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# Guarding the Airways

**Protective breathing equipment reduces risk of smoke inhalation injury.**

BY WAYNE ROSENKRANS

Immediate, aggressive action is required at the first sign of an in-flight fire, according to updated guidance for cabin crews. With that advice, some recommendations also remind crewmembers to pay attention to their defenses against smoke inhalation injury.

The importance of correctly donning and activating protective breathing equipment (PBE) at the appropriate time — considering the limited number of PBEs and hand fire extinguishers aboard aircraft — to prevent incapacitation by smoke is detailed in U.S. Federal Aviation Administration (FAA) Advisory Circular (AC) 120-80, *In-Flight Fires,* that in January 2004 updated guidance about fires that may not be visible or easily accessed by the crew.

"Remember, it is critically important that you protect yourself from the effects of smoke and fumes while attempting to fight a fire," the AC said. "Do not enter an enclosed area or begin to battle a fire that is generating heavy smoke without first donning your [PBE]. A small fire can quickly grow to be large and uncontrollable. … Any delay might result in a crewmember's inability to breathe and/or see."

Smoke comprises airborne solid and liquid particulates and gases. The exact composition of smoke is determined by the materials burned, temperature, rate at which temperature increases, humidity, duration of the exposure to heat and amount of oxygen present. One report by FAA's Civil Aerospace Medical Institute (CAMI) said, "Since the aircraft structure is composed of a variety of carbon- and nitrogen-containing polymeric materials, there is a strong potential for the generated smoke to be rich in carbon monoxide and hydrogen cyanide."[1]

U.S. Federal Aviation Regulations, like those of some other civil aviation authorities, require operators to provide "a breathable atmosphere to protect crewmembers from the effects of smoke, carbon dioxide or other harmful gases and oxygen deficiency caused by other than an airplane depressurization, while attempting to locate and/or extinguish an in-flight fire onboard an airplane. Crewmember PBE is required whether the airplane is pressurized or not, and is not intended as an evacuation aid."

Current PBEs protect one wearer for at least 15 minutes; research is underway to develop a new generation of PBEs that could extend protection to at least 20 minutes and possibly up to five hours.[2] Some PBEs use a continuous flow, open circuit design; others use a closed circuit, rebreather design.

Familiarity with the specific PBE model(s) aboard the aircraft, which may differ from a training model, saves time in an emergency, reduces chances of damage while handling or donning the PBE, helps ensure a tight neck seal that will maximize breathing time and keep out toxins, and may remind crewmembers that the

breathing gas will escape if the PBE is passed to another person after activation.[3] Because 24 months elapse between recurrent operating drills with PBE in the United States, for example, it can be useful to mentally rehearse when to use PBE, what to do if PBE fails preflight inspection and how to open the sealed pouch, don and activate the PBE, monitor any low-oxygen (breathing gas) indicator and immediately remove the PBE when breathing gas has been depleted or the unit fails.

In Airbus procedures, examples of when to wear PBE include situations in which smoke or fire is still present after initial steps to extinguish an oven fire and upon feeling the door panel of a lavatory with the back of the hand and finding it hot.

## Smoke Experiences

In November 2000, the first officer of a McDonnell Douglas MD-80 Super 80 operated by a U.S. airline said that he regretted his failure to use a PBE while investigating the source of smoke in the cabin.

"Five to eight minutes after takeoff, I smelled an electrical burning smell with a slight chemical odor," he said. "I jumped up to check the cabin and found smoke in the cabin. … The smoke would appear and dissipate in waves. … We landed without incident. Later (two hours or so), my eyes burned, [my] throat hurt and [I] became hoarse, and I had bronchial irritation. I realized if there is smoke in the cabin, not knowing the source, crewmembers and passengers should be warned to cover their mouths [and noses with cloth]. … I know if it were to happen again, I [would] consider [wearing the PBE] or covering my mouth with a wet cloth to reduce irritation."[4]

Circumstances in the following accident have been cited in discussions of crew responses to in-flight fires and smoke. Soon after takeoff, the first officer, two flight attendants and five passengers received minor injuries from smoke inhalation in August 2000 when AirTran Airways Flight 913, a McDonnell Douglas DC-9-32, returned to the Piedmont-Triad International Airport in Greensboro, North Carolina, U.S. The emergency landing was prompted by an in-flight fire in an enclosed forward area accessible from the cabin and smoke in the cockpit. Five other passengers and one ground crewmember received minor injuries during the evacuation.

B/E Aerospace

Clear polycarbonate visor panels in this PBE design provide a wide field of vision.

In its final report, the U.S. National Transportation Safety Board (NTSB) said, "Examination of the airplane revealed severe smoke and heat damage around the electric power center (EPC) and within the cockpit. Removal of the forward and aft EPC panels revealed heavy sooting, melted wire insulation, visibly broken wires and localized heat damage. … [NTSB] also learned during its investigation of this accident that neither flight attendant on board … attempted to locate the source of the smoke in the cabin or to use any of the fire fighting equipment available to them."[5]

Some medical journals note that the human body's upper airway naturally provides significant protection to the lower airway and lungs against extreme heat from hot, dry air, unlike steam, which quickly can cause severe lung injury. The primary causes of smoke-inhalation injury include direct heat energy; insufficient oxygen to breathe; toxic effects of chemicals such as asphyxiants, irritants and systemic toxins; and the choking effect of airborne particulates such as soot and dust. The most deadly and common asphyxiants in fires are carbon monoxide and hydrogen cyanide. Lethally hot smoke and extremely low oxygen levels are

most likely to occur at an advanced fire stage. Irritants in smoke tend to dissolve on water-covered surfaces of the body, causing inflammation of the mucous membranes that line the eyelids, nose and the passageway from the nasal cavity into the throat.

Several medical researchers during the past 10 years have urged greater awareness of the threat of hydrogen cyanide poisoning in smoke inhalation. "If hydrogen cyanide is present and has been inhaled in a sufficient amount to paralyze respiration, there is no immediate treatment (antidote) available at the fire scene," one article said. "The only antidotal procedure approved in the United States for cyanide poisoning [from smoke inhalation] … is impossible to use when [carbon monoxide in the blood, as carboxyhemoglobin] is present unless special precautions are taken [in a hospital setting]."[6]

## Uncommon Events

Like airline accidents generally, occurrences of serious injury or death from smoke inhalation while fighting an in-flight fire have been rare. According to the *Statistical Summary of Commercial Jet Airplane Accidents* published by Boeing Commercial Airplanes, 10 of 237 fatal accidents (4.2 percent) in the worldwide commercial jet fleet during 1987–2005 fell into the "fire/smoke (non-impact)" category. These smoke/fire accidents involved 618 onboard fatalities. Smoke-caused fatalities typically have occurred while the airplanes were on the ground, where the cabin crew's priority shifts from fire fighting to passenger evacuation.

The apparent infrequency of in-flight medical events involving smoke inhalation is reflected in international airline crews' requests for medical advice. David Streitwieser, M.D., medical director of MedAire's MedLink service and a specialist in emergency medicine, said, "I can recall only a few patches [radio/telephone communications involving emergency physicians on the ground] involving fumes of some kind — and none involving smoke — in the 50,000 patches I have reviewed over 10 years. The presence of the fumes was never actually verified in some of the cases."

## Medical Care

Pilots or flight attendants concerned about health effects from their exposure to smoke in the cockpit or cabin may consider MedLink's medical advice protocols or seek medical attention if injury is suspected anytime after the exposure. "Medical oxygen would be the primary onboard treatment," Streitwieser said. "The albuterol inhaler [a bronchodilator medication] might be useful for passengers [or crew] with audible wheezing or a history of asthma and a smoke exposure. Persons exposed to smoke would need to be seen by first responders or later [by a physician] if they had shortness of breath, persistent cough, chest pain, pain with swallowing, [sensation of] throat burning or noisy breathing — technically, wheezing or stridor," a high-pitched sound while breathing.

In serious smoke/fire injuries, thermal injury to the upper respiratory tract may lead to significant upper airway swelling, resulting in noisy breathing, airway occlusion and respiratory arrest, said one medical journal.[7] "Patients initially may [visit a physician without any symptoms], as symptoms may take up to 24 hours to develop," the journal said. "Signs that indicate potential significant inhalation injury include singed nasal hairs, carbonaceous [carbon particles in] sputum, and burns to the face or any major burn. Patients may [see the physician] with cough, [labored breathing] or hoarseness. Rales [crackling/rattling sound] and wheezing may be heard on physical examination. … Fiberoptic bronchscopy has long been … the gold standard for early diagnosis and also may help clear carbonaceous debris from the respiratory tract, predict development of acute respiratory distress syndrome and allow for [insertion of a tube to assist breathing] if significant inhalation injury is found." ●

### Notes


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