 50291-2 are available for motorhomes, caravans and boats for less than £20. These devices have a sensor life in the region of 7 years and battery lives of between 1 and 10 years, making them very cost-effective.

Aviation standard (e.g. approved in accordance with EASA's ETSO-2C48a) units are also available if permanent installation is preferred or required. These components often have additional functions and adhere to specific aviation-related requirements, but are more costly, typically around £300. There is also an increasing trend for active CO detectors to be bundled with other aviation equipment such as ADS-B, headsets, etc, which is helping to increase their presence in GA aircraft.

Carbon Monoxide Detector Trial – Results

Overview

The active CO detector trial involved 98 participants who were asked to complete monthly surveys over the course of 12 months. The average response rate to the monthly survey over the course of the trial was 68%. Except for some small changes based on participant feedback, the monthly survey questions were not changed throughout the trial to ensure the data gathered for the 12 months was consistent. A full list of the survey questions is included in Appendix I. At the start of the trial, participants were asked to provide the make/model of each active CO detector they were using in the trial as well as the aircraft type/age they fly.

Detectors

There were 22 different brands of active CO detector in the trial and 36 different individual models. A full list of all CO detectors used in the trial can be found in Appendix II. The five most popular CO detector models used in the trial are shown in Table 2 below.

CO Detector Models
1. FireAngel CO-9D
2. Forensics Detectors CAR001 (TW-5IA7-GGTV)
3. VLOXO Z807EBCMD001BK
4. FireAngel CO-9X
5. Kidde 10LLDCO

Table 2: Most Popular CO Detector Models used in the Trial

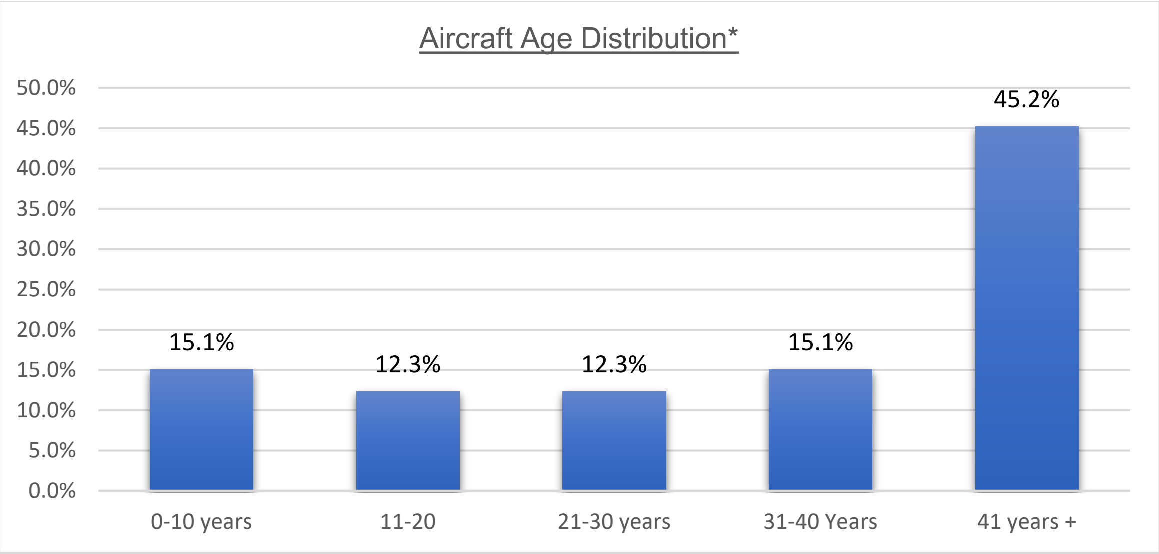
Aircraft

The trial involved over 90 individual aircraft from 38 manufacturers. A full list of the 56 aircraft types used in the trial can be found in Appendix III. Approximately 65% of the aircraft in the trial had a Certificate of Airworthiness while 35% had a Permit to Fly. The five most represented aircraft types in each of these airworthiness categories is shown in Table 3 below.

Certificate of Airworthiness Types	Permit to Fly Types
1. Piper PA-28	1. Eurofox 912
2. Cessna 172	2. Europa XS Mono
3. Robin DR400	3. Ikarus C42
4. Cessna 182	4. Luscombe 8
5. Grumman AA-5	5. Vans RV-8 and RV-9A

Table 3: Most Popular Aircraft Types used in the Trial

The aircraft age distribution for the trial is shown in Figure 1 below. Approximately 45% of the aircraft in the trial were at least 41 years old while the other age ranges were relatively evenly distributed. Historically, CO occurrences tend to increase with aircraft age so the fact that the trial involved a larger proportion of older aircraft is noteworthy.



*Data is based on the approximately 80% of participants who provided aircraft age data

Figure 1: Aircraft Age Distribution for the Trial

Flying Activity

To understand detector usage over the full flying season, participants were asked how many times they flew with their active CO detector each month. The results for each month of the trial are shown in Figure 2 below, which makes clear that participants remained active throughout the 12-month trial. As expected, there was a small drop off in flying activity during the winter months, but the majority still managed to fly at least 1-5 times per month.

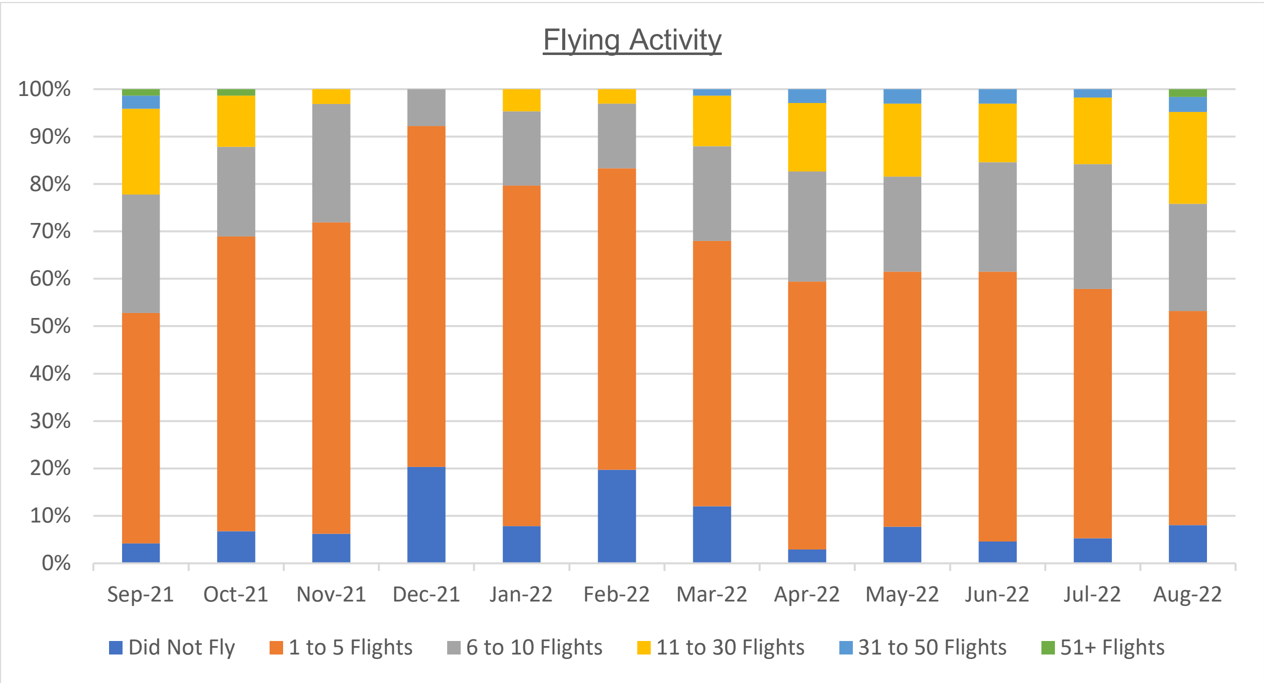


Figure 2: Monthly Flying Activity during the Trial

Detector Location

Identifying the optimal cabin location for an active CO detector is crucial for early and consistent CO detection. The best cabin location can vary not only by aircraft type, but also by individual aircraft as factors such as condition and modification status mean that no two aircraft are ever the same.

To help us understand how pilots currently use their devices, participants were asked to provide the location in the aircraft cabin where they kept their active CO detector when flying. This question was asked each month to understand if pilots were keeping their device in the same location or if they were trying different locations within the aircraft cabin. While some participants did experiment with different locations, most kept their device in the same location throughout the trial.

CO detector locations for each month of the trial are shown in Figure 3 below. Most participants kept their detector attached to the instrument panel when flying. This location offers clear benefits as the device is likely to be in the pilot's line of sight, helping to ensure that alerts are noticed. For devices with a digital screen, it also allows the pilot to visually monitor CO levels.

The second most popular answer choice was 'Other', which allowed participants to provide a written description of their detector location. The data showed a wide variety of alternative CO detector locations used by participants including, attached to the yoke, panel integrated (non-TSO), cabin floor area, seat frame, between front seats, forward bulkhead, window (via suction cup), door post, clipped to flying bag or passenger seat belt.

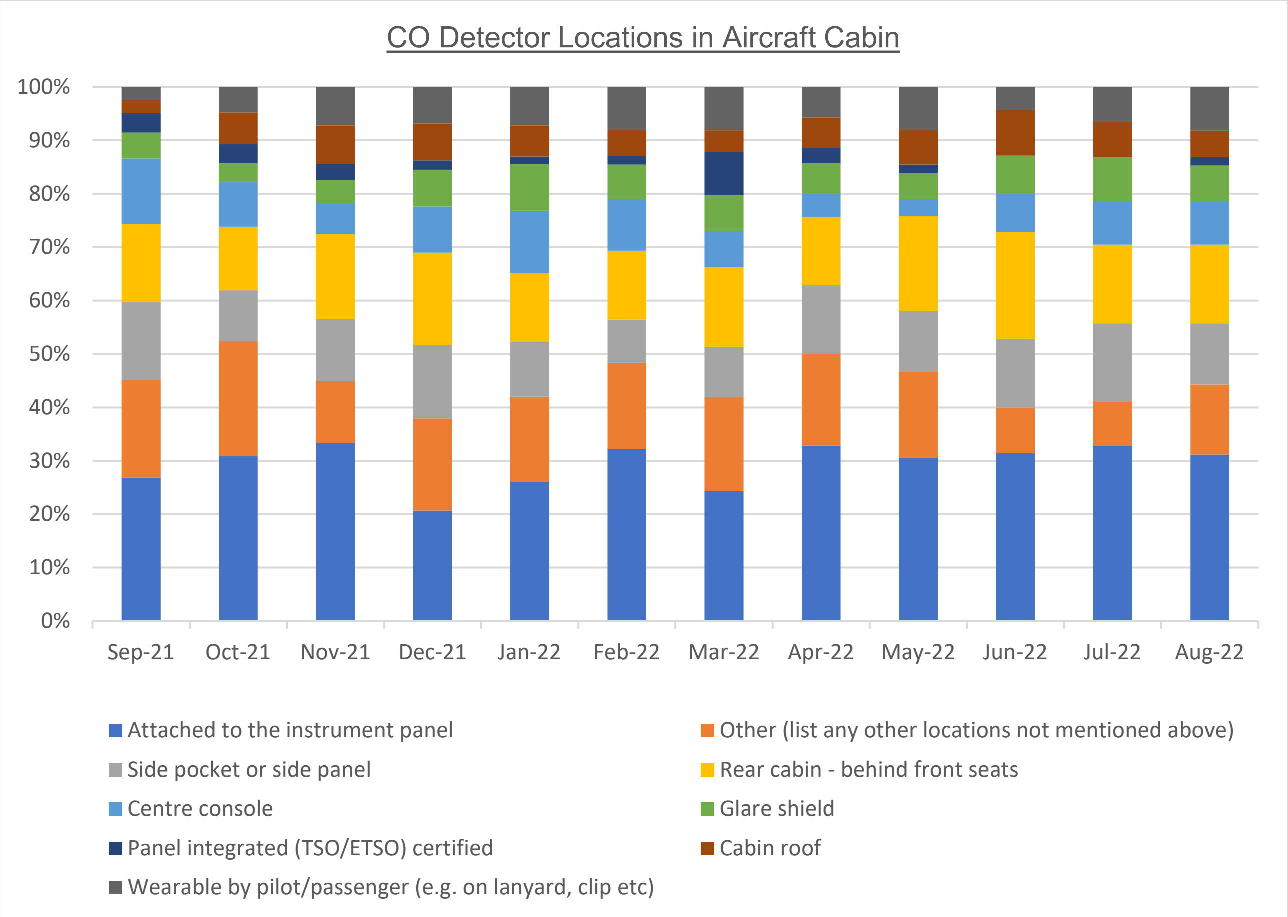


Figure 3: CO Detector Aircraft Locations

Number of CO Alerts

An important part of the trial was gathering data on the number of CO alerts over the course of a full flying season. The results are shown in Figure 4 below and indicate that at least 80% of respondents reported no CO alerts in each month of the trial. The highest number of CO alerts was seen in December, January, March, and April. With the exception of February, which had a low survey response rate, there was a small increase in the number of CO alerts during the colder months. This trend was expected and aligns with FAA research.

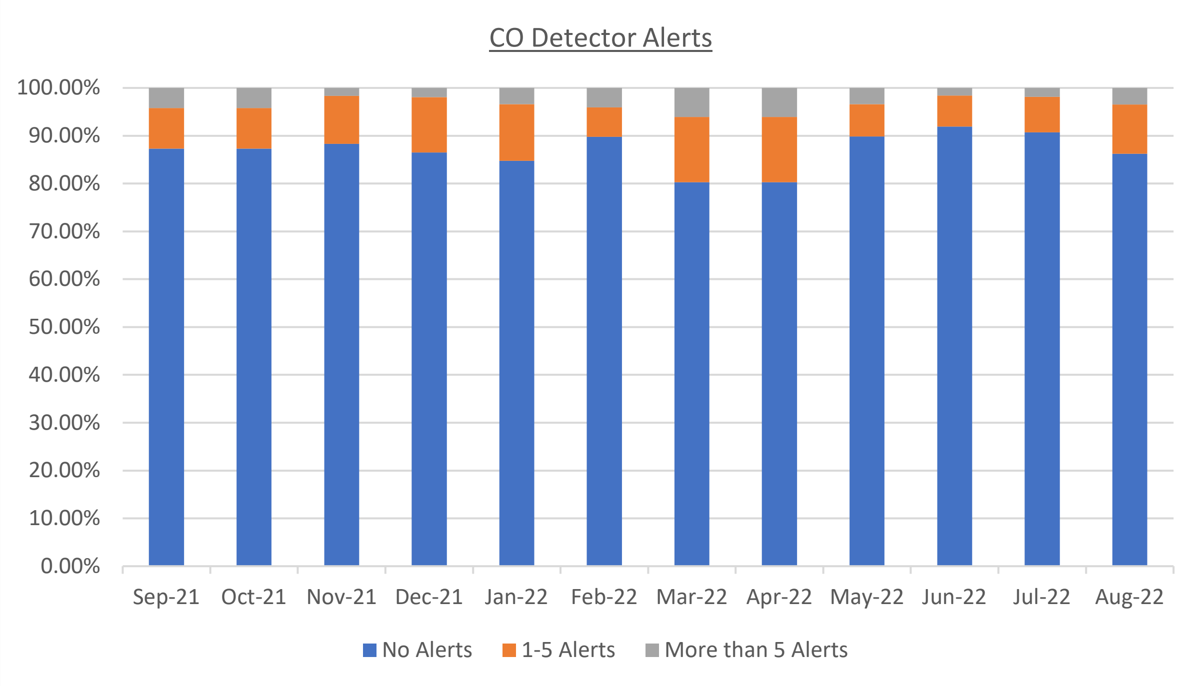


Figure 4: CO Alerts during the Trial

CO Alerts and Aircraft Age

Although most participants reported no CO alerts each month during the 12-month trial, there was a small but consistent number of alerts each month. We received a total of 70 responses for 1-5 alerts and a total of 26 responses for more than 5 alerts. Mapping these reported alerts against aircraft age yields the graph in Figure 5 below, which shows that the risk of CO generally increases with aircraft age. This trend was true even after adjusting for the fact that there was a greater number of older aircraft participating in the trial.

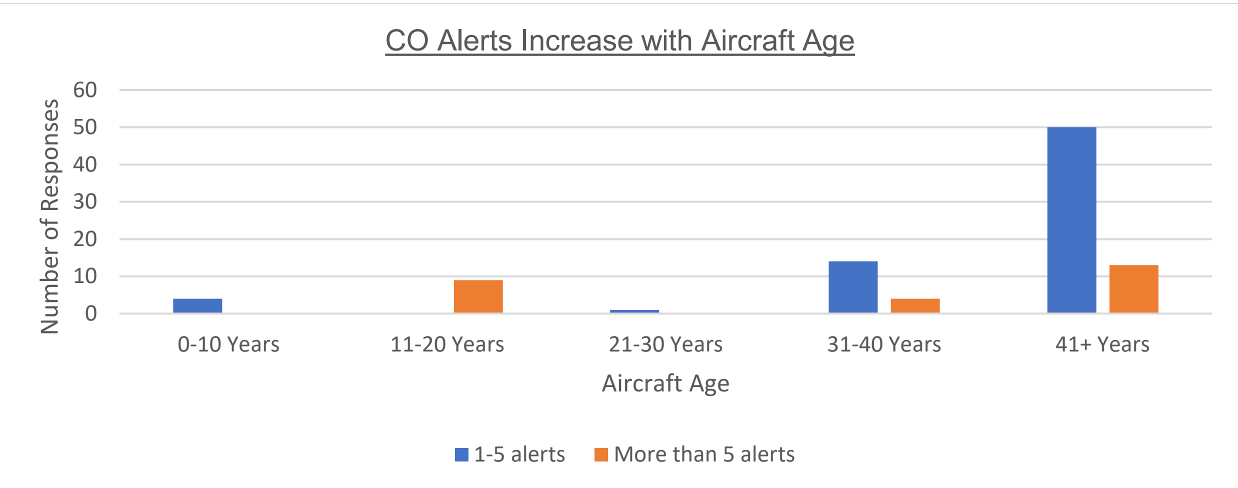


Figure 5: CO Alerts Increase with Aircraft Age

Recorded Peak CO Levels

In addition to CO alerts, participants were also asked to provide peak CO readings each month as recorded by their detector. Figure 6 below shows that for each month of the trial at least 75% of respondents recorded a peak CO reading of less than 50 ppm with many recording 0 ppm. Only 2% of reported peak CO readings throughout the trial exceeded 50 ppm; there was never more than three instances in any month. Additionally, there was no noticeable increase in peak CO readings during the colder months.

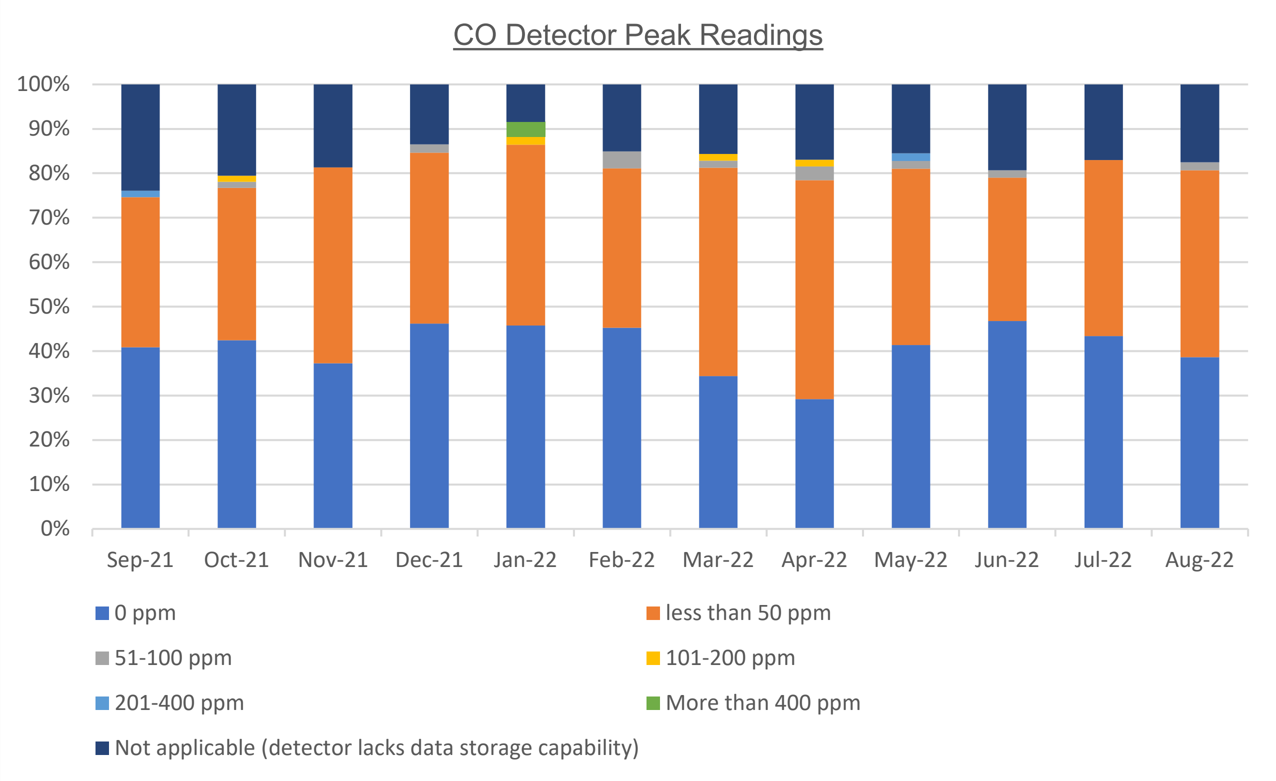


Figure 6: CO Detector Peak Readings during the Trial

Reported CO Poisoning Symptoms

Participants were asked each month if they experienced any health symptoms associated with CO poisoning (e.g. dizziness, headache, fatigue, vertigo, nausea). Over the full 12-month trial there was one report of a participant feeling light-headed despite relatively low levels (less than 50 ppm) of CO indicated by their detector.

While we cannot know for certain if the symptoms were attributable to CO in this instance, it is nevertheless a worthwhile reminder that CO builds up in the body over time. The cumulative nature of CO means that low-level, long exposure can be as dangerous as a concentrated, short duration event. An active CO detector can help pilots spot both situations.

There were no other reports of CO poisoning symptoms.

CO Detector Safety

Active CO detectors offer the clear benefit of alerting pilots to danger but introducing these devices into GA aircraft may also create unintended safety issues such as distraction or loose article risk (if portable). Participants were therefore asked each month if they had experienced any potential safety concerns due to flying with an active CO detector. The results are presented in Figure 7 below, which show that the overwhelming majority (over 88%) of respondents experienced no safety issues from flying with an active CO detector.

Of those who did report a potential safety issue, loose article risk and detector inaudibility made up 3.6% and 2.6% of reports respectively. There were even fewer reported instances of the CO detector causing a distraction (1.1%).

Participants also had the option of providing a written description of any other safety issues incurred from flying with an active CO detector. Most of the descriptions we received were to provide additional detail justifying selection of a specific answer choice (e.g. loose article, distraction etc.) rather than describing a new safety issue. However, the following issues were highlighted by participants:

- Malfunction believed due to hot/cold weather
- Battery going flat mid-flight
- Forgetting to turn device on or off
- Unit found failed without indication

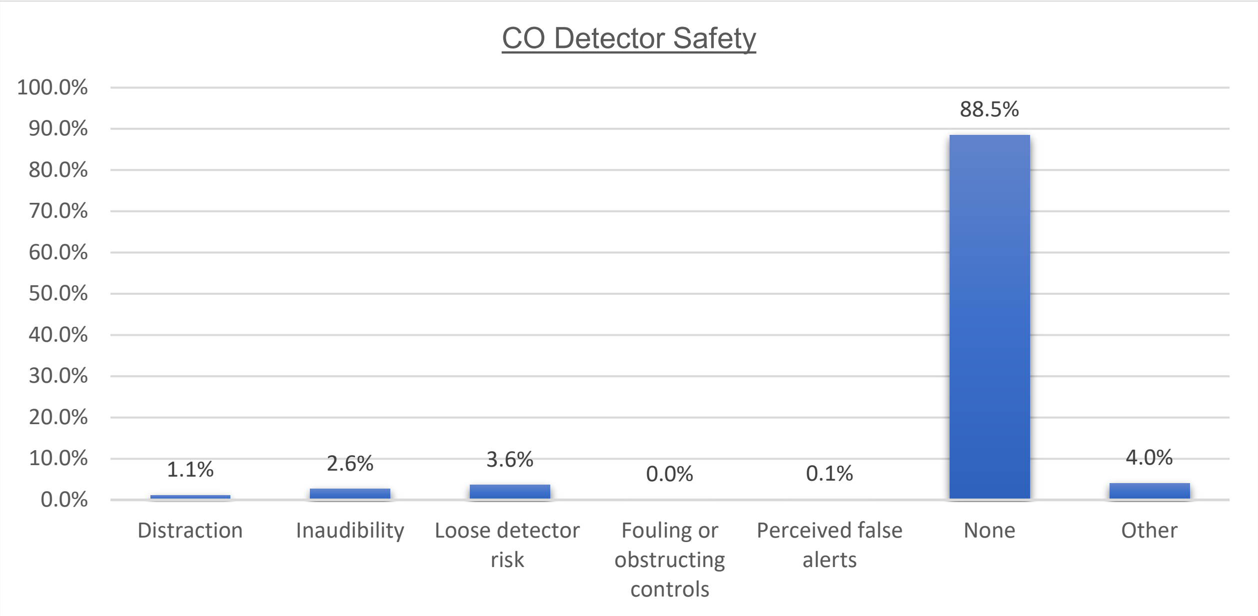


Figure 7: Reported Safety Concerns from Flying with an Active CO Detector

Findings

The year-long trial has generated valuable qualitative and quantitative data, improving our understanding of how low-cost active CO detectors perform in UK GA aircraft. Additionally, the study has given us important insight into pilot's user experience of flying with these devices as well as CO levels in a cross-section of the UK GA fleet.

The following points are some of the more significant findings from the 12-month study:

- For each month, at least 80% of respondents experienced no CO alerts.
- There was a small increase in the number of CO alerts during colder months with the highest number of alerts occurring in December, January, March, and April.
- All reported CO alerts came from 26 participants. Approximately a third came from just 3 participants and half came from 5 participants.
- The results support the notion that the number of CO alerts tends to increase with age. Approximately 66% of all CO alerts occurred on 41+ year old aircraft and 85% occurred on 31+ year old aircraft. However, it is worth emphasising that CO can be an issue for any aircraft, irrespective of age.
- For each month of the trial at least 75% of respondents recorded a peak CO reading below 50 ppm. Only 2% of all reported peak readings exceeded 50 ppm.
- There was one report of a participant feeling light-headed during the trial whilst their CO detector indicated a CO level below 50 ppm. We cannot know for certain if their symptoms were caused by CO, but low-level, long CO exposure can be as dangerous as sudden, high-concentration events.
- Approximately 88% of respondents experienced no safety issues as a result of flying with an active CO detector.
- We received over 100 descriptions of CO occurrences throughout the trial, not all of which resulted in an alert. Approximately 60% of these took place on the ground, during start-up and taxi.

The monthly surveys allowed participants to make additional comments, for example to elaborate on a previous answer or to raise additional points. The following points are a summary of the comments received throughout the trial:

- Multiple reports of pilots being alerted by their active CO detector to a fault with their engine or exhaust system. Active detectors are also being used by pilots to identify pathways for CO to enter the cabin e.g. worn seals, drain holes, gaps.
- Several participants described dissatisfaction with passive 'spot type' detectors due to their lack of alerting and in some instances failure to indicate the presence of CO by changing colour.
- For CO detectors that can be turned on/off, there were numerous reports of participants either forgetting to turn their device on before flying or forgetting to turn it off post-flight, resulting in a drained battery. Some updated the relevant checklists to prevent this.
- Many participants commented on the benefits of having an active CO detector with a digital display, allowing them to monitor ppm readings in real time. If your device has a digital display, ensuring it is in line-of-sight of the pilot is highly recommended.

- Some active CO detector models consume batteries at a quicker rate. For this reason, some pilots choose to carry spare batteries when flying. Pilots are encouraged to shop around and speak to other pilots to find a device that suits their needs.
- A small number of participants experienced a CO detector failure with the display either showing 0 ppm or an error code such as ‘888’, which could be mistaken for a CO reading. Pilots are encouraged to routinely test their device to ensure it is working correctly and familiarise themselves with the various audio/visual communication means used by their device to avoid surprises when flying.
- Whilst most participants did not report audibility issues some described difficulty hearing alarms when wearing noise cancelling headsets. There are detectors on the market that alarm at higher decibel levels, which may be better suited to some pilots, especially if they fly with a noise cancelling headset.

Conclusion

Firstly, the CAA would like to thank all those who participated in the 12-month active CO detector study. Their commitment and diligence in completing the monthly surveys is greatly appreciated and will help to advance aviation safety. The contributions from the participants have yielded important insights into how low-cost active CO detectors perform in GA aircraft and has also helped us fully understand the user experience of flying with these devices. Additionally, the monthly surveys have given us a better sense of CO levels in the UK GA fleet.

Findings from the 12-month trial combined with a review of CAA MOR data suggest the risk of CO exposure remains a persistent background threat throughout the year and is somewhat elevated during cold weather operations. Anecdotal test evidence supported by results from the 12-month study suggest that active CO detectors designed for domestic use can function reasonably at typical recreational GA altitudes (up to 5000’). However, bearing in mind domestic devices are designed for ground use, reliance on specific ppm readings should not be assumed as being 100% accurate.

The Skyway Code describes good decision making as being key to avoiding or mitigating risk rather than relying on skill or luck. Whilst effective maintenance remains the first line of defence against CO and is the only way to avoid exposure, choosing to fly with an active CO detector is a decision pilots can make to protect themselves and their passengers from CO should maintenance fail. With a wide range of active CO detectors on the market it has never been easier for pilots to find a device that suits their needs and budget. Active CO detectors are increasingly being built into other aviation equipment as standard, including ADS-B and headsets, making them ever more prevalent in GA aircraft. Additionally, some active CO detectors can be paired to personal electronic devices such as smartphones and smartwatches, increasing the likelihood of being alerted to elevated CO levels.

The evidence gathered to date indicates that active CO detectors capable of alerting pilots via aural and/or visible warnings are a net safety benefit to GA pilots and their passengers. Whilst the risk of CO poisoning may be known and understood by many GA pilots, the same cannot be said for consumers and third parties generally, who may fly in piston engine aircraft on a commercial or recreational basis. Pilots therefore ought to consider the significant safety benefits offered by flying with an active CO detector – it could not only save your life, but your passengers’ as well!

Recommended Reading

The following sources contain useful general information on the nature and effects of carbon monoxide as well as specific prevention and detection measures available to pilots.

- Carbon monoxide in general aviation | Civil Aviation Authority (caa.co.uk)
- CAA Safety Notice SN-2020/003 Version 3
- Piper PA-46 Malibu (N264DB) AAIB Special Bulletin S2/2019 and Final Report
- Scheibe Super Falke SF25E (G-KDEY) AAIB Final Report
- CAA Publication (CAP) 562 'Civil Aircraft Airworthiness Information and Procedures' CAAIPS Leaflet B-190 'CO contamination'
- CAA Publication CAP 747 'Mandatory Requirements for Airworthiness' Generic Requirement (GR) 11
- LAA 'Light Aviation' magazine article 'The Canary & the Silent Killer', July 2017
- FAA Report 'Detection and Prevention of Carbon Monoxide Exposure in General Aviation Aircraft', 2009 (DOT/FAA/AR-09/49)
- FAA Pilot Safety Brochure, Carbon Monoxide: A Deadly Menace
- CAA Clued Up (July 2021), Carbon Monoxide
- FLYER article 'Top Gear; Carbon Monoxide Monitors'; August 2019
- EASA Safety Information Bulletin (SIB) No. 2020-01R1
- Transport Canada Civil Aviation Safety Alert (CASA) 2019-07
- Australian Civil Aviation Safety Authority Airworthiness Bulletin, AWB 02-064 Issue 5 – 30 June 2023, 'Preventing Carbon Monoxide Poisoning in Piston Engine Aircraft'

Appendix I

Monthly Survey Questions

* 1. Please provide your contact email address. We need this to track and monitor responses.

2. Do you need to update any details you shared in the previous survey relating to:

- Make & Model of active CO detector
- Make & Model of aircraft mostly flown
- Age of aircraft mostly flown

◯ Yes

◯ No

3. Please provide the make and model of each active CO detector(s) you are using for this trial. e.g. FireAngel CO-9D, Kidde 10LLDCO

Detector Make:

Detector Model:

4. In the last month, which aircraft type and model have you flown the most? e.g. Cessna 172, Van RV-12, Robinson 44, etc

Aircraft Make:

Aircraft Model:

5. Approximately how old is the aircraft that you mainly flew in the last month?

☐ 0-10 years

☐ 11-20

☐ 21-30 years

☐ 31-40 Years

☐ 41 years +

6. In the last month, approximately how many times have you flown with your active carbon monoxide detector?

◯ 1-5

◯ 6-10

◯ 11-30

◯ 31-50

◯ 51+

◯ I did not fly with my CO detector in the last month

Anything else you would like to add:

7. In the last month, approximately how many CO alarms* have you had?
*by alarms we mean that you have heard or been alerted to your CO detector(s) reacting to a possible CO leak in the cockpit

- ◯ 0
- ◯ 1-5
- ◯ More than 5

8. In the last month, what is the highest parts per million (ppm) reading recorded by your CO detector(s)

- ◯ 0 ppm
- ◯ less than 50 ppm
- ◯ 51-100 ppm
- ◯ 101-200 ppm
- ◯ 201-400 ppm
- ◯ More than 400 ppm
- ◯ Not applicable (detector lacks data storage capability)

9. In the last month, where have you kept your CO detector(s) while flying (tick all that apply)
If you would like to share photographs of the location of your CO detector(s) when flying please send to CODE@caa.co.uk

- ☐ Panel integrated (TSO/ETSO) certified
- ☐ Attached to the instrument panel
- ☐ Cabin roof
- ☐ Side pocket or side panel
- ☐ Centre console
- ☐ Glare shield
- ☐ Rear cabin - behind front seats
- ☐ Wearable by pilot/passenger (e.g. on lanyard, clip etc)
- ☐ Other (list any other locations not mentioned above)

10. In the last month have you experienced any of the following while flying with your CO detector(s)? Please tick all that apply.

- ☐ Distraction (e.g. unable to silence detector following activation, low battery warning etc)
- ☐ Inaudibility (e.g. due to noise cancelling headset, general background noise etc)
- ☐ Loose detector risk (CO detector loose in the cockpit)
- ☐ Fouling or obstructing controls
- ☐ Perceived false alerts
- ☐ None

Other (Please list any other issues experienced)

11. If your CO detector(s) had a measurable reading in the last month, did you experience any of the following symptoms? Please tick all that apply.

- ☐ Dizziness
- ☐ Headache
- ☐ Fatigue
- ☐ Vertigo
- ☐ Nausea
- ☐ Did not experience any symptoms
- ☐ Anything else you would like to share?

12. If you did experience a CO alert in the last month, please can you provide a brief description of each occurrence? Please can you include a reference to the CO reading, if known, the flight phase when you experienced the CO alert and if the cabin heat was on or off.

13. Are there any other comments you would like to make?

Appendix II

List of CO detectors used in the trial (duplicates not shown, unique models only)

Active CO Detector Trial - Detector Make & Model
Aico Ei208
Aithre Shield Ex 2.0
Aithre Shield Ex 3.0
CO Experts 2016
FireAngel CO828
FireAngel CO-9B
FireAngel CO-9D
FireAngel CO-9X
FireAngel TCO-9BQ
First Alert CO400
First Alert CO-FA-9B
Flight Data Systems GD-40
Forensics Detectors CAR001 (TW-5IA7-GGTV)
Guardian Avionics Aero 353
Guardian Avionics Aero 452
Guardian Avionics Aero 551
Honeywell BWC2R-M20100
Honeywell XC100
Kane 77

Active CO Detector Trial - Detector Make & Model
Kidde 10LLCO
Kidde 10LLDCO
Kidde 5CO
Kidde 5DCO
Kidde 7COC
Kidde 7DCO
Otis Tocsin OI-315
Ourjob OJB-CO701-Y
S805
Scondaor DL-C101A
Senko SO-SGT-CO
Sensorcon AV8 Inspector
Sensorcon AV8 Inspector Pro
Sensorcon Inspector
SleepSafe COA10
Smartwares RM370
ST9700
Testo 317-3
Toxin Sensors CM-2010
VLOXO CO Detector (Z807EBCMD001BK)

Appendix III

List of aircraft types in the trial (duplicates not shown, unique types only)

Active CO Detector Trial - Aircraft Types

Aeropro Eurofox 912s	Grumman AA-5
Aquila A210	Jabiru J430
Auster 5J4	Jodel DR1050
Auster J1	Luscombe 8
Beechcraft BE24	Maule M-4
Best Off Skyranger Swift 2	Mooney M20
Binder CP-301 Smaragd	Morane-Saulnier MS-893
Bolkow BO 208C	Piper PA-17
BRM Aero Bristell NG 5	Piper PA-22
Cessna 120	Piper PA-25
Cessna 152	Piper PA-28
Cessna 172	Piper PA-30
Cessna 180	Piper PA-31
Cessna 182	Piper PA-32
CFM Streak Shadow SA-1	Piper PA-46
Cirrus SR22	Reims Cessna FR-172
Comco Ikarus C42	Reims Cessna FRA150
CSA SportCruiser	Robin DR400
Cubcrafters Carbon Cub	Rockwell Commander 114B

Active CO Detector Trial - Aircraft Types

Denney Kitfox Mk2	Slingsby T67 Firefly
Diamond DA-42	Socata TB10
Diamond Dimona TMG	Vans RV-10
Eurofox 3K	Vans RV-12
Europa XS Mono	Vans RV-8
Evektor EV-97	Vans RV-9
Flight Design CTSW	Wassmer WA-52
Fuji FA-200	Zenair Zenith CH701SP
Grob G109	Zenair Zodiac CH601XL