Knowing where carbon monoxide is generated and how to reduce or stop it are important to not becoming one of this poison's victims

■■ Is carbon monoxide poisoning in the cockpit fate or suicide? Suicide is at least 75% of the correct answer, but it is suicide through lack of knowledge, like spiral crashes. As long as the cabin air is heated by direct exposure to the exhaust pipe, the leakage of exhaust gases into the cabin air will be a possibility.

In a four-year period, FAA found 38 reports of carbon monoxide (CO) in the cockpit causing 19 illnesses and 12 fatalities. As little as 0.06% of CO in the air we breathe can cause unconsciousness within two hours, so says FAA. However, pilots are not told that they have a great deal of control over the generation of CO. They are told to have exhaust heaters checked for cracks, etc., but not one word as to what can be done about reducing the formation of CO.

What prompted the writing of this article was the article in the November 1966 issue of FAA Aviation News, entitled "Where 'Good Enough' Is Not Good Enough." The article tells about FAA's extensive program to reduce the CO hazard, such as 3,500 hours of engine tests. After three years of research and testing, the only advice FAA has for us pilots is that a low-cost CO detector is needed, and "be especially careful when you smell fumes. CO is probably present, too." There was not one word on the most important knowledge needed by the pilot. This is not a matter of turning down the cabin heater and opening the fresh air vents because the pilot will then be knocked out by freezing air rather than by CO poisoning. I am confident that I could safely fly an airplane with a defective exhaust muff cabin heater that FAA has found to have caused a proven fatal CO poisoning and use the exhaust pipes and cabin heater from the crashed airplane (assuming that they have not been damaged in the crash). I am confident that I could do this with the cabin heater full on and on an extremely cold day when minimum outside air ventilation would be used.

What is the secret? There is really no secret. One must know where CO comes from and be able to reduce or stop the generation of this poison. CO is the product of fuel wasted in the combustion process. No wasted fuel, no CO. Just that simple. Figure 1 shows the relationship between mixture setting, exhaust gas temperature (EGT), and CO generated. For the illustration shown, the mixture is 200° F below peak EGT which gives a mixture setting of 9.3 pounds of fuel per 100 pounds of inducted air and a CO content of the exhaust gases of 8.8%. It is quite common for pilots to cruise at full rich at 5,000 feet and even higher, especially those pilots who have been mistakenly told to run good and rich, because fuel is cheaper than engines. At 5,000 feet and full rich, the EGT can be 200° to 400° F from peak EGT, and from Figure 1, it will be noted that the CO generated is 8.8% to 17.6%. It is evident from Figure 1 that an EGT indicator is a CO indicator in addition to being a mixture indicator.

Don't conclude from Figure 1, however, that the CO content of the exhaust gas can be reduced to the low value shown by leaning to peak EGT or leaner, because the data shown in Figure 1 are for a single cylinder or for an engine where all cylinders receive the same mixture, i.e., perfect fuel-air distribution. Therefore, part of the blame for CO poisoning can be laid to the engine design. When the aircraft engine manufacturers go to the same effort to reduce wasted fuel in the exhaust that some automotive engine manufacturers are now doing in order to reduce smog, the data shown in Figure 1 will apply very closely to the total engine exhaust.

Because fuel-air mixture distribution is now far from ideal for most aircraft engines, the average engine has 2% to 4% CO content for the total exhaust when the leanest cylinder is leaned to peak EGT. By leaning the leanest cylinder to 50° F below peak on the lean side, the CO content for the total exhaust is cut to 1% to 2%. If all cylinders received the same fuel-air mixture, the CO content would closely approach zero at peak EGT. As to whether one should cruise with a mixture setting on the lean side of peak EGT is a controversial matter. Continental says no and Lycoming says yes for their fuel-injection engines. This writer gave his views in the October 1965 issue of The PILOT, "How Lean Is Too Lean?" (page 38). As controversial as this subject may be, there is no question that running on the lean side of peak reduces the generation of CO.

With minor engine changes, the CO content generated could be significantly reduced. For example, about a year ago the author flew a very popular lightplane that is widely used for student training and low-cost private flying in which the CO generated could have been reduced considerably by a two-bit change. This plane was equipped with an ALCOR Engine Analyzer; i.e., it had an exhaust probe in each cylinder for reading EGT. The spread in EGT between the richest and leanest cylinder was from 250° to 300° F when at full throttle, such as used for takeoff and climb and cruise at the higher altitudes.

CARBON MONOXIDE IN THE COCKPIT

by AL HUNDERE / AOPA 42710

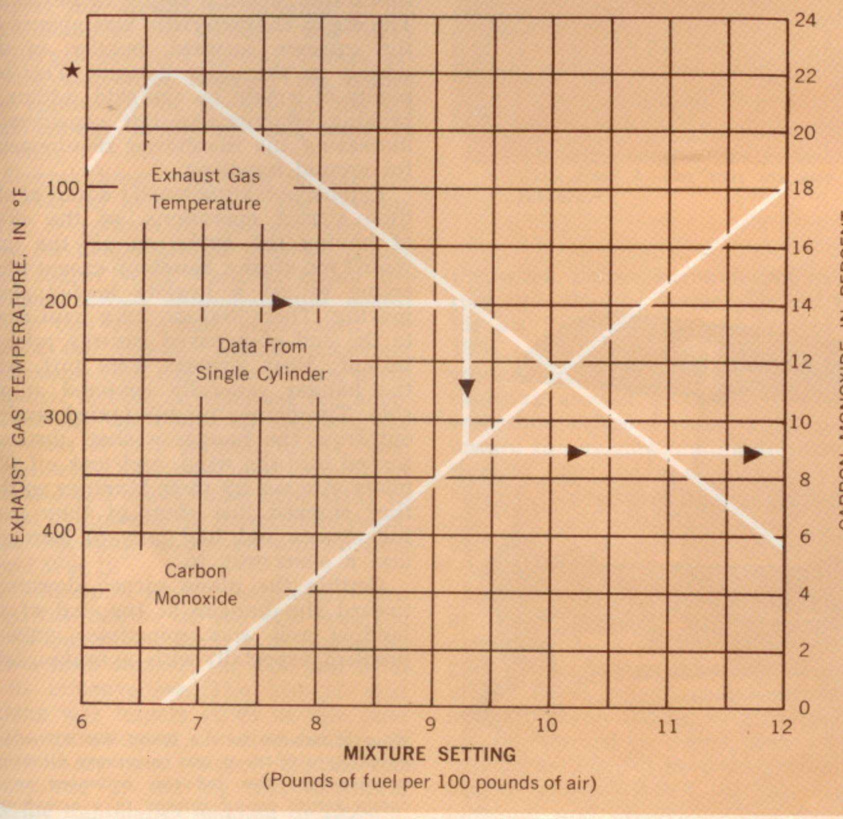

FIGURE 1. CO and EGT as function of mixture settings.
(Star indicates point of complete combustion— —no CO developed.)

By simply pulling the thottle back slightly, but not enough to reduce manifold pressure or power, the spread in EGT between cylinders was reduced to 50° to 70° F. By putting a stop on the throttle to keep the butterfly from going into a vertical position, the mixture distribution of this engine under full-throttle conditions can be greatly improved, thereby reducing the CO hazard.

Just what should a pilot do in the operation of his airplane if he wants to reduce the generation of CO to a minimum? The first thing to remember is that as the outside air temperature decreases, and the amount of cabin heat required increases, the amount of excess fuel required for engine cooling decreases. In fact, when it is so cold that it is difficult to keep the cabin warm enough to satisfy you, you can be sure that your engine is likewise having the same trouble keeping warm enough. The engine manufacturers don't recognize this in their leaning instructions; therefore, specific instructions cannot be given without conflicting with their recommendations.

This writer, in order to generate minimum CO on a cold day when full cabin heat is required, would (1) set the mixture for 100% power takeoff to give an EGT about 100° F higher than normal; (2) during climb up to 75% power, operate at peak EGT or on lean side (holding sufficient airspeed for engine cooling); and (3) during cruise, not only operate at peak or lean side, but select carburetor heat and throttle position to give best mixture distribution. The latter requires an EGT Engine Analyzer; i.e., EGT Indicator with an exhaust probe for each cylinder and a selector switch as described in the August 1966 issue of The Pilot, "Analyzing Your Engine's Health" (page 48).

In conclusion, it is this writer's firm opinion that most of the accidents that have occurred due to CO poisoning could have been avoided if the above information about CO generation had been put to good use. Of course, those accidents also would not have occurred if we had leak-proof muff heaters. Until such heaters are available, the most important solution to our problem of aircraft cabin air contamination is the same as cleaning up our city air to eliminate smog—don't generate excessive contaminants. □

THE AUTHOR

Al Hundere adds another to his list of technical articles on airplane engines and fuels that have appeared in The PILOT. In addition to the two mentioned in "Carbon Monoxide In The Cockpit," Hundere wrote "Accurate And Consistent Mixture Control" (November 1962, page 36) and more recently, "How Good Is Aviation Gasoline?" (June 1967, page 68). He is president of ALCOR Aviation, Inc., at San Antonio, Tex.