



# Federal Aviation Administration



## SMOKE TOXICITY

*The specter of fire in the air is a pilot's recurrent nightmare...*

**F**IRE is an integral part of our everyday life, and smoke is one of its products. There have always been efforts to control fire and use it for constructive purposes, but even then, accidental fires do occur and fire continues to cause loss of lives and property.

Uncontrolled fires threaten homes, factories, and transportation systems. The specter of fire in the air is a pilot's recurrent nightmare, carried over from the early days of fabric covered aircraft, when the time between ignition and loss of the aircraft could be measured in relatively few minutes.

Modern aircraft benefit from flame retardant materials and improved fire extinguishing systems to such an extent that in-flight fires are rare occurrences.

However, survivable crashes followed by fire happen, primarily from fuel spills around the downed aircraft. In the confined environment of an aircraft cabin, the presence of smoke automatically indicates the existence of an emergency situation.

Extinguishment of fires obviously has first priority, but smoke inhalation should be recognized as a very real danger while this is being accomplished. Inhalation of toxic gases in smoke is the primary cause of fatalities in most fires—this is true whether the fire is in an aircraft cabin, a residential bedroom, or a high-rise building. Smoke gases do not need to reach lethal levels to seriously impair pilot performance. Sublethal exposures can cause even experienced pilots to make potentially fatal mistakes.



In view of the seriousness of any aircraft fire, let us examine the various aspects of fire and smoke.

## FIRE

*Each fire is different...*

**F**ire is a complex, dynamic, physico-chemical event and is the result of a rapid chemical reaction generating smoke, heat, flame, and light. Each fire is different. Smoke composition and heat generated in a fire depend on types of burning materials and environmental conditions.

## SMOKE

*Its gases could be toxic...*

**S**moke is a complex of particulate matter, as well as a variety of invisible combustion gases and vapors suspended in the fire atmosphere. Smoke may diminish light and obscure vision, and its gases could be toxic.

## SMOKE GASES

*Carbon dioxide levels increase and oxygen concentrations decrease...*

**C**arbon monoxide and hydrogen cyanide are the two principal toxic combustion gases. Most cabin furnishings contain carbon and will generate both carbon monoxide and carbon dioxide when burned; carbon monoxide can also be released from faulty cabin heaters. Burning wool, silk, and many

nitrogen-containing synthetics will produce the more toxic hydrogen cyanide gas. Irritant gases, such as hydrogen chloride and acrolein, are generated from burning wiring insulation and some other cabin materials. Generally, carbon dioxide levels increase and oxygen concentrations decrease during fires.

## SMOKE EFFECTS

*At high altitude, the effects are greatly enhanced...*

**V**isual smoke can delay escape from a fire, while the irritant gases can induce tears, pain, and disorientation. The visual obscuration is obvious, but the subtle effects of carbon monoxide and hydrogen cyanide inhalation, although less readily detected, can cause physical incapacitation and subsequent death. Toxicologically, carbon monoxide combines with the hemoglobin in blood and interferes with the oxygen supply to tissues, while hydrogen cyanide inhibits oxygen utilization at the cellular level. Carbon dioxide, a relatively innocuous fire gas, increases the respiration rate causing an increase in the uptake of the other combustion gases. The decreased oxygen level found in most fire scenarios further enhances the problem of getting enough oxygen to the biological sites to maintain normal function. Continued inhalation of these gases can result in severe hypoxia. At high altitude where oxygen levels are lower, the effects of carbon monoxide and hydrogen cyanide are greatly enhanced.

## SIGNS AND SYMPTOMS

*Not all symptoms will necessarily be experienced...*

**C**arbon monoxide poisoning produces headache, weakness, nausea, dizziness, confusion, dimness of vision, disturbance of judgment, and unconsciousness followed by coma and death. Although carbon monoxide causes deleterious effects on the central nervous system, death usually occurs from cardiotoxicity.

Not all symptoms will necessarily be experienced by every individual exposed to this gas. Some have succumbed from inhaling low carbon monoxide levels, while others have survived breathing higher concentrations. Hydrogen cyanide poisoning signs and symptoms are weakness, dizziness, headache, nausea, vomiting, coma, convulsions, and death. Death results from respiratory arrest. Hydrogen cyanide gas acts very rapidly—symptoms and death can both occur quickly.

## SURVIVAL

*Knowledge of the less obvious hazards and a few simple preparations can increase one's chances...*

**T**here is no universal best procedure to follow in the event of an aircraft fire because no two fires are likely to be the same. Extinguishing the fire, if possible, is the immediate priority. An equally obvious second priority is to breathe as little smoke for as short a duration as possible.

Some larger aircraft are supplied with portable, self-contained breathing masks for the crew, but small private aircraft usually are not. Any cloth held over the nose and mouth will provide protection from smoke particulates; if the cloth is wet, it will also absorb most of the water-soluble gases (i.e., hydrogen cyanide and hydrogen chloride).

Cabin venting will reduce the concentrations of combustion gases, but is not usually a viable option while actually fighting the fire. Knowledge of the less obvious hazards and a few simple preparations can increase one's

chances for survival in an aircraft fire. A small, hand-held fire extinguisher can be used to put out small onboard fires. Careful inspection and maintenance of cabin heaters will minimize the chance of carbon monoxide leakage into the cabin air system. A carbon monoxide detector could also be installed in the cockpit to detect the presence of this colorless, odorless gas. As always, planning your probable actions before an emergency arises will increase your chances for acting quickly and correctly.

### *Remember...*

- **Fires** are the main hazard for the occupants of a survivable crash
- **A fire** generates smoke, heat, flame, and light
- **Inhalation of toxic gases in smoke** is the primary cause of death in most fires
- **Carbon monoxide** and hydrogen cyanide are the main toxic gases in smoke
- **Exposure** to carbon monoxide can also be the result of faulty heaters
- **A wet cloth** held over the nose and mouth provides some protection from smoke inhalation
- **A small, hand-held fire extinguisher** should always be carried aboard general aviation aircraft
- **Install a carbon monoxide detector** in the cockpit

## MEDICAL FACTS FOR PILOTS

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