Carbon Monoxide in the Cockpit

FAA Safety Seminar

May 1, 2006

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Honeywell Analytics

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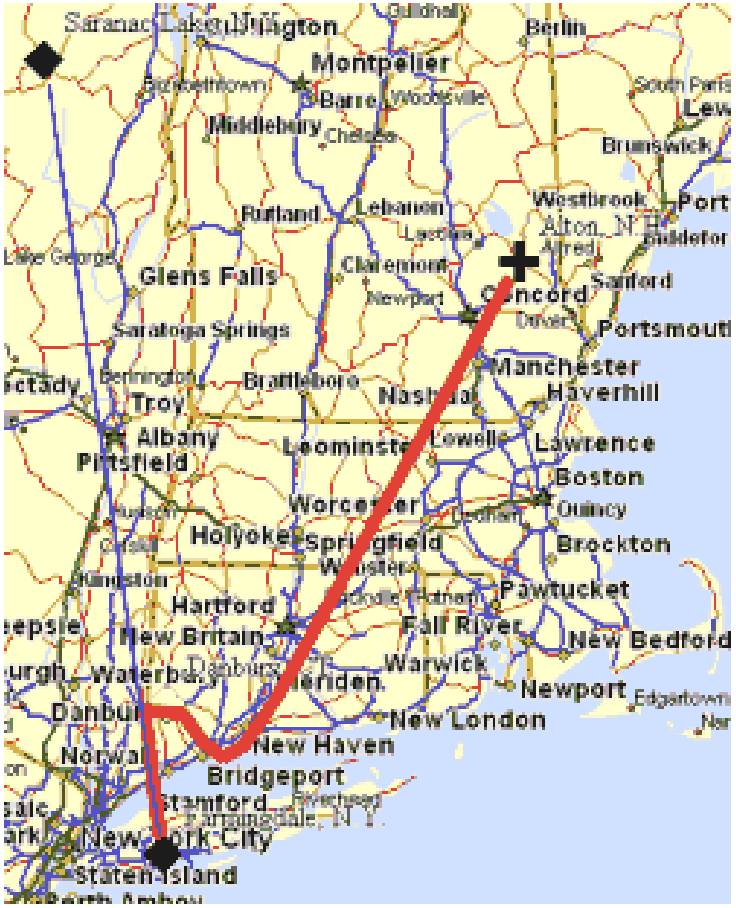
The Fatal Flight of Piper Dakota N8263Y

- An instrument-rated pilot and his 71 year-old mother departed Farmingdale Airport on Long Island at 11:15 a.m. on a VFR flight to Saranac Lake, NY
- Less than a half hour into the flight, the PIC passed out cold
- 36 minutes into the flight, the passenger, a low-time private, radioed ATC and took the controls intending to land ASAP
- 45 minutes into the flight, the passenger reported feeling tired and nauseous
- Shortly thereafter, the aircraft turned right and started climbing
- The aircraft crashed in central NH killing both occupants



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What Happened?

- Toxicological tests in the FAA lab in Oklahoma City revealed that the pilot's blood had a carboxyhemoglobin (CO) saturation of 43%, and the passenger's measured 69%
- Those concentrations are sufficient to produce convulsions and coma
- NTSB metallurgists determined that the muffler contained a large crack and an irregular hole, both of which appeared to have been leaking exhaust gas for some time
- The NTSB determined the probable cause of the accident to be incapacitation of the pilot-in-command from carbon monoxide poisoning

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AOPA Air Safety Foundation Responds

- A week after the Dakota crash, the AOPA Air Safety Foundation issued a press release cautioning pilots about the dangers of carbon monoxide poisoning, and recommending that pilots of single-engine aircraft install a CO detector
- However, ASF executive director Bruce Landsberg noted that CO accidents are "extremely rare," adding that "a search of the Air Safety Foundation accident database revealed only two accidents caused by carbon monoxide between 1985 and 1994."

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Extremely Rare? Don't Bet Your Life on it

- **March 1983:** Piper PA-22-150 N1841P (4 Non-fatal)
- **February 1984:** Beech Musketeer N6141N (3 Fatal)
- **November 1988:** Cessna 185 N20752 (1 Non-fatal)
- **July 1990:** Olsen Pursuit N23GG (2 Fatal)
- **August 1990:** Cessna 150 N741MF (2 Fatal)
- **July 1991:** Champion 7AC N3006E (2 Fatal)
- **October 1992:** Cessna 150 N6402S (1 Non-fatal)
- **April 1994:** Cessna 182 N9124G (1 Non-fatal)
- **October 1994:** Cessna 150 N7XC (1 Non-fatal)
- **March 1996:** Piper Cherokee 140 N95394 (2 Non-fatal)
- **August 1996:** Mankovich Revenge N7037J (1 Fatal)
- **December 1997:** Piper Comanche 400 N8452P (1 Non-fatal)

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More Data

- Analysis of toxicology samples from fatal U.S. aircraft accidents between 1967 and 1993 showed that at least 360 victims had been exposed to sufficient carbon monoxide before or after the crash to impair their abilities
- Non-fatal carbon monoxide poisoning in aviation is likely a more common occurrence than currently believed
- No one is sure how many times pilots or passengers became ill, not realizing they had been exposed to carbon monoxide
- Because no significant incident or incapacitation occurred, the matter was not reported and, hence, not investigated. Symptoms that could be attributed to airsickness, altitude hypoxia, fatigue, or a variety of other conditions actually could have been carbon monoxide poisoning
- Carbon Monoxide is killing pilots!

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What is Carbon Monoxide and How Does it Kill?

- CO is an invisible, odorless, tasteless, colorless gas that is created by the incomplete burning of fossil fuels
- When carbon monoxide is inhaled, the CO combines with your hemoglobin to form "carboxyhemoglobin" (COHb)
- The COHb bond is over 200 times stronger than oxygen's bond with your hemoglobin
- Thus, the CO effectively puts your hemoglobin "out of commission" and deprives your body of the oxygen it needs to survive
- Because of the strong COHb bond, even very tiny concentrations of carbon monoxide can poison you slowly over a period of several hours, and why it may take a long time for your body to eliminate CO buildups from your bloodstream

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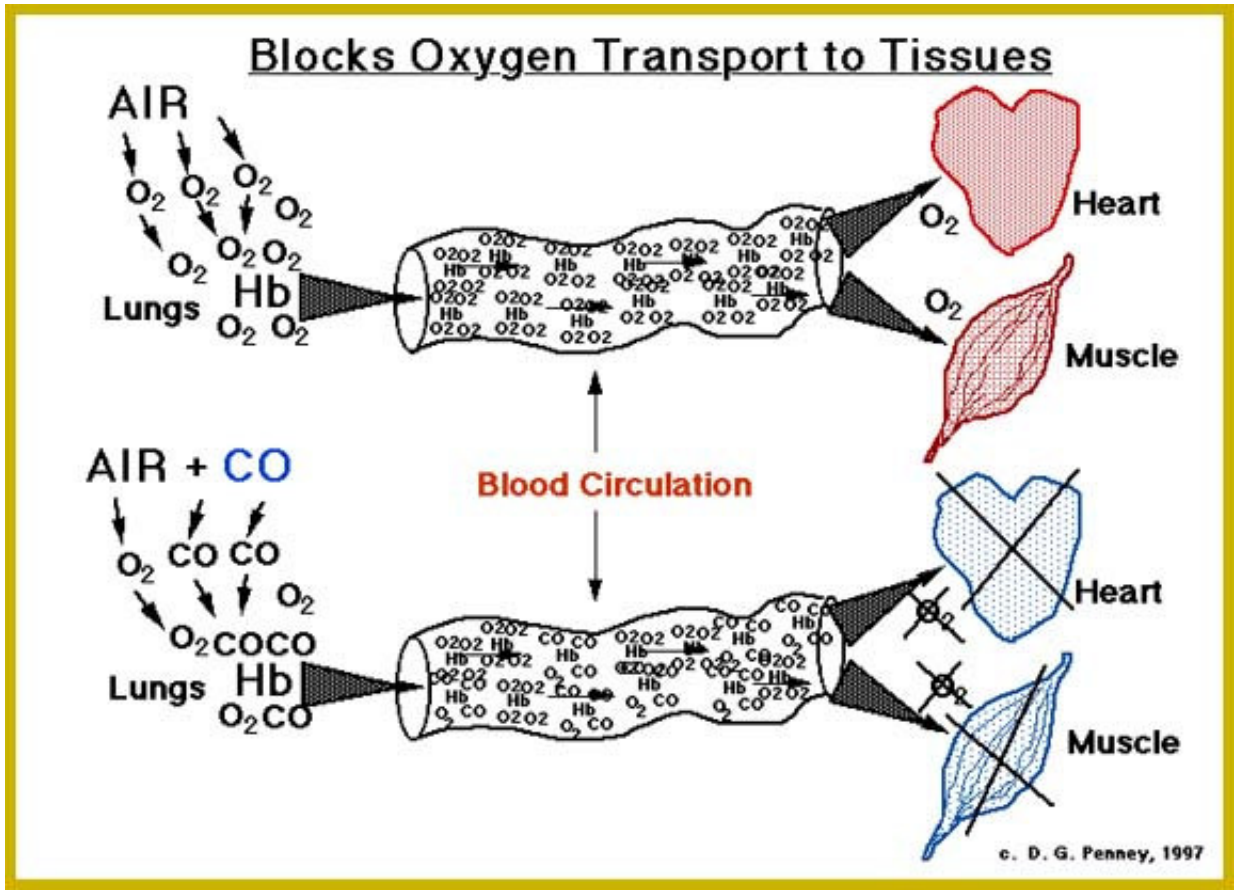
CO Blocks Oxygen Transport to the Tissues



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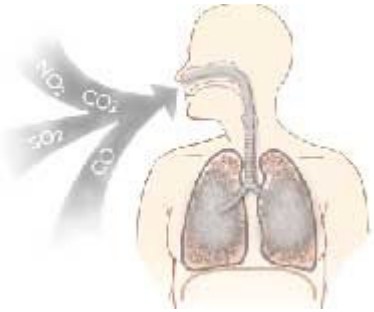
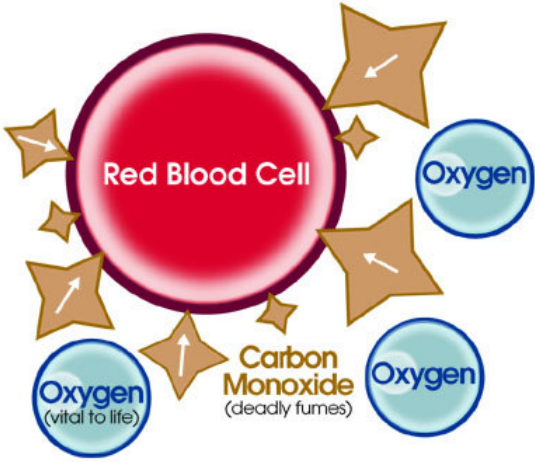
What are the Symptoms?

Percent CO in Blood	Typical Symptoms
<10	None
10-20	Slight headache
21-30	Headache, slight increase in respirations, drowsiness
31-40	Headache, impaired judgment, shortness of breath, increasing drowsiness, blurring of vision
41-50	Pounding headache, confusion, marked shortness of breath, marked drowsiness, increasing blurred vision
>51	Unconsciousness, eventual death if victim is not removed from source of CO





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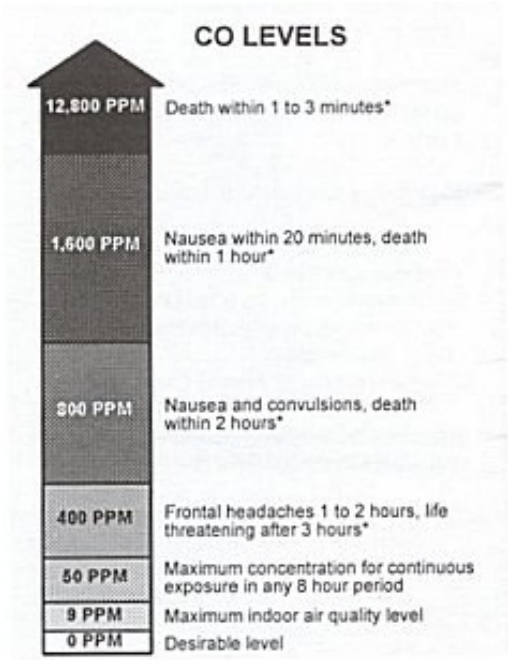
Exposure related to Parts per Million

CO Concentration (parts per million)	Symptoms
35	No obvious symptoms after 8 hours of exposure.
200	Mild headache after 2 to 3 hours.
400	Headache and nausea after 1 to 2 hours.
800	Headache, nausea and dizziness after 45 minutes; collapse after 2 hours.
1000	Unconsciousness after 1 hour.
1600	Unconsciousness after 30 minutes.



*concentrations at sea level. (The effects of CO poisoning and hypoxia are cumulative at altitude)

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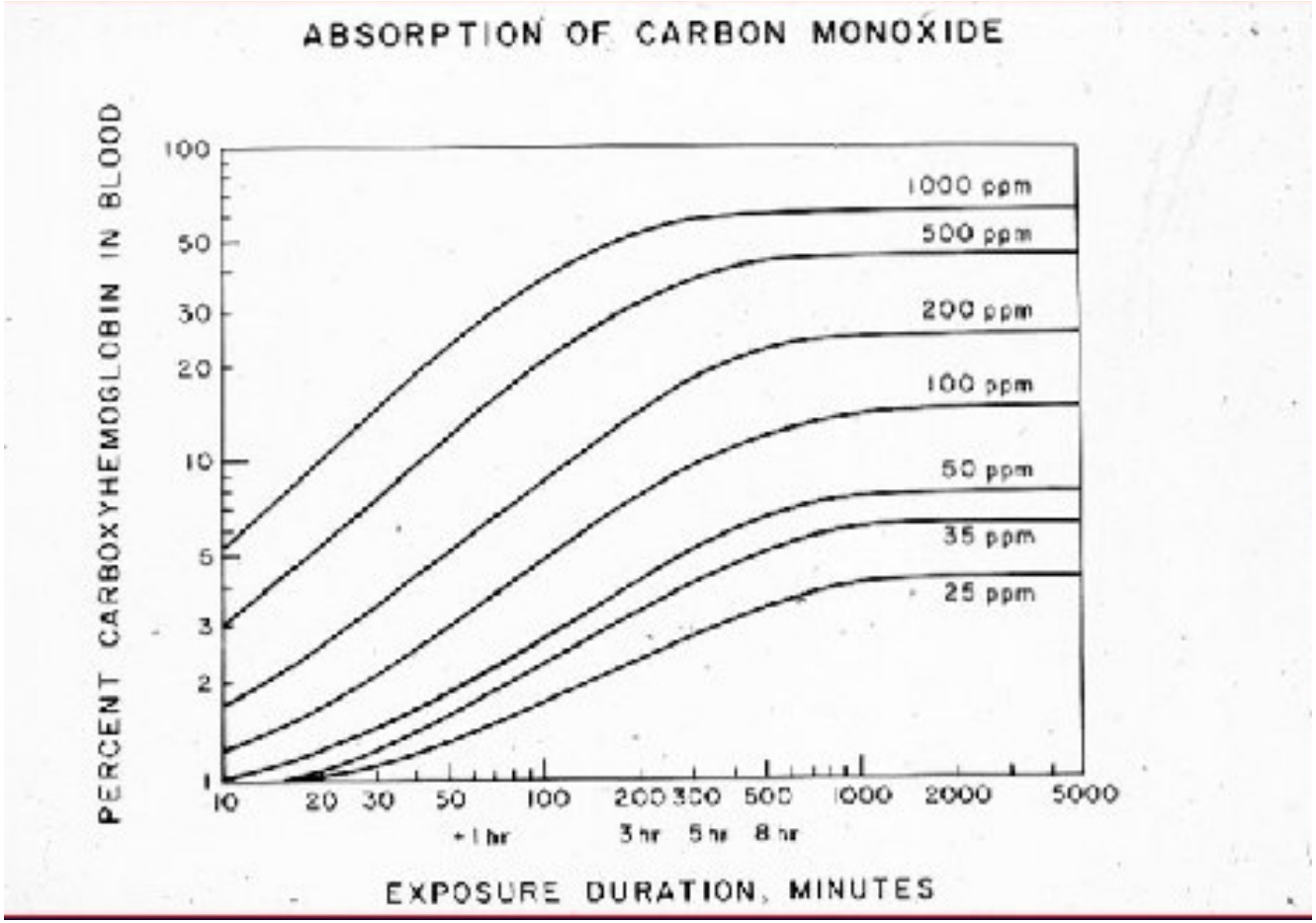
Time and Concentration



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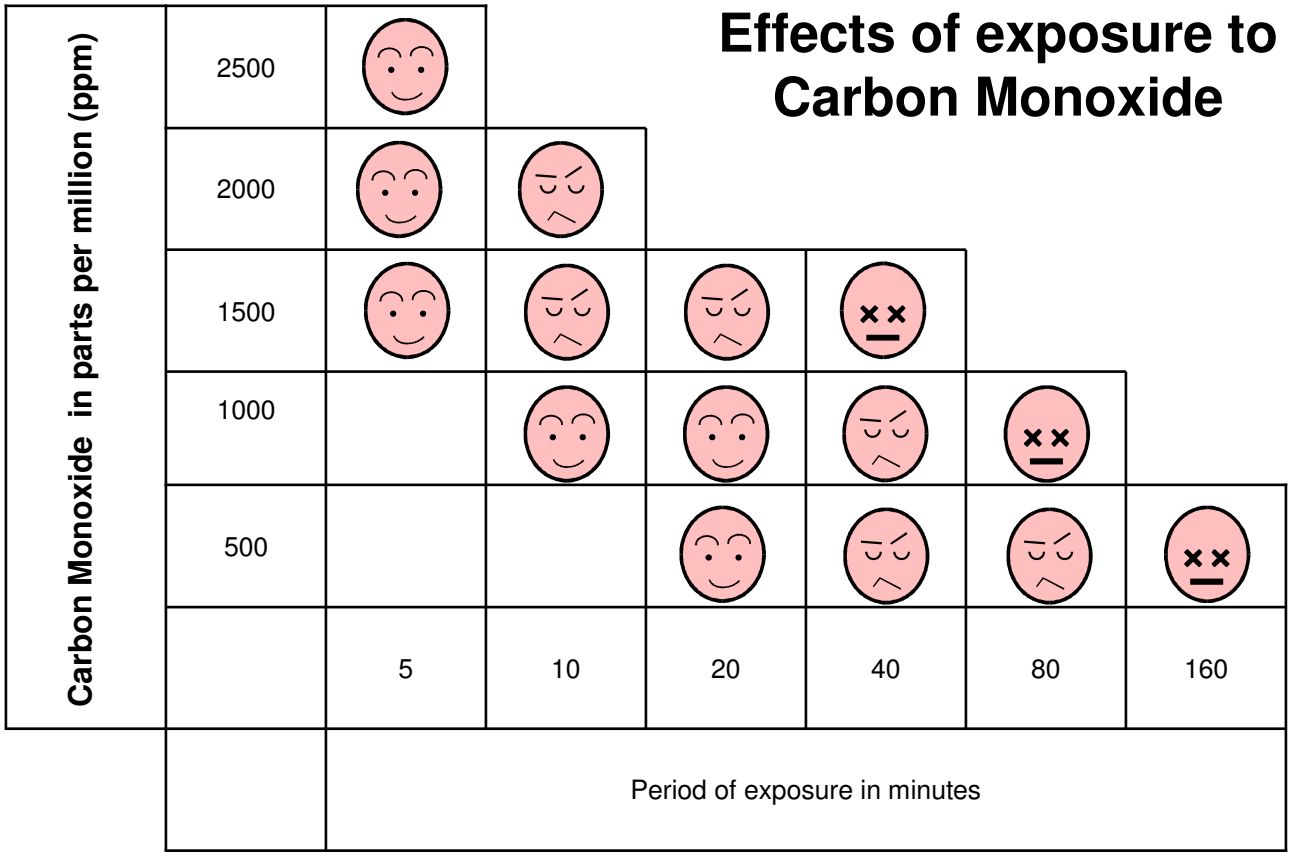
Time and Concentration

Effects of exposure to Carbon Monoxide



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How Does CO Get Into the Cabin?

- The exhaust of piston powered aircraft engines contain high concentrations of CO, particularly at mixture settings rich of peak EGT
- Most piston aircraft obtain cabin heat by routing fresh air over surface of the muffler
- When cabin heat is being used, any cracks or holes in the muffler can allow CO-rich exhaust gas to contaminate the cabin air
- Other possible causes include inadequate sealing of the firewall, wheel wells, or other air leak that allows exhaust to leak into the cabin.

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Doctors are Not Immune

December 1997. Dr. Bob Frayser, a family physician, was piloting his Piper Comanche 400 N8452P from his hometown of Hoisington, KS to Topeka when he fell asleep at the controls. The airplane continued on course under autopilot control for 250 miles until it ran a tank dry and glided to a soft wings-level crash landing in a hay field near Cairo, MO. The pilot was only slightly injured, and walked to a nearby farm house for help. Toxicology tests revealed a 26.8% carboxyhemoglobin saturation some two hours later. Post crash inspection revealed that the right muffler had a crack around one of its seams that would allow exhaust fumes into the cabin heat system.

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How to Protect Yourself

- The best protection against carbon monoxide poisoning is to avoid exposure
- Ensure that aircraft heating/ventilation systems and exhaust manifolds are all in good working order, as specified by the manufacturer and the Federal Aviation Administration
- Certified mechanics must conduct all required inspections
- Special attention should be paid to older aircraft because of corrosion or simple wear and tear.
- A certified mechanic should verify firewall and aircraft structural integrity and seal any defects
- **Pilots should monitor for CO in the cockpit**

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Thinking about a CO Monitor yet?

Desirable Features of a Cockpit CO Monitor

- Provide direct readout of actual CO concentrations
- Sensitivity to detect low CO levels
- Immunity from false readings from common aircraft maintenance chemicals
- Fast speed of response
- Return to zero when no CO present
- Ability to test to confirm detector is working
- Audible, visual, and vibratory alarm annunciation

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Chemical Spot Detectors – Better Than Nothing?

- Disposable chemical spot detector
- Incapable of detecting low levels (<100 ppm)
- False readings from common aircraft maintenance chemicals – read the fine print!
- No indication of actual CO level
- No way to verify performance
- Cumulative measurement – does not "reset" when levels go down
- 30 day life, $4-5 each, Annual cost $48-60
- No audible or vibratory alarm

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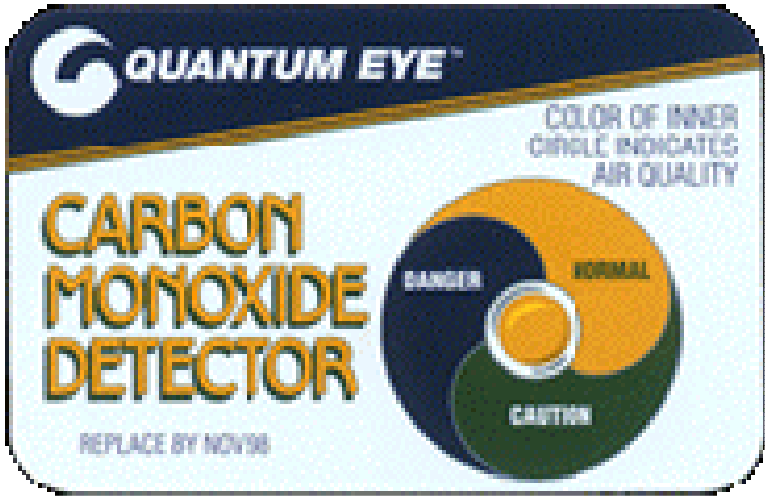
Biometric Detectors – Better?



- Biometric sensor element with similar affinity for CO to blood hemoglobins
- Better low level detection capability than chemical spot detector
- Still vulnerable to false readings from common chemicals
- No indication of actual CO level
- No way to verify performance
- Cumulative measurement – does not “reset” when levels go down
- Can’t distinguish short exposure to high level or long exposure to low level
- No audible or vibratory alarm

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Electronic Detectors – Your Best Option

- Real-time readout of actual CO concentrations in PPM
- Pre-set audible, visual, and vibratory alarm levels
- No interference from common aviation chemicals
- Non-cumulative reading – returns to zero when no CO is present
- Peak reading hold function
- Electronic self-test function
- Can be tested and calibrated with certified calibration gas
- Long-term operation with no maintenance

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What to do if You Suspect CO in the Cockpit

- Turn the cabin heat fully off
- Increase the rate of cabin fresh air ventilation to the maximum
- Open windows if the flight profile and aircraft's operating manual permit such an action
- Consider using supplemental oxygen if available
- Land as promptly as possible
- Do not hesitate to let Air Traffic Control know of your concerns, and ask for vectors to the nearest airport
- Lean fuel mixtrure
- Once on the ground, seek medical attention
- Before continuing the flight, have the aircraft inspected by a certified mechanic

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Can it Happen in a BRAND NEW Aircraft?

December 1997. A **BRAND NEW** Cessna 182S was being ferried from the factory in Independence, KS, to a buyer in Germany when the ferry pilot felt ill and suspected carbon monoxide poisoning. She landed successfully, and examination of the muffler revealed that the muffler had been manufactured with defective welds that allowed CO to enter the cabin through the cabin heat system. Subsequent pressure tests by Cessna of new Cessna 172 and 182 mufflers in inventory revealed that 20% of them had leaky welds. The FAA stepped in and issued an emergency Airworthiness Directive requiring muffler replacement on some 300 new Cessna 172s and 182s. [Priority Letter AD 98-02-05]

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Thank You!

Questions?

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