Carbon Monoxide

In this issue of *Vector* there is an article about the tragic loss of an aircraft and pilot due to the effects of carbon monoxide. This article takes a generic look at carbon monoxide, how it is formed, the effects on the human body, and some preventive measures to help you avoid a fate similar to that of the unfortunate pilot in the accompanying article.

Carbon monoxide (CO) is a by-product of combustion in engines. If you can remember your high school chemistry, you will recall that the process of combustion combines oxygen from the air with fuel – basically a series of carbon, oxygen and hydrogen molecules – to produce as the main exhaust products, carbon dioxide (CO_2) and water (H_2O). If the combustion is incomplete, or if there is a shortage of oxygen in the burning mixture, then sometimes instead of forming carbon dioxide, the result is an increase in the levels of carbon monoxide (CO).

Carbon dioxide (CO_2) forms a small but significant percentage of the air around us. Indeed, when you breathe out, the air you exhale contains CO_2 that your body has produced as part of your metabolism. In that respect, your body is just like an engine; it turns oxygen and food (carbon/oxygen/hydrogen molecules) into energy, water and CO_2. The oxygen that keeps this process going is carried around your body in the red cells of your blood, attached to molecules of haemoglobin. The CO_2 produced by the cells is also carried away by the haemoglobin, to be excreted through your lungs. Your body actually needs a certain level of CO_2 in it to trigger and regulate your breathing and cardiovascular system.

The key difference between carbon monoxide and carbon dioxide, from our point of view, is their effect on our bodies.

Carbon dioxide (CO_2) is a natural part of the respiratory cycle, and it is constantly being exchanged for oxygen in our blood.

Carbon monoxide (CO) is a much more reactive molecule, and it has a far greater affinity for haemoglobin in the blood. Rather than being easily exchanged for oxygen in the lungs, it tends to stick to the haemoglobin, and this prevents the blood picking up oxygen. This lack of oxygen has basically the same effect as hypoxia – that of being at too high an altitude. Early symptoms include degradation of vision and increasing loss of concentration and cognitive skills. Skin colour changes as the blood loses oxygen. Motor skills also degrade, making it harder to keep coordinated, or to carry out manual tasks with any degree of finesse. Prolonged exposure to high concentrations of CO can lead to loss of consciousness – then death. Unlike lack of oxygen due to being at high altitude, CO poisoning can not be fixed quickly or simply by descending to thicker air, or by taking some breaths of oxygen. Because of the affinity of the CO molecule for haemoglobin, it takes quite a while (up to several hours) for the body to replace the CO in the blood with oxygen.

CO is tasteless and odourless, which adds to the danger it poses to pilots. Where CO poisoning has occurred through a fault in the exhaust system, it is possible that the pilot may detect other smells from exhaust gases, but the CO itself is undetectable. Given the very insidious nature of the symptoms of CO poisoning, similar to hypoxia, it would be easy to miss the telltale signs until it is too late to react effectively.

Carbon Monoxide Detectors

One line of defence is to fit the aircraft with a CO detector. These come in two basic types.

The simplest, and initially the cheapest, are panel mounted 'spot' detectors. About the size of a credit card, these units have an exposed spot of a chemical that changes colour in the presence of CO.

These cards do have a downside, in that all of the currently available products have a limited life in service. While the chemical reaction that causes the spot to darken is nominally reversible, in practice most units discolour over time. The instructions that come with the unit will state the in-service life of the particular product. They typically range from one to 18 months, depending on the cost of the unit. Costs are generally in the order of $10 to $20.

Place your CO detector where it can be easily seen.

The *Vector* observation is that, towards the end of the stated in-service life, most of these detectors start to show significant darkening or discoloration. This could pose a dilemma to the pilot who isn't sure whether the colour observed is due to the age of the detector, or is a result of the presence of CO. It therefore pays to replace the units whenever discoloration is apparent, or the stated life, whichever comes first.

These units are also passive, which means they won't explicitly warn you about CO – you have to look at them. This means that they have to be part of your regular cycle of instrument scan or airmanship checks. The unit should also be located in the cockpit in an easily seen, prominent location. The expiry date of the unit should be clearly marked on it.

The other generic type of CO detector uses similar technology

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to that found in home smoke alarms. They are generally about the size of a cigarette packet, and they use an electronic system to provide programmable warnings about CO levels.

These units are more expensive than spot detectors, around $80 to $100 for the cheapest, with more expensive ones available. Some of these units have a limited service life, but this is usually measured in years rather than months.

They have the distinct advantage of providing an alarm function, normally visual (flashing lights) as well as audio, so give a better warning of the presence of CO. Another advantage these units have over the spot type is that they generally have a shorter reaction time, and they can indicate the presence of CO much more quickly than the spot type. They can also show when the ambient CO level has decreased (eg, from turning off the heater), while the spot type take some time to return to the original colour. Like all things electronic, they are only as good as the battery, so this needs to be checked regularly and changed when necessary.

An increasing number of GA aircraft are being fitted with a detector, which is good to see. Some pilots are also choosing to purchase their own personal detector, which they carry with them in their flight bag. Given the low cost of detectors, this is a fairly cheap form of insurance. Note that such detectors have uses apart from aviation – CO poisoning from vehicles or gas burners is not unknown.

The *Vector* advice is that all piston-engine aircraft, where there is a possibility of exhaust gas reaching the cockpit, should be fitted with a CO detector. Pilots should check the detector as part of the preflight. The check should include colour and expiry date for the spot type, or a system and battery check for the alarm type.

Preflight and Inflight Precautions

The preflight check should always include a careful examination of the exhaust system and any heating ducts that the aircraft uses. Cracks in the exhaust pipes, or perished ducting, can increase the potential for CO to enter the cockpit. At a deeper level of check, the firewall should be inspected to ensure that all holes and gaps remain sealed. Similarly, all cowls and seals around the engine and cockpit should be regularly checked for integrity.

Even a well-tuned engine with the right mixture setting will produce some carbon monoxide. A poorly-tuned engine, damaged spark plugs, or incorrect mixture settings can all significantly increase the amount of CO being produced.

A regular check of the CO detector should be part of your activity cycle in flight. It would pay to be particularly vigilant if using the cabin heating.

Suspected CO Poisoning

What are you going to do if your detector indicates that you have been exposed to carbon monoxide? The actions you take will depend on circumstances, including the location of the aircraft, the proximity of somewhere suitable to land, and the degree of exposure. We can't legislate for all circumstances, but we can give some general guidelines.

Firstly, try to isolate the source of the CO. If cabin heat is selected on, turn it off. Ventilate the cabin with as much fresh air as you can. If you are fortunate enough to have oxygen available, use it. Changing power setting, mixture setting, aircraft configuration or speed may all change airflow and CO levels in the cabin.

Check yourself for symptoms. Check your vision. Advanced CO poisoning may show up by a change in your skin colour – maybe your fingernails have turned bluish (but be careful not to confuse temperature effects, such as cold fingers, for CO exposure).

Let someone know of your predicament. A PAN or MAYDAY call to ATC may be in order. They may be able to help you to the nearest suitable landing place, or monitor your flight path.

Remember that the effects of CO take a considerable time to clear. A couple of breaths of fresh air might make you feel better, but the effect of the CO on your cognitive ability and motor skills may take some time to disperse. For that reason, it will generally be advisable to land as soon as you can. You might have to remain airborne a long time to regain your full faculties, and in that time may continue to be exposed to CO, or have more of a chance to make a mistake. Think carefully before you do anything, and make the simplest arrival you can. Don't make life any harder on yourself than it has to be.

Summary

- Carbon monoxide is a known killer of pilots.
- Carbon monoxide has an effect on the body similar to hypoxia, but it takes longer to clear after the source of CO is removed.
- Carbon monoxide is odourless and tasteless.
- The only sure warning is an up-to-date CO detector.
- Check exhaust and heating systems thoroughly as part of the preflight.
- Be particularly vigilant for the effects of CO if you are using cabin heating.
- If CO is detected or suspected, isolate the source and ventilate the cabin.
- Let someone know of your predicament, and land sooner rather than later. ■

STOP PRESS

In recognition of the safety hazard posed by carbon monoxide, the CAA has decided to present a CO detector to most piston-engine aircraft operators in New Zealand. These will be delivered about the same time as this issue of *Vector*. We are sending CO detectors to operators of the aircraft we think most applicable. If you have received one and do not need it, please pass it on to someone who does. If you have not received one and feel you should have, please email info@caa.govt.nz with your client number and aircraft registration.

The units chosen are the commercially available 'Dead Stop' detectors available from a number of sources within New Zealand. They have a limited life of not more than 90 days. If you are already using a detector in your aircraft, well done – consider this a bonus. If you are not, CAA hopes this will act as the impetus for you to continue to fit a detector to your aircraft.

The CAA has consulted with a number of importers of detectors. Choosing the 'Dead Stop' detector is in no way a CAA endorsement of this or any other product. Nor is it expected that the importers will lose business as a result of this initiative. Rather, it is expected that there will be an increased demand for detectors once operators get into the habit of having one fitted to their aircraft.