



THE CANARY & THE SILENT KILLER

Doug Blair, mining engineer, pilot and LAA Safety Group member, on the dangers of carbon monoxide poisoning in aircraft

In 1913, an explosion occurred at Universal Colliery, Senghennydd, South Wales, which claimed the lives of 439 'men and boys'. In 1866, an explosion at The Oaks Colliery, Barnsley, claimed the lives of 361 men and rescuers. And in 1910, one at the Pretoria Pit in West Houghton, Lancashire, killed 344 men, there being only four survivors. These examples are the UK's three worst mining disasters.

However, contemporary accounts suggest that very few of the victims actually died from

(Above) This carving of a miner with his caged canary in Strasbourg, northeastern France, commemorates the crucial role played by the bird in detecting the presence of carbon dioxide underground. (Photo: Ji-Elle/Wikicommons)

the violence of the explosion. In the Inspector of Mines' reports, comment is often made about the uninjured state of the victims, most of whom died from the gases produced by the resulting fires.

Decades on, in his reports concerning the disasters at the William Pit (Whitehaven, Cumbria, 1947) and the Creswell Colliery (Derbyshire, 1950), Sir Andrew Bryan, the Chief Inspector of Mines, called for research to take place into providing self-rescue apparatus for miners to carry which would give them some protection against carbon monoxide (CO), the 'silent killer'. Despite that, a usable 'self-rescuer' wasn't carried by every miner until 1967.

Over the last forty years, increasingly more reliable carbon monoxide detectors have been developed and coal mines have extensive air monitoring systems. Coal will oxidise in situ or spontaneously combust, so early warning is vital. This happens in an oxygen-deficient atmosphere, producing carbon monoxide. An ambient reading might be three ppm (parts per million) and a warning might start at six ppm.

FIRST, BACK TO SCHOOL...

If hydro carbons are burnt in an oxygen-deficient atmosphere, then the incomplete combustion creates carbon monoxide, as a fire has to have copious quantities of oxygen for complete combustion. For example, when you're having a bonfire in the garden, look at the yellow flames, they're oxygen deficient. However, if you see yellow flames in a gas appliance, have it checked!

Returning from underground to the surface, the unfortunate expression 'stick your head in the oven' worked very effectively in the days of

CARBON MONOXIDE, IN PARTS PER MILLION (PPM) OF OXYGEN

CONCENTRATION	SYMPTOMS
35ppm (0.0035%)	Suffering a headache and dizziness within six-to-eight hours of constant exposure.
100ppm (0.01%)	Slight headache in two-to-three hours.
200ppm (0.02%)	Slight headache within two-to-three hours, loss of judgment.
400ppm (0.04%)	Frontal headache within one-to-two hours.
800ppm (0.08%)	Dizziness, nausea, and convulsions within 45 minutes, insensible within two hours.
1,600ppm (0.16%)	Headache, increased heart rate, dizziness, and nausea within 20 minutes, death in less than two hours.
3,200ppm (0.32%)	Headache, dizziness and nausea in five-to-ten minutes. Death within 30 minutes.
6,400ppm (0.64%)	Headache and dizziness in one-to-two minutes. Convulsions, respiratory arrest, and death in less than 20 minutes.
12,800ppm (1.28%)	Unconsciousness after two or three breaths. Death in less than three minutes.



(Above) Guardian Avionics makes a number of CO detectors. This is the company's panel-mount Aero 353 detector, which costs from \$289 to \$389, depending on the specification.



(Above) This is an example of a 'Dead Stop' CO warning card, which goes black in the presence of carbon monoxide. These cards are lifed, generally for no more than twelve months after opening, and some, once they've gone black, are no longer serviceable. Others, like this example from Aircraft Spruce and Specialty, return to their neutral colour once the CO presence has ceased and can continue to be used. Make sure you date the card and replace it when its life has expired.

(Right) A domestic CO detector may be used, though they're somewhat larger than purposely designed aviation examples. A quick trawl of the internet brought up this FireAngel CO-9D device, which is 120mm x 74mm x 40mm deep, runs for seven years on its lithium battery and costs just £18.



coal gas, which was made by heating coal in the absence of oxygen. Coal gas had a high CO content to burn and provide carbon dioxide (CO₂).

Today's natural gas is rather less effective as a domestic killer, as it suffocates by lack of oxygen rather than poisons people, but it's still deadly. Carbon monoxide is colourless and odourless, it's the 'silent killer'.

The current safety requirements around combustion heaters, gas fires, coal fires, wood burners, etc, are largely based around having sufficient ventilation to obtain complete combustion and also to ensure that the products of combustion are flued away from people. We'll all have read of cases where people have fallen asleep on the arm chair in front of a nice cosy fire, never to wake up.

HOW THE SILENT KILLER WORKS

Red blood cells contain a dark-crimson chemical called haemoglobin that combines with oxygen in the lungs to form oxyhaemoglobin, which transports the oxygen to where it's needed around the body.

Unfortunately, haemoglobin prefers to combine with carbon monoxide to form carboxyhaemoglobin, thus excluding the oxygen. Carboxyhaemoglobin takes a long time to reduce in the blood, four-to-six hours to reduce by half. Therefore, with increasingly less oxygen being transported around the body we slowly and quietly die, blissfully unaware of our symptoms.

The legislation requiring canaries or other small birds to be kept at coal mines was only rescinded in the mid-1980s, with the development of reliable carbon monoxide detectors. The law required a small bird to

be taken to a fresh air base when rescue teams were deployed.

The canary has a much faster heartbeat than the human and it therefore absorbs the carbon monoxide faster, and obligingly falls off its perch before we do. Some clever cages with oxygen cylinders to revive the poisoned birds were developed, but remember, it takes a long time to clear carbon monoxide from the blood and return it to transporting oxygen, in both canaries and humans.

GREAT DANGER ALOFT!

We all fly about in a device with a hydrocarbon and oxygen-exploding device up front, one which emits exhaust fumes that, due to imperfect, incomplete combustion, contain carbon monoxide.

Aviators aren't helped by the oldish design of our engines and the lack of the emission control add-ons which are found in today's automobile powerplants. We only have short exhausts, unlike in automobiles where the nasty stuff is piped to the rear, and often cockpits aren't very well sealed. The gaps in the seals and some of our vents also create suction as we fly along. That's why an inside static might read higher on the altimeter (less pressure), than an outside one. Also, the propeller creates a swirl of air, probably containing exhaust gases, around the fuselage. The above describes my Jodel, and most other light aircraft, very well.

Reduced pressure in the cabin will suck in any carbon monoxide that isn't being forced out into the slipstream. And if there are exhaust leaks and suitable small holes in the firewall, CO can be readily sucked into the cabin. In addition, during cold weather or at altitude, a cabin heater uses an exhaust heat exchanger

and if it's corroded or cracked, then it'll blow in carbon monoxide.

As the CO is odourless and colourless, you'll have no idea that you're being poisoned and the effects will slowly build up. You may become sleepy and get a thumping headache, by which point your brain is poisoned and will slow down, impairing logical thought.

METHODS OF DETECTION

We can't personally detect carbon monoxide so we must either take a canary flying or install a device to detect it. The latter amounts to either the 'dead stop' colour-changing card, which should be included in your regular checks, or a domestic or purposely designed aviation CO alarm.

I use a domestic alarm, which also has a readout. LAA Engineering are happy that, providing common sense is used, we can use portable carbon monoxide monitors, but be aware that the domestic fixings may not be adequate for aircraft use.

So if you're flying, start to feel unwell and think that you may be in the initial throes of suffering carbon monoxide poisoning, or your detector turns black or sounds an alarm, in the first instance continue to pilot the aircraft.

You'll need lots of fresh air so, if you have an exhaust heater and it's on, turn it off. If the vents will rotate to force air into the cabin, that'll also help — I've also read of a rolled-up map being used to duct air to the pilot's face via the direct vis panel.

Next, check that the engine is correctly leaned so it has efficient combustion, tell someone about your predicament and accept that your brain power is more reduced than normal — go for simple options. ■