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Getting Out Alive — Would Smoke Hoods Save Airline Passengers or Put Them at Risk?

The debate about smoke hoods for passengers on commercial transport-category aircraft began in the 1960s and is continuing today. Questions remain about whether smoke hoods would make emergency evacuations from burning aircraft safer or would cause deadly delays.

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Editorial Staff Report

Aircraft cabin fires are rare, but their prospect is terrifying. When they do occur, passengers often only have seconds to escape a deadly brew of toxic fumes and acrid smoke.

"Nearly all aircraft accident fatalities that are not the result of crash/impact injuries are the result of post-crash fires and the inability to exit aircraft quickly, which in most cases is attributed to incapacitation from toxic smoke, fumes or injuries,"[1] said Rudolf Kapustin, president of Intercontinental Aviation Safety Consultants. Kapustin, who was investigator-in-charge of 47 major aviation accidents during 24 years with the U.S. Civil Aeronatics Board (CAB) [the forerunner of the U.S. National Transportation Safety Board (NTSB)], said that during the past 30 years, at least 250 transport-category aircraft accidents have involved fires.

In an aircraft fire — particularly one fed by aircraft fuel — the air is filled with dense, black smoke with hot and highly toxic gases, in addition to ash and debris that are emitted by burning cabin components and baggage. Breathing becomes difficult. Smoke and toxic gases often incapacitate passengers and crews before they can escape a burning aircraft, and they are then asphyxiated.

Smoke hoods are protective head coverings that prevent wearers from breathing the smoke, particulates and toxic gases generated in a fire. Some smoke hoods filter the contaminated air; the number of different gases filtered and the effectiveness of the filtration varies among smoke hoods. Other smoke hoods provide breathable oxygen from a cylinder of compressed gas. Requiring smoke hoods as standard equipment on passenger-carrying transport-category aircraft has been a contentious and emotional issue in the aviation community.

Opponents say that the donning of smoke hoods may cause a slower emergency evacuation of an aircraft after an accident, thus causing a greater loss of life.

Proponents argue that while an emergency evacuation may be slowed, ultimately passengers will be more likely to survive the incapacitating smoke and toxic gases common in an aircraft fire and the likelihood of their escape from the aircraft will be enhanced. Proponents also argue that donning smoke hoods should not be characterized as being any more difficult than donning water-flotation lifejackets, which are carried on overwater flights.

Issues of cost and liability have also intensified the debate, and questions have been raised about passenger briefings and uniform standards for smoke hoods.

Thus far, no government agency has mandated smoke hoods for passenger-carrying transport-category aircraft, in part, say some proponents, because regulatory decisions have been based on flawed research. Early smoke

hoods, described in 1967 and 1970 reports by the U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine, had the appearance of plastic bags that passengers could pull down over their heads.[2,3]

After three decades of research and development, two general types of smoke hoods have evolved in the marketplace: one has a self-contained source of breathable oxygen, and the other filters ambient air for breathing.

[Smoke hoods should not be confused with the protective breathing equipment required "to protect the flight crew from the effects of smoke, carbon dioxide and other harmful gases, or an oxygen-deficient environment ... and protect crew members from the above effects while fighting fires on board the airplane."[4] U.S. Federal Aviation Regulations (FAR) Part 121.337, issued in 1987 and amended most recently in 1992, requires aircraft to have protective breathing equipment that includes a portable supply of breathable gas in easily accessible and convenient locations in cargo compartments, in passenger compartments and on the flight deck. This equipment is for crew members only.

The emergency overhead oxygen-mask system is designed to provide breathable oxygen to passengers during an inflight depressurization of the aircraft. It is not designed to be used during an aircraft fire.]

"Get up and get out – quickly," is the current escape strategy behind emergency evacuations, which do not include smoke hood use. FAR Part 121.291 requires that each certificate holder must demonstrate an emergency evacuation after an aborted takeoff, without using more than 50 percent of the aircraft's emergency exits, to show "that each type and model of airplane with a seating capacity of more than 44 passengers to be used in its passenger-carrying operations allows the evacuation of the full seating capacity, including crew members, in 90 seconds or less."[5]

The demonstration must be conducted in the "dark of night" or in simulated darkness. Normal electrical power is "deenergized" and a representative passenger load is used.

"At least 30 percent of them must be females," according to the regulation. "Five percent must be over 60 years old with a proportionate number of females. At least five percent but not more than 10 percent must be children under 12 years old. Three life-size dolls, not included as part of the total passenger load, must be carried by passengers to simulate live infants two years old or younger. Crew members, mechanics and training personnel, who maintain the airplane in the normal course of their duties, may not be used as passengers." [No mention of simulated smoke is made in the requirement.]

Safety Trainers Say There May Be a Place for Smoke Hoods in Corporate Operations

There is no consensus about smoke hoods, even among safety-training experts. Opinions range from "yes, they're great for any passenger" to "no, not everyone," to "just get off the plane."

Kenneth Burton, president of Sea Tropic Arctic and Regional Knowledge (STARK) Survival, in Panama City, Fla., U.S., trains corporate flight crews and executives to survive in an aircraft emergency.

After Patrick Shannon, chief pilot for Hoechst Celanese Corp., participated in Burton's safety training, Shannon decided to provide smoke hoods for the passengers on the company's two Canadair Challenger 600s, based in Charlotte, North Carolina, U.S. That was in the late 1980s.

"After we had Ken Burton in from STARK Survival [I realized that] anything that could buy you seconds in getting out of an airplane [after an accident] could save your life," said Shannon.[48]

Shannon said that the smoke hoods on the company's aircraft are kept with the water-flotation life-jackets under the seats. He said that passengers are informed of the smoke hoods' locations during preflight safety briefings, but the equipment is not demonstrated.

Shannon said that he encourages all of his regular passengers to attend Burton's seminar, which is conducted periodically at Hoechst Celanese. He said that there is not a company-wide policy that mandates attending Burton's seminars, but that many departments within the company do mandate attendance. Shannon said that he relies on passengers who have been trained to use smoke hoods to assist those who have not been trained if there is an emergency.

Shannon said that participants in the company's training often ask him to order smoke hoods for their personal use when they travel on commercial carriers or stay in hotels.

Burton said that executives who have taken his training developed a positive attitude about smoke hoods.

Burton said that in training corporate executives who fly in corporate aircraft, he briefs them before he places them

The regulation details additional requirements aimed to allow a realistic demonstration, but no one in the aviation industry suggests that such a demonstration should mirror the terror and confusion of a real-life evacuation from a burning aircraft.

Researchers agree that in a fire, carbon monoxide, hydrogen cyanide and carbon dioxide, for example, are among the many gases generated that affect the nervous and cardiovascular systems, which cause loss of consciousness followed by death from asphyxiation.

Table 1
Toxic and Physical Hazards Analysis[6]

Effects on a victim exposed to aircraft cabin fire conditions are predicted as follows:

1. From 10 seconds up to 2 minutes the concentrations of hydrogen chloride (HCl) and hydrogen flouride (HF) [in the cabin] would be severely irritating to the eyes and respiratory tract, impeding escape attempts;
2. During the beginning of the third minute the concentrations of HC1 and HF would exceed the tenability limit for sensory irritancy sufficiently to inhibit severely and possibly prevent escape;
3. At the end of the third minute the average [air] temperature would be 631 degrees F (333 degrees C), and sufficient heat would be accumulated in the skin surface to cause skin burns resulting in incapacitation;
4. At the beginning of the fourth minute a victim is likely to lose consciousness due to the combined effects of the accumulated doses of narcotic gases;
5. At the end of the fourth minute the tenability limit from visual obscuration is reached; and,
6. It is predicted that a victim escaping or rescued after the third minute would suffer severe post-exposure effects due to skin burns, possible laryngeal burns with accompanying oedema [swelling] and danger of obstructive asphyxia, and also pulmonary oedema and inflammation which might well be fatal (due to the combined effects of inhaled hot gases, chemical irritants and the pulmonary secondary effects of skin burns). After the fourth minute it is likely that a victim would die at some time between a few minutes and one hour [later] because of the effects of narcosis, circulatory shock and possibly hyperthermia.

in a simulated emergency situation onboard the client's aircraft. For smoke and fire evacuation training, "I fill the aircraft with [nontoxic theatrical] smoke so thick you can't see your hand in front of your face," said Burton.[49]

"The smoke hood enhances your protection against the residue — the ash — falling from the ceiling into your eyes and nose," he said.

Burton said that he carries a filtration-type smoke hood with him when he flies on commercial aircraft. He added that when fellow passengers see the smoke hood in his pocket or briefcase, they usually ask him about it [the smoke hood]. After he explains to them what the smoke hood is and what it is supposed to do, he said, fellow passengers usually respond positively, saying that they believe carrying a personal smoke hood is a good idea.

"The fact is that most people have plenty of time to put on a smoke hood because of the time it takes to get out of an airplane," he said. "It only seems to be the [regulatory] authorities and the airlines who think smoke hoods would take too long [for passengers to don them]," Burton said.[50]

He said that any expeditious exit depends on the passenger's knowledge; the passenger should know where the exits are and how he or she will escape, if escape becomes necessary.

"What it really comes down to is the cost factor and the fear of litigation: What if someone puts it [a smoke hood] on and suffocates?" said Burton.

Whether passengers have training or not, Burton said that he believes that smoke hoods would help passengers to escape an aircraft in a fire emergency.

"This is not a fear thing," he said. "It's not something you're trying to make people have paranoia over. But when you look at the number of people who die each year from smoke inhalation [from all types of fires] — boy, the numbers are there."

Dennis Wright, vice president of operations for the National Business Aircraft Association (NBAA), said that NBAA has not taken an official position on smoke hoods.[51]

In the United Kingdom, Dick Duffell, the Civil Aviation Authority's (CAA) head of the Aircraft Systems Department, said that the CAA arrived at the same finding for corporate aircraft as it had for commercial aircraft. "When we looked at the corporate aircraft, we didn't see much benefit that would be derived by outfitting them [with smoke hoods]," Duffell said.[16]

Beau Altman, president of HBAcorp, in Olympia, Wash., U.S., is also involved in aviation-oriented survival training.

Irritant products of combustion cause immediate painful sensory stimulation of the eyes, nose, throat and lungs.

"Visual obscuration by smoke reduces escape efficiency or renders a victim unwilling to enter a smoke-filled escape route, while heat initially hinders or prevents escape due to pain and burns or hyperthermia, and may cause death either during or after exposure," said David A. Purser, Huntingdon Research Centre, in a paper that modeled time of incapacitation and death from toxic and physical hazards in aircraft fires (Table 1).[6]

Purser said, "It is unlikely that an otherwise healthy adult would be able to escape from a fire such as this [based on a large scale aircraft test that simulated a post-crash fuel fire] if he or she remained longer than 2-2.5 minutes (120-150 seconds) after ignition. ... These measurements were made at 5 feet, 6 inches [1.7 meters] above the floor, and ... the tenability of conditions improves nearer the floor, so that at 3 feet, 6 inches [1.1 meters], where a crawling victim might be, conditions are tenable for approximately a further 30 seconds."

Other research has shown that in an aircraft accident that involves a fuel-fed fire, cabin air temperatures could be expected to reach 662 degrees F (350 degrees C) and higher. During inhalation, the air temperature might be reduced to between 360 degrees F and 302 degrees F (182 degrees C and 150 degrees C [respectively]) by the time the air reached the larynx, but "it is often virtually impossible to separate the effects of direct thermal injury from smoke inhalation injury."[7]

Twelve of the survivors of an aircraft accident that involved fire [see discussion of the Boeing 737 accident, in Manchester, England, further in this article] answered a survey and reported having experienced a variety of symptoms while they evacuated the burning aircraft. The symptoms included searing chest pain, chest constriction, severe headache, wheezing, coughing, dizziness, faintness, choking, suffocation, acrid smell, lung irritation, streaming eyes, fighting for breath, rapid breathing and gasping for breath.[8]

Aircraft accidents involving fire are often tragic — and dramatic. They attract attention from the general public, the press and the aviation-associated regulatory agencies. After such accidents, there are usually increased public demands to know what the regulators are doing to protect passengers.

Brief descriptions of several major fire-involved aircraft accidents are listed below:

- November 11, 1965. A United Air Lines Boeing 727 landed 335 feet (102 meters) short of the runway threshold at 1752 hours local time at Salt Lake City Municipal Airport, Salt Lake City, Utah, U.S. The main gear sheared, and the plane caught fire and slid more than half a mile (.8 kilometer) on the nose gear and the bottom of the fuselage.

Although he strongly recommends smoke hoods for corporate passengers, he is not quick to recommend them for airlines as standard equipment.

"I believe that these devices have benefits for aviation safety if there is proper education and training," he said. "[But] without proper education and training, they could possibly cost lives. Unless you put those two [education and training] together with your hoods, do not put them on the plane."[52]

Altman said that on a corporate aircraft outfitted with passenger smoke hoods, the crew needs to be familiar enough with the passengers' smoke hoods to teach the passengers to use them. He said that he sees hands-on training as the optimum method of training passengers to use smoke hoods.

"You must be trained to properly use any of the smoke hoods on the market today," Altman said. "You can imagine the confusion of trying to train [all the passengers on a commercial transport-category aircraft].

"It is the same thing as life-jackets, oxygen masks, bracing — the passengers must be briefed on their use."

Altman said that he believes that corporate operations provide more controlled environments than commercial operations, and that a corporate passenger is more likely than a commercial passenger to pay attention to a safety briefing.

Neil Hawkins, principal of Neil Hawkins and Associates, an aviation-oriented safety-training company in Sydney, Australia, does not train his corporate clients to use smoke hoods, and he does not believe that training for commercial passengers would be effective.

"If it is a corporate flight, where you have a small number of people with relatively high I.Q.s [intelligence quotients], they might benefit from a demonstration, but on a commercial flight, less than 5 percent watch the safety demonstration," Hawkins said.[53] He was employed by Qantas Airlines for 30 years, first as an engineer, then in management of safety training.

Hawkins does not believe that smoke hoods are the best way to save lives in an aircraft fire.

"The time spent by the passenger finding it [the smoke hood] would be far better spent trying to get off the airplane," he said.♦

The CAB said, "This was a survivable accident. There were 91 persons aboard the aircraft and 50 were successful in evacuating, although many were severely burned and some sustained injuries during their egress. The remaining 41 occupants were overcome by dense smoke, intense heat and flames, or a combination of these factors, before they were able to escape. There were no traumatic injuries which would [have prevented] their escape."[9]

- August 19, 1980. A Saudi Arabian Air Lockheed L-1011 crew reported an inflight fire about 1820 hours local time (about 12 minutes after takeoff), and returned to the airport at Riyadh, Saudi Arabia.

"[The plane] made a right 180-degree turnoff at the end of the runway at 1837:59 and came to a stop at 1839:03, which was two minutes and 40 seconds after touchdown," the Saudi Arabian accident report said.[10] During this period, the cockpit crew asked the tower if any fire was noted in the tail of the aircraft; after checking with fire vehicles on the scene, the tower told the cockpit crew that no fire was seen. The report said, however, that while the aircraft was on short approach to landing, witnesses had observed smoke trailing from the rear of the aircraft.

At 1839:06, the tower personnel asked the crew if they wanted to shut down the engines or to continue to the ramp; the crew said that they were shutting down the engines and beginning evacuation. The accident report said, "During this time period and immediately thereafter, there were communications between tower and firefighters regarding an increase in the fire and their requests to the crew to shut down the engines.

"At 1840:33, after being told by the tower that they have a fire in the tail, [a crew member] stated, 'Affirmative, we are trying to evacuate now.' This was the last transmission received from the aircraft," the report said.

The report added: "After further conversations by the tower and fire personnel regarding the fire and the need to have the engines shut down, the engines were shut down … three minutes and 15 seconds after the aircraft had come to a stop on the taxiway."

None of the aircraft's 301 occupants survived. The report said, "Attempts by the crash/fire/rescue (CFR) personnel to enter the aircraft and open the doors were unsuccessful until the No. 2 door on the right side of the aircraft was opened at about 1905, about 23 minutes after all engines had been shut down. At 1908, the fuselage interior was observed to be engulfed in flames.

Clearing the Air About Smoke Hoods

In 1965, after several aircraft accidents involving fire, the U.S. Federal Aviation Administration (FAA) took a closer look at evacuation problems and fabricated two protoypes of a passenger smoke hood, according to E. Arnold Higgins, Ph.D., in 1989 when he was acting manager of the Civil Aeromedical Institute's (CAMI) Protection and Survival Laboratory.[54] Changes in the prototypes led to a simple, lightweight, protective, bag-shaped hood with a neck seal, the forerunner of current designs.

Higgins said that in 1967, CAMI conducted evacuation tests with 124 subjects who wore smoke hoods, and determined that "the presence of [non-toxic, theatrical] smoke was the primary variable influencing speed of evacuation, since evacuations with smoke were much slower than those undertaken without smoke. The use of the [smoke] hoods did not seem to have a significant effect on evacuation rate."

The Aircraft Industries Association of America (AIA) worked with The Boeing Co., Douglas Aircraft Co. and Lockheed Aircraft Corp. to study eight different types of passenger protective breathing devices, said Higgins. The study found that seals were not satisfactory because all the devices failed to protect against smoke and fumes, but it "emphasized that simplicity of the [smoke] hoods motivated more of the subjects to use them."

The FAA conducted further evacuation tests in 1968 and determined that "there are indications that the use of smoke hoods during an emergency evacuation of a typical air carrier jet aircraft causes a small increase (approximately 8 percent) in the overall time required for naive passengers to evacuate," said Higgins.

He also said that other tests were conducted during 1968 by CAMI to "determine the extent to which the smoke hood acts as a barrier to the transmission of sound. The tests showed that the [smoke] hoods [used in the tests in 1968] do not interfere with the transmission of sound waves."

Higgins also reported that tests in 1968 found that "vision in emergency illumination was so reduced with aluminized hoods as to make them unusable" [modern smoke hoods have clear or slightly tinted windows].

On January 11, 1969, NPRM (Notice of Proposed Rulemaking) 69-2, "Protective Smoke Hoods for Emergency Use by Passengers and Crewmembers" was published in the *Federal Register.* The NPRM called for smoke hoods to be on passenger-carrying commercial aircraft. There

were 21 responses to the docket: three neutral, ten supportive and eight opposed. The FAA withdrew the NPRM because the [smoke] hoods might cause a delay in evacuation, according to Higgins.

CAMI continued testing and development of various protective breathing devices for passengers, and after the Air Canada DC-9 accident in Cincinnati, Ohio, in 1983, Higgins said that "the U.S. National Transportation Safety Board recommended that research be expedited at CAMI to develop the technology, equipment standards, and procedures to provide passengers with respiratory protection from toxic atmospheres during in-flight emergencies aboard transport-category airplanes."

During the 1980s, the FAA joined with aviation authorities in Canada, France and the United Kingdom to study passenger protective breathing equipment (PPBE). *Smoke hoods: net safety benefit analysis*, published by the U.K. Civil Aviation Authority, presented the results of the cooperative effort. [See "Getting Out Alive — Would Smoke Hoods Save Airline Passengers or Put Them at Risk?"] Today, not one government aviation authority has mandated that smoke hoods for passengers be standard equipment on commercial transport-category aircraft.

Unlike the protective breathing equipment required for flight and cabin crews by U.S. Federal Aviation Regulations (FAR) Part 121, for transport-category aircraft, for example, a passenger's smoke hood is not intended as a firefighting tool; a smoke hood is designed to protect a passenger for a limited period from inhaling smoke, particulates and toxic gases, while providing the wearer's head [e.g., eyes] limited protection from heat and ashes, until the aircraft can be evacuated.

Two primary types of smoke hoods are available to consumers — both types have a hood that covers the wearer's head. Filtration-type devices have at least one built-in filter that filters and cools ambient air before the smoke-hood wearer breathes the air; they do not provide oxygen where none is present. Oxygen-supply devices have a small cylinder-supply of breathable oxygen on which the smoke-hood wearer depends for breathing, without involving contaminated air. In the United States, FARs prohibit passengers from bringing compressed oxygen aboard aircraft. [Most, if not all, other countries have similar regulations.]

The compressed gas is considered a hazardous material, said Ron Welding, manager of Operations Standards of the Air Transport Association (ATA) of America. Welding said that an airline has no way of determining how well a unit containing compressed gas has been maintained. An improperly maintained container of compressed oxygen, which might leak, could make a fire emergency even more dangerous, he said.

"Postmortem examinations and toxicological findings revealed that the deaths in this accident were attributable to the inhalation of toxic gases and/or exposure to the effects of the fire, heat and lack of oxygen. There were no unusual forces transmitted to the aircraft occupants as the landing and subsequent roll-out were normal."

The report also said that the flight crew and cabin crew were probably incapacitated by a flashover that consumed all available oxygen or by the inhalation of toxic gases created by burning materials in the cabin. [Flashover occurs when gases that are trapped at the top of the cabin react and ignite spontaneously.] The cause of the fire could not be determined.

- June 2, 1983. The crew of an Air Canada McDonnell Douglas DC-9-32, while en route from Dallas, Texas, U.S., to Montreal, Quebec, Canada, reported an inflight fire in the left rear lavatory. Smoke from the fire was discovered at 1903 hours local time, and the flight made an unscheduled landing at Greater Cincinnati International Airport in Covington, Kentucky, U.S., at 1920. All five crew members escaped, along with 18 passengers. The remaining 23 passengers were killed when a "flashfire" destroyed the aircraft — 60 seconds to 90 seconds after passengers and flight attendants opened the left and right forward cabin doors, the left forward overwing exit and the right forward and aft overwing exits.

  The NTSB accident report concluded, "Although fatalities occurred, this accident must be considered survivable because none of the survivability factors were violated."[11]

  In a survivable accident, the report said, the forces transmitted to the occupants do not exceed the limits of human tolerance to abrupt acceleration, either positive or negative. In addition, the structure in the occupants' immediate environment remains intact to the extent that an occupiable volume is provided for the occupants throughout the crash sequence.

  "In this accident, the fuselage integrity was not breached during the landing and none of the occupants were exposed to decelerative forces beyond the limits of human tolerances," the NTSB report said.

  The report added: "According to the passengers and flight attendants, when the airplane landed, the visibility in the cabin was virtually nonexistent at heights higher than one foot (.3 meter) above the cabin floor. In addition, during the descent and landing, the passengers and crew were exposed to

constantly increasing quantities of smoke and toxic gases, and these factors combined to make the evacuation procedures more difficult to execute and complete."

The report said that the flight attendants attempted to move passengers away from the source of the smoke and heat, to brief them on procedures for bracing themselves and to instruct some passengers how to open the exits.

"However, because of the smoke and toxic gases in the cabin, they had great difficulty communicating, and in some cases, passengers did not hear all these instructions. Virtually all the survivors stated that they had covered their mouths and noses with towels, articles of clothing, or other like items, as instructed by flight attendants," the NTSB report said. Although this procedure was not contained in the company manual, the initiative on the part of the flight attendants to distribute wet towels and to instruct the passengers to breathe through the towels or other items of clothing may have aided the survival of the passengers, the report said.

"Wet towels will filter out smoke particles, acid gases such as hydrogen chloride and hydrogen fluoride, and hydrogen cyanide. Breathing through clothing will also filter out smoke particles, but it will be less effective in filtering out acid gases and hydrogen cyanide. Neither a wet towel nor clothing will filter out carbon monoxide."

The NTSB report said, "The location of the fatalities in the cabin tends to confirm that those who succumbed either made no attempt to move toward an exit or started too late and were overcome as they attempted to move toward an exit. ... It is also possible that some of the passengers were incapacitated because of exposure to toxic gases and smoke during the descent and landing."

The NTSB report added: "Based on the results of the FAA's cabin environment research studies, the Safety Board concludes that the cabin environment became nonsurvivable within 20 to 30 seconds after the flashfire."

The probable causes of the accident, said the NTSB, "were a fire of undetermined origin, an underestimate of fire severity and misleading fire progress information provided to the captain."

In the original 1984 report, [revised in 1986] three years before FAR Part 121.337 was issued, the NTSB said that "had an oxygen bottle with a

"It creates a potentially hazardous situation. If you do have a fire and it is fed by the oxygen, you have a horrific fire very quickly," said Welding.[55]

Although smoke hoods with a cylinder-supply of oxygen are prohibited from being brought by passengers aboard a U.S. commercial transport aircraft, passengers are permitted to carry filtration-type smoke hoods aboard U.S. aircraft.

In 1991, the U.K. CAA took a similar position and said, "Where an individual has gone to the effort of acquiring his own smoke hood, it is reasonable to suppose that he will take the trouble to familiarize himself with its use."[44]

When wearing a filtration-type smoke hood, the wearer's head is covered by the hood, and he or she breathes air through the filter. Chemicals in the filter react with the toxic gases and render them harmless. The chemicals used in the filters vary from manufacturer to manufacturer, but carbon compounds are a common component.

Smoke hoods are constructed from a variety of materials. Primary components include heat- and flame-resistant rubber, flame-retardant fabric, Teflon® and special plastics. Some, but not all, smoke hoods allow all-around vision; of those, some are clear while others are tinted.

The filtration-type smoke hood is designed for one-time use and is sealed in a small package, which makes it easy for carrying in a purse or briefcase. A properly sealed filtration-type smoke hood has a shelf life of about five years. Some manufacturers suggest buying two smoke hoods — one to practice donning and one to carry on aircraft and cruise ships, and in hotels and high-rise buildings.

The FAA has not set standards for smoke hoods, but according to G.A. "Mac" McLean, supervisor of the Cabin Safety Research Section of the Aeromedical Research Division at CAMI, the FAA uses standards for guidance in evaluating smoke hoods set forth in 1991 by the European Organization for Civil Aviation Equipment (EUROCAE), an international nonprofit organization that is open to European, and under certain conditions, non-European users and manufacturers of equipment for aeronautics.[56] The standards were published in *Minimum Operational Performance Specification for Passenger Protective Breathing Equipment* (EUROCAE Document No. ED-65). EUROCAE performance specifications are recommendations only, and become regulatory only if they are enacted by a particular government.

Prior to 1991, said McLean, there were no criteria to test smoke hoods against. Since the EUROCAE standards were released, he said that the FAA has "never been approached with data that said [a particular product] met the specification." Nevertheless, he said that the U.S. Air Force in July 1993 asked manufacturers for 15 to 20 samples of each of

their respective smoke hoods. McLean said that testing on seven vendors' submissions is scheduled to be completed in May 1994.

McLean, who was on the committee that wrote the EUROCAE standards, said that among the standards is a requirement that a smoke hood must function effectively for 25 minutes (20 minutes to allow for landing if there is an inflight fire and five minutes to allow for evacuation from the aircraft after it is on the ground). In addition, a wearer must be able to remove the smoke hood from its package, don it and have it functional within 10 seconds, using information obtained only from a normal preflight briefing/demonstration or review of a passenger briefing card. The smoke hood must be able to be removed from the wearer (by the wearer or by a third party) within five seconds — even if the wearer is also wearing a flotation life-jacket.

McLean said that the neck seal is particularly important, because a seal that allowed smoke to leak into a hood defeated the purpose of the device.

To meet the EUROCAE standards, a smoke hood must be able to withstand the following: 11.4 kilowatts per square meter of radiant heat for 60 seconds; a 100-degree C (212-degree F) ambient air temperature for two minutes; a 950-degree C (1,742-degree F) flame for five seconds; and, flaming, molten, dripping plastic at 200 degrees C (392 degrees F). Once air passes through the filter it should not exceed 90 degrees C (194 degrees F) [47 degrees C (116 degrees F) in 100 percent humidity]; these standards must be maintained for 25 minutes. The standards also list specific requirements for testing.[57]

The U.K. Civil Aviation Authority (CAA) published its own standards in 1988, after studies by the Aircraft Accidents Investigation Branch (AAIB) of the Department of Transport and an AAIB recommendation that the CAA consider formulating a requirement to provide passengers with smoke hoods.[43] Dick Duffell, head of the CAA's Aircraft Systems Department, said that because the CAA never mandated smoke hoods, these standards were not formally adopted. Duffell said that the significant differences between the U.K. standards and the EUROCAE standards were that the U.K. standards required smoke hoods to meet a 20-minute inhalation standard and the U.K. standards did not detail test specifics as much as the EUROCAE standards.[16]

Lisa Barros, marketing manager for Essex PB&R Corp., which produces the Essex Plus 10 smoke hood, stressed the necessity for the ease of donning the equipment. "When you are in a panic situation, you do not have time to sit down and read directions. ... You need to be able to pull it [a smoke hood] over your head and go."[58]

full-face smoke mask been available and used, it might have encouraged and enabled the first [flight] attendant to take immediate and aggressive actions to locate the source of the smoke and to fight the fire."

- August 22, 1985. About 0612 hours local time in Manchester, England, the left engine of a British Airtours Boeing 737 exploded while the plane was accelerating on the runway, and the takeoff was rejected. The explosive engine failure had caused a rupture in the wing's fuel tank and a fire had erupted when the fuel reached the hot engine. The aircraft was turned off the runway and stopped. Fuel pooled and burned, intensified by a light wind, beneath the rear of the aircraft. Fifty-five of the 137 occupants of the aircraft were killed.

  In a *Flight Safety Digest* article, author Sharon Barthelmess described the accident with firsthand accounts from surviving passengers and crew.[12] Barthelmess, president of Free to Fly, a company that conducts seminars to help people to overcome their fear of flying, had been a cabin safety specialist with the FAA, where she was responsible for the development, management and evaluation of its Aircraft Cabin Safety Program. She also was employed for seven years by United Airlines as a flight attendant.

  Barthelmess reported that "pathological examination of the 54 people who died aboard the British Airtours Boeing 737 indicates that 45 people, that is 85 percent, perished as a result of having been incapacitated by the effects of toxic gas and smoke inhalation, thereby eliminating any chance of escape from the aircraft. Nine passengers died from the thermal effects of the fire."

  Purser Arthur Bradbury described conditions inside the cabin: "I was ... aware of smoke coming into the galley ... [the smoke] became denser and darker ... I was in total darkness, working by touch only. The smoke was extraordinarily dense and thick.

  " I took a good lung-full of this acrid smoke. I felt I could not take more than one or two more or I would have passed out. Visibility was then about two or three inches. ... I could not shout due to smoke inhalation."[12]

  [In 1988, Flight Safety Foundation awarded its Heroism Award, the Graviner Sword, to British Airtours flight attendants Jacqueline Urbanski (posthumously), Sharon Ford (posthumously) and Joanna Toff, and Arthur Bradbury for their actions during

the Manchester accident. (See "Award Winners Honored at Sydney Seminar," *Flight Safety Foundation News*, January/February 1989.)]

In the 1989 proceedings of an Advisory Group for Aerospace Research and Development (AGARD) conference on aircraft fire safety, Claire Marrison and Helen Muir, Ph.D., then both of the College of Aeronautics at England's Cranfield Institute of Technology, said that the passengers in the Manchester accident did their best to evacuate the aircraft quickly, even climbing over seats. "Human blockages occurred adjacent to the overwing exit and the vestibule area of the galley ... which dramatically lowered the efficiency of the evacuation, as passengers were overcome by smoke and trampled by others in the anxiety-ridden push to the exits," said the researchers.[13]

The accident received international attention and prompted further examinations of smoke hoods, particularly in the United Kingdom.

- February 1, 1991. A landing USAir Boeing 737 collided with a Skywest Fairchild Metroliner awaiting takeoff clearance on the runway at Los Angeles International Airport, Los Angeles, California, U.S. All 12 people on the Skywest flight were fatally injured; 22 of the 67 occupants died on the USAir flight. Both aircraft were destroyed.

  The NTSB accident report said that on the USAir aircraft, "A deceased flight attendant and 10 deceased passengers were found lined up in the aisle from 4.5 to 8 feet [1.4 meters to 2.4 meters] from the overwing exits. They most likely collapsed while waiting to climb out the overwing exit. They perished as a result of smoke and particulate inhalation, strongly suggesting that they were able to make their way, possibly guided by floor path emergency lights, to the overwing area from as far away as the forward cabin."[14]

  David Koch, a passenger who survived the collision [and who reported his experience in *Cabin Crew Safety*], described the smoke as heavy, black and "extraordinarily painful to breathe." He also described looking for his jacket so that he could use it as a mask to protect his lungs from the smoke.[15]

Dick Duffell, head of the U.K. Civil Aviation Authority's (CAA) Aircraft Systems Department, said that the attention and the traumatic nature of aircraft accidents tend to rush officials toward a solution. "You [a regulatory agency] tend to react to the specific initially and not look at the overall," he said.[16]

A would-be smoke-hood purchaser might want to consider a smoke hood's level of heat resistance and its ability to filter out carbon monoxide, a deadly, tasteless, colorless and odorless gas.

• **Heat resistance.** Smoke hoods are made of heat-resistant materials, but how much heat should they resist? Experts acknowledge that while the hood may protect a person's head, the rest of the body and clothing remains exposed to heat and flames.

• **Carbon monoxide filtering.** Carbon monoxide and hydrogen cyanide are the primary gases that cause the aphyxiation of passengers in aircraft accidents, although they are only two of many toxic gases that are generated during an aircraft fire. Hydrogen cyanide and many other toxic gases, along with smoke, are easily scrubbed by the filters in modern smoke hoods; some smoke-hood manufacturers have chosen not to have their products filter carbon monoxide from the breathable air because filtering carbon monoxide requires a more expensive filtering process. There has been some debate about whether a smoke hood should filter carbon monoxide, especially when considered as an "all-or-nothing" issue in selecting or approving a smoke hood.

John S.S. Stewart, FRCS, of England's Royal Albert Edward Infirmary, said, "The effect of carbon monoxide is important if there is prolonged exposure but [it] cannot explain [the] collapse [of passengers] after exposure for only 30 to 60 seconds. Cyanide [generated by burning cabin components] may cause rapid incapacitation but it does not occur in kerosene [a wide range of petroleum-derived hydrocarbons that form the basis of air-breathing jet fuels] smoke. Carbon monoxide does occur in kerosene smoke but it does not cause rapid incapacitation."[8]

Stewart said that evidence from past accidents "suggested that duration of exposure to smoke is important and that there is greater risk of death if the passenger is seated further from an exit" and that "kerosene smoke alone may cause incapacitation."

C.R. Crane, Ph.D., the now-retired chief of CAMI's Biochemistry Research Aviation Toxicology Laboratory, said, "Although CO [carbon monoxide] protection has the obvious advantage of an increased survival time, a simple and convenient mask that would provide for 5 to 10 minutes of functional time *in the smoke* [Crane's emphasis] is more than adequate. ... Furthermore, the lower cost and increased convenience will assure its purchase and *use* [Crane's emphasis] by many who would otherwise be denied such important protection for themselves and their families."[59,38]

Barros said that carbon-monoxide filtration, along with ease of donning, determines which are the better smoke

hoods. "A lot of the hoods on the market today do not filter any carbon monoxide," she said. "Many others filter enough to say they do it, but not enough to save you."

The FAA's McLean said that carrying a smoke hood may be a good practice for a motivated frequent traveler, but only if it removes carbon monoxide. Carbon monoxide is generated by incomplete combustion of fuel, he said, and carbon monoxide will be generated whether or not flashover occurs.

"As a duly-informed government official, I could not possibly advocate anybody buying a piece of gear [a smoke hood] that does not protect them against carbon monoxide," McLean said. "As an ethical scientist, I would not [advocate] it either."

Roger Killen, who is the chief operating officer of Brookdale International Systems Inc., said that he serves as secretary of an American National Standards Institute (ANSI) subgroup that is designing North American standards for passenger smoke hoods. He cautioned against devices that do not filter carbon monoxide: "The ones that don't handle carbon monoxide are more of a liability — worse than useless," he said.[60]

He said that there are at least four manufacturers that do not sell smoke hoods in North America because of liability claims that might result from the lack of specific U.S. standards.♦

When Duffell began his work with smoke hoods in 1985 (in the aftermath of the Manchester accident), he said that he believed that smoke hoods were the obvious tools to prevent another such tragedy. "There was significant information to suggest that more people would have survived the Manchester accident if they had had respiratory protection," he said.

But Duffell has since changed his mind: "When I first started work on the [smoke-hood] standard, I was quite enthusiastic about the potential benefit. But after I looked at the work [his and others'], I had to conclude that there was no real benefit to be achieved."

Duffell said that he found no justification for mandating smoke hoods because research that the CAA conducted jointly with the U.S. FAA, French Directorate General of Civil Aviation (DGAC) and Transport Canada led to the conclusion that the number of lives saved by smoke hoods each year would be "modest."

Results of the multi-country research were published by the CAA in a November 1987 report, *Smoke hoods: net safety benefit analysis.*

The collaborative program, said the CAA report, aimed at "an assessment of the safety benefit [for smoke hoods], and any likely offset due perhaps to delays in evacuation induced by its use."[17]

The report was based on an assessment of previous aircraft accidents and said "that the assessment should be as realistic as practicable and that smoke hoods should not be given credit for the saving of life which it is reasonable to expect from recent cabin safety improvements, such as fire blocking [material treated to be fire resistant] of seats, floor proximity escape path lighting, lavatory smoke detectors and fire extinguishers."

The report said that fire blocking of the seats would have delayed the buildup of smoke and toxic fumes, which would have allowed the cabin environment to remain survivable for a longer period of time to allow for more sustained peak evacuation rates. Floor proximity escape path lighting would have enhanced the evacuation rate at night and during periods of dense smoke.

The report's collaborators recognized "that the analysis should take account of any delay to evacuation attributable to the donning of smoke hoods, and any extension of the evacuation time due to wearing this equipment."

The FAA provided the computer program for the analysis and the models for each of the accidents analyzed, which were selected from a review of the FAA's own accident data, and data from the CAA and the International Civil Aviation Organization (ICAO). Based on a 20-year period that began in 1966, the FAA selected 74 accidents with 2,686 fatalities that met specific criteria, which included accidents where fire was involved in passenger operations with transport aircraft certificated to carry more than 30 passengers. Nonsurvivable accidents and sabotage/terrorist-related accidents were not included. The analysis was finally limited to 20 accidents (1,022 fatalities), and the method was based on modeling "cabin survivability and evacuation rate[s] as functions of time," which allowed for successive comparisons of improvements that included fire blocking, floor proximity lighting, lavatory fire detectors and extinguishers, and smoke hoods.

The report said that the "essential contribution [of a smoke hood] would be a substantial improvement to survivability in the cabin fire atmosphere. It would not be expected to improve evacuation rates but would sustain evacuation up to the point where the cabin becomes unsurvivable even with smoke hoods."

Nevertheless, the report concluded that after applying the various improvements to the accident models, smoke hoods in the benefits analysis could be credited with an estimated potential of preventing 179 fire-related deaths — about nine fire-related deaths worldwide per year during the 20-year period.

"This proportion is modest," said the report, "not because of any assumed limitations as to the protection provided by smoke hoods, but rather because of the contributions that would already have been made by other improvements. In the absence of fire blocking [477 estimated potential lives saved, which was heavily weighted by the Saudi Arabian Air Lockheed L-1011 accident] or floor proximity lighting [39 estimated potential lives saved], the contribution which would have been made by smoke hoods could have been substantial indeed."

The report also determined "that the wearing of smoke hoods does not delay or slow down the evacuation," but concluded "that even if the wearing of smoke hoods were to result in a delayed or slower evacuation, the net benefit would remain positive, but reduced."

The report said that the estimated saving of 179 lives was based on the assumptions of "perfect" protection by smoke hoods and that every person who would benefit from a smoke hood would use it.

"Ready availability, ease of donning and adequate briefing would help but even if there is no actual resistance by passengers to the wearing of hoods, it would be unrealistic to assume that all passengers in all accidents will remain so self-possessed and rational that all [the passengers] will make use of the smoke hoods," said the report.

The report attempted to consider this factor in the accidents that were reviewed, with special attention to the degree of crash damage and the likelihood of smoke-hood use.

[Likelihood of] Use of smoke hood		Degree of damage [to aircraft]
Very high	(100 percent)	Inflight fires (premeditated use).
High	(75 percent)	No cabin damage.
Moderate	(50 percent)	Little or no cabin damage, rapidly developing fire threat.
Low	(25 percent)	Major to severe cabin damage, including complete fracture.
Negligible	(0 percent)	Severe/extreme damage, cabin in many cases in a number of pieces.

After this assessment was applied to the 20 accidents, the smoke hood's estimated potential of preventing 179 fire-related deaths was reduced to 134 of the total 1,022 fire-related deaths.

The FAA released its own report in 1988, *Study of Benefits of Passenger Protective Breathing Equipment from Analysis of Past Accidents*, with its results of the computer model of the 20 accidents studied in *Smoke hoods: net safety benefit analysis*. The FAA report noted that "the results of exercising this model ... indicate that the 'lives saved' is very sensitive to assumptions."[18]

The FAA report also noted that the "effectiveness of protective breathing equipment was shown to be greatly influenced by the assumed time to don the devices [smoke hoods], and a delay of 15 seconds in donning time [would have] resulted in 82 additional fire deaths."

The CAA cited several specific points by which the results of *Smoke hoods: net safety benefit analysis* could be criticized. It said that past accidents may not be a good guide to the future, but noted that "no better measure is available"; no account was taken of the growth of aviation, which doubled during the period, and appeared to have been offset by improved safety records of newer aircraft; "smoke-hood wearers in noncritical levels of smoke are subject to some small levels of risk associated with hood malfunction"; "the safety benefit [preventing 179 fire-related deaths] assumes no delay or adverse effect on evacuation when [smoke] hoods are worn," a situation that may not occur in an actual accident; and finally, "No credit is given for the possible influence of smoke hoods in reducing panic and inducing more orderly evacuation. This may have influenced the outcome in some but by no means all accidents."

In their AGARD paper, Marrison and Muir noted that there is a psychological aspect to aircraft fires: "If fire or smoke are present in the cabin and are allowed to persist, they create an environment which impairs breathing and vision. Equally, the combinations of toxic fumes which emanate from cabin fires also have the potential to influence psychological functioning, which may, in turn, affect the behavioral responses of individuals in an emergency evacuation.

"In addition to the specific impact of smoke and fire, toxic fumes can also lead to a number of behavioral responses which include disorientation, anxiety and depersonalization."

E.J. "Ed" Trimble, Ph.D., a principal inspector of air accidents for the U.K. Air Accidents Investigation Branch (AAIB) of the Department of Transport, had an important exposure to smoke hoods while investigating the Manchester accident. After looking into the accident and reading survivors' testimonies, he also recognized the adverse affects that fire had on passengers. Trimble said that he believed that smoke hoods could have increased safety.

"Initially I was tasked with looking at the survival side and at that time we thought it would just be the normal things that kept people from getting out of the plane, such as a jammed door," Trimble said. "The real key thing was that people were being incapacitated."[19]

Table 2

All Smoke Hoods Are Not Created Equal*

Company & Contact ***All information has been provided by manufacturers' literature and by telephone queries to company representatives. This information might not be entirely accurate.**	**Brookdale International** **1-8755 Ash Street** **Vancouver, British Columbia** **Canada V6P6T3** **Telephone: (604) 324-3822** **Fax: (604) 324-3821** **Roger Killen, chief operating officer**	**Dowty Environmental and Safety Products** **Hearthcote Road** **Swadlincote, Derbyshire** **DE11 9DX England** **Telephone: 0283 221122** **Fax: 0283 222911** **Gorden Neale, sales manager.** **[Survival Products Inc., North American distributor** **P.O. Box 100428** **Fort Worth, TX, U.S. 76185** **Telephone: (817) 923-0300.** **Graham O'Connor, president]**	**Drager** **101 Technology Drive** **P.O. Box 120** **Pittsburgh, PA, U.S. 15230** **Telephone: (412) 787-8383** **Fax: (412) 787-2207** **Jan-aake Hammarlund, senior product manager for Respiratory Products, National Drager Inc.**
Smoke hood model?	**EVAC • U8 Emergency Escape Smoke Hood**	**SMOKESHIELD Personal Fire Smoke Escape Hood**	**Parat C Smoke Escape Mask**
Is your smoke hood designed for use by airline passengers?	Originally designed for home use; also marketed for airline passengers.	Designed for corporate passengers — has not addressed commercial market.	Originally intended for use in high-rise hotels.
What kind of system?	Filter system. Consists of hood, filter with mouthpiece, nose clip.	Filter.	Filter (with nose cup).
Have you sold to any airlines?	Some individual pilots and flight attendants have purchased it for personal use.	No comment.	Some airlines have purchased these for their crews for hotel stays during layovers (not for flight).
Has it been tested by the FAA or CAA?	No.	Distributor does not know.	No.
Has it been tested against EUROCAE standards?	Yes, by Miller Nelson Laboratories in California, U.S.	No. It is not designed to meet EUROCAE standards.	No.
Does it meet EUROCAE standards? **Where does it fall short?**	Its duration is five minutes less than that standard dictates.	(not tested)	(not tested)
Heat levels?	Hood heat-resistant to 800°C (1,472°F); canister (filter) to 300°C (572°F).	Passed flame-lick test with 500°C (932°F) flame	Flame-tested for 5 seconds at 2,000°C (3,632°F).
Packaged size and weight?	11 ounces (311.8 grams); slightly larger than a soda can (5 x 2-1/2 inches [12.7 x 6.35-centimeters] cylinder).	Less than 3.5 ounces (100 grams); less than 8 x 5 x .3 inches (20 x 13 x .75 centimeters).	1.3 pounds (600 grams); 3 x 7 1/2 x 5 1/2 inches (8 x 19 x 13.5 centimeters).
How long have you been selling passenger smoke hoods?	EVAC•U8 went on the market in 1993.	Product has been in existence (through various company and name changes) since the mid-1980s.	The Parat C was first marketed in 1980, but was not marketed in the United States until 1993.
Are you in any other business?	No.	Dowty is owned by Tube Investments.	Respiratory equipment, gas detection, alcohol detection.
Has your smoke hood been used in an actual emergency?	No.	No.	No.
How much does it cost?	US$49.95-$59.95.	US$47.95.	US$160-$180.
Does it fit over glasses, beards, hair?	OK. If the neck seal is loose, the filter would not be jeopardized because it is a mouthpiece.	Difficult, but it can be done.	Not a problem. If long hair was left down, it would affect the neck seal quality, but not the quality of the nose cup seal.

Table 2

All Smoke Hoods Are Not Created Equal

Duram Rubber Products Kibbutz Ramat Hakovesh 44930 Israel Telephone: 972-9-458458 Fax: 972-9-458479 [Life Safety Products Inc., distributor 12842 Valley View Street Suite 207 Garden Grove, CA U.S. 92645 Telephone: (714) 893-5505 J. Edgar Barnhill III, chief executive officer.]	**Essex PB&R Corp. 505 Blue Ball Court P.O. Box 791 Elkton, MD U.S. 21921 Telephone: (410) 398-3353 Steven Luthultz, general manager**	**Fuji Safety Inc. Tokyo, Japan Telephone: 3405-5011 Katsumi Fujinuma, president. [Fuji Safety Inc. (USA) 655 Montgomery Street Suite 1450 San Francisco, CA, U.S. 94111-2631. Telephone: (415) 677-5140 Fax: (415) 391-4999. William B. Murphy, director of marketing and administration.]**	**S.M. Alexander (Plastics) Ltd. Levellers Lane, Eynesbury, St. Neats, Cambs PE19 2JU England Telephone: 0480-473140 Fax: 0480 406968 [Euro Marketing & Import (EMI), Inc., North American distributor P.O. Box 6352 Santa Barbara, CA U.S. 93160 Telephone: (805) 964-1447 Thomas Bakker, president]**
Duram Emergency Escape Mask	**Plus 10 Filter Breathing Unit**	**Fuji Ace Mark II Emergency Escape Mask**	**Provita Smoke Hood**
Yes.	Yes.	Not designed exclusively for airline passenger use.	Yes.
Filter.	Filter.	Filter (with nose cup).	Filter.
Letter from aerospace manufacturer says company purchased Duram hoods for its traveling executives.	Has sold to airline pilots and flight attendants for personal use (e.g., off-duty flying, hotel stays). Two sales representatives are with airlines; one is a pilot.	No. Interest has been expressed by corporate operators.	No.
No.	No.	No.	No.
No.	No.	No. It has been tested against Japanese standards, which it meets or exceeds.	Yes, by TNO Defense Research Lab in Liden, Holland.
(not tested)	Manufacturer said Plus 10 would not meet ED-65; Plus 10's duration is too short.	(not tested)	Distributor did not know.
Hood will withstand up to 315.5°C (600°F).	Hood will withstand up to 310°C (590°F).	81.7°C (179°F) (hot air stream); 107.2°C (225°F) (500W heat lamp at 250 mm).	Hood will withstand up to 500°C (932°F).
3.9 ounces (110.6 grams); 4 x 5 x 1/4 inches (10.4 x 12.7 x .6 centimeters).	1 pound (.45 kilogram); 5 1/2 x 8 1/2 x 2 1/2 inches (14 x 21.6 x 6.3 centimeters).	Less than 15 ounces (466.5 grams); 4 1/2 x 2 3/4 x 7 inches (11.4 x 7 x 17.8 centimeters).	Less than 5 ounces (125 grams); 5 x 6 x 1 inches (12.7 x 15.2 x 2.5 centimeters).
Duram has been making smoke hoods for 4 years.	Essex PB&R Corp. has sold self-contained units (SCUs) for 10 years; the Plus 10 has been on the market for over a year.	This mask was first produced and distributed in the early 1980s.	Provita has been sold for about 9 months. Developed in response to Persian Gulf War and aircraft fires.
Duram Rubber Co. also makes rubber products.	Personal breathing equipment for commercial crew members; SCU for corporate passengers and crew.	Produces a nose cup with a headband that acts as a filter.	Makes protective clothing and safety devices.
Yes. One distributor entered an office building that was on fire and helped evacuate people.	No.	No.	Distributor did not know.
US$59 - $69.	Starts at US$195.	US$99.95 (lower if purchased in large quantities); practice mask sells for US$14.95.	US$49.95 (retail).
Fits over glasses.	Long hair can be tucked in.	It is intended to fit over hair and glasses. A strap adjusts the filter, which is in a nose cup, and there is a seal around the neck.	No problem over glasses; plenty of space for hair.

Table 2 (continued)

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Smoke hood model?	**EVAC • U8 Emergency Escape Smoke Hood**	**SMOKESHIELD Personal Fire Smoke Escape Hood**	**Parat C Smoke Escape Mask**
How many are actually in consumers' hands?	Did not know. 8-10 thousand have left the factory.	Will not disclose sales figures.	Did not know.
Does it filter carbon monoxide?	Yes. 2,500 parts per million (ppm) for 20 minutes.	No.	Yes. 2,500 ppm for at least 15 minutes.
What is the hood made of?	Kapton™ (a heat- and flame-resistant polymide film that is very thin, orange and looks like plastic).	Kapton.™	Flame-retardant, self-extinguishing fabric.
Neck seal?	Drawstring. Manufacturer says it cannot be pulled so tightly that it would choke the wearer.	Rubber.	Elastic.
Shelf life?	5 years.	5 years.	6 years for filter (can be replaced if it has not been used); 12 years for hood.
How long will the product function? Under what conditions?	15-20 minutes (very thick smoke).	Manufacturer does not list duration time because actual fire conditions cannot be replicated.	15 minutes ("normal" fire).

He added that the pathology results that he reviewed indicated that 50 of the 55 deaths in the Manchester accident resulted from the smoke and toxic fumes that incapacitated the passengers and crew before they could escape from the burning aircraft.

In his doctoral thesis (published in 1993 by The Robert Gordon University in Aberdeen, Scotland), Trimble said that he came to the conclusion that smoke hoods would keep passengers conscious and mobile.

"Nobody is going to come in [the aircraft] and get you. You have got to get out yourself, and to do that you have to be mobile," he said.

Trimble's thesis, *The Management of Aircraft Passenger Survival in Fire*, concluded that evacuations were delayed when people became incapacitated. The longer the delay, the more likely that conscious passengers would become incapacitated. Trimble called it "debilitation-induced evacuation suppression."[20]

Trimble said that he does not believe that the use of smoke hoods will delay an emergency evacuation of an aircraft. He said that he believed that delays reported in smoke-hood evacuation tests were related more to the dark interiors of the aircraft because of the loss of major illumination than to the donning and wearing of smoke hoods.

No matter what the cause, testing has demonstrated the potential hazard of delays that might be caused by smoke hoods, according to Constantine P. "Gus" Sarkos, manager of the Fire Safety Branch at the FAA Technical Center in Atlantic City, New Jersey.

"Using a model tied into full-scale fire data, we showed that if there was even a 10-second delay ... in past accidents, more people would have died than would have been saved," said Sarkos.[21]

Tom McSweeny, director of the FAA's Aircraft Certification Service, said that in an aircraft with only two main cabin doors (Type A doors [72 inches (183 centimeters) high by 42 inches (107 centimeters) wide]) available, FAA tests showed that four people can evacuate in one second. If an evacuation is slowed by even one second, he said, it could cost one life.[22] McSweeny said that evacuation slides are wide enough for two people to evacuate almost simultaneously, and that the FAA's tests

Table 2 (continued)

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Duram Emergency Escape Mask	**Plus 10 Filter Breathing Unit**	**Fuji Ace Mark II Emergency Escape Mask**	**Provita Smoke Hood**
About 1,000 per month.	Did not know.	Still trying to get significant sales.	Will not disclose sales figures.
No.	Yes. 2,500 ppm for 3 minutes; plus 10,000 ppm for 2 minutes.	Tests were not conclusive.	No.
A latex-type material.	Teflon PFA; 7.5 mil (thickness).	Laminated, flame-retardant polyvinyl chloride (PVC) sheet on heat-resistant fabric ("fire-retardant PVC leather").	Kapton.™
Neck seal is part of hood; conforms to neck.	Silicone rubber.	Elastic band; hood collar covers it.	Neoprene latex.
4 years.	5 years.	5 years.	4 years.
20 minutes.	10 minutes (extremely toxic atmosphere).	15 minutes (fairly severe conditions).	10 minutes (chemical fire with a high concentration of chlorides); 20 minutes (airplane fire).

assume that in an actual evacuation, passengers will push to the doors and others will be immediately behind them in the aisles.

"The reality of any evacuation is people are standing in the aisle, waiting for the door [to reach the door and exit the aircraft]," he said.[23]

"If you measure the effect of any piece of equipment for fire safety," McSweeny said, "you have to test in relation to today's standards. In simple terms, it is the argument 'Are you saving the same lives over and over again?' You can only save them once."

If smoke hoods were required for commercial air carriers, McSweeny said, "You have the cost of purchasing them, the cost of maintaining them and the cost of replacing them [assuming pilferage, wear and damage]. And, there's the weight — for every pound you put on the plane you take a pound from cargo, which means the extra weight not only burns fuel but costs revenue."

Denis Warren, head of the CAA's Research and Management Support Department, suggested that if passengers in a more recent non-fatal aircraft accident had been provided with smoke hoods, the smoke-hoods might have contributed to fatalities.

"We look at accidents like the TWA [Trans World Airlines] L-1011 accident at Kennedy Airport, where everyone got out but it was a very rapid evacuation, and we wonder if they would have gotten out if people were unpacking their smoke hoods," said Warren.[24]

[On July 30, 1992, at John F. Kennedy International Airport in New York, the flight crew of a TWA Lockheed L-1011 rejected the takeoff just after liftoff. The NTSB said that when the plane came to rest, it was upright and burning. Most of the reported 10 injuries were minor, and there were no fatalities. The aircraft was destroyed by fire. (See "Faulty Angle-of-attack Sensor Provokes Go/No-Go Decision with an Inadequately Coordinated Crew," *Accident Prevention*, August 1993.)

The NTSB accident report said, "The evacuation of the airplane occurred within two minutes. The speed in evacuating 292 passengers and crew from the airplane was complemented by the following: TWA's requirement (in accordance with TWA's normal operating procedures) for nine flight attendants, which was three more than the

FAA minimum; and the fact that the nine flight attendants were assisted by five TWA nonrevenue (off-duty) flight attendants and two off-duty TWA captains who were occupying the cockpit jumpseats.

"TWA flight attendants undergo recurrent training on the operation of all cabin doors every 12 months. This is twice as often as the every-24-months requirement of the FAA. The flight attendants reported no problems operating the exits, and the Safety Board believes that the training they received helped in this regard."[25]

The report concluded, "Although certain deficiencies were noted in the cabin furnishings that require corrective actions ... the performance of the flight attendants and the pilots in leading the emergency evacuation prevented significant loss of life."

The NTSB recommended that the FAA "research the effect of aging on the self-extinguishing ability of cabin interior furnishings."]

"I would rather spend my money [U.S. taxpayers' money] and efforts in preventing [an inflight fire] from happening or getting the fire extinguished [than on providing passengers with smoke hoods]," said the FAA's Sarkos.

EVAC•U8 Emergency Escape Smoke Hood

Henri Branting, manager of the FAA's Technical Analysis Branch, said that the FAA's number one priority is to introduce materials into cabins that burn more slowly to prevent or delay the point of flashover. "FAA testing revealed that toxic fumes in a cabin reached dangerous levels when the cabin was engulfed in fire. Flashover is the most dangerous situation," he said.[26]

Branting said that although fire-blocked seat cushions were mandated, "it was far too expensive to have the airlines tear out perfectly good interiors [wall and ceiling panels] and have them replace them with better [fire-blocked] ones."

The FAA, however, was criticized recently by the U.S. General Accounting Office (GAO), a nonpartisan congressional agency that audits federal programs. The GAO calculated that the entire U.S. airline fleet will not be in compliance with 1988 cabin interior standards until 2018. The latest standards apply to cabin panels and walls, and aircraft built since August 1990 must comply with the new standard. Nevertheless, when parts on older aircraft are replaced, only the specific parts being replaced must comply with the new standards. Original FAA forecasts estimated that 85 percent of the U.S. airline fleet would be in compliance with the 1988 standards by 2000; current trends indicate that only 55 percent of the fleet will be in compliance by 2000. [See "U.S. Report: Progress Slow in Fireproofing Aircraft Cabins," *Cabin Crew Safety*, March/April 1993.]

There have been significant regulatory changes for aircraft interiors in the United States since the mid-1980s.[1] McSweeny said that actions by the FAA have increased the level of aircraft cabin fire safety since the late 1970s and early 1980s. He said that these improvements have reduced the potential, overall benefit of smoke hoods. [Improvements have included fire blocking of seat cushions, fire blocking of sidewall and ceiling panels, lavatory smoke detectors, hand held fire extinguishers, improved cargo liners, protective breathing equipment for flight crews and cabin crews, and floor emergency escape path lighting.]

Matt McCormick, chief of the NTSB's Survival Factors Division, said that the NTSB has not made a recommendation for or against mandating smoke hoods for passengers. He said, "We don't want to see anything that will slow them [the crew] down getting them [the passengers] out of the plane."[27]

The Aviation Consumer Action Project (ACAP), a U.S.-based advocacy group begun by lawyer and consumer activist Ralph Nader, believes that the FAA's reluctance to mandate smoke hoods on commercial aircraft is not based solely on safety grounds.

Geraldine Frankoski, director of ACAP, said that ACAP filed in 1987 a petition for proposed rulemaking that asked the FAA to require filtration-type smoke hoods that would allow 20 minutes of uncontaminated breathing air for each aircraft passenger. Frankoski said that the FAA denied ACAP's petition in March 1993, citing possible theft of smoke hoods, cost and potentially longer evacuation times.

"We do not believe that any of these reasons are valid," said Frankoski, a passenger-survivor of the 1991 Los

Angeles USAir/Skywest accident. Frankoski accused the FAA of denying ACAP's petition because of "[aviation] industry pressure and industry concerns about cost and convenience."[28]

The Association of Flight Attendants (AFA) supported ACAP's petition in a 1988 letter to the FAA from AFA's then-Director of Air Safety and Health Matthew H. Finucane:

"Too many passengers seem to be overcome by an incapacitating panic, perhaps exacerbated by the irritating gases, and putting on the [smoke] hood could provide them with a sense of orientation and being able to escape the aircraft."[29]

Christopher Witkowski (former ACAP executive director), who became AFA's director of air safety and health in 1992, said AFA continues to stand behind the 1988 letter.

"Toxic fumes are a problem, and until the FAA makes advances in getting rid of them, the FAA should pursue the feasibility of passenger smoke hoods on commercial passenger aircraft," Witkowski said.[30]

Witkowski also said that the approximately 70-member AFA staff bargained for an additional provision in their new work contract that specified that staff members would be issued a smoke hood whenever they traveled on AFA business. Thus far, he said, a specific smoke-hood model has not been selected and purchased for staff use, although several months have passed since the contract was approved.[31]

SMOKESHIELD Personal Fire Smoke Escape Hood

In the United Kingdom, Survivors' Campaign to Improve Safety in Airline Flight Equipment (SCI SAFE) advocates the use of smoke hoods, and co-chairman William Beckett disagreed with arguments about the expense of providing smoke hoods to passengers. [SCI SAFE was founded by the families of some of the nonsurvivors of the Manchester accident and by some of the accident-survivors.]

"The cost of introducing a smoke hood is minimal in relation to the cost of introducing a video in the back of your seat, a telephone in the back of your seat, or whatever gadgets are being introduced in business class," Beckett said.[32]

Beckett, whose daughter was killed in the Manchester accident, also said that he believes CAA and FAA arguments about delayed evacuations are flawed.

"The argument they are putting forth is a spurious one," he said. "Does it mean that because some people can't put them [smoke hoods] on, they shouldn't be there?"

"All the research necessary [to produce smoke hoods that can be installed on commercial transport-category aircraft] has been done and it is reported in Dr. E.J. Trimble's detailed thesis," said Derek Dempster, a former pilot with British Overseas Airways Corp. (BOAC), who became head of safety and security for the then-Air Transport Users Committee (AUC) [now the Air Transport Users Council] during the 1980s.[33] The AUC was a volunteer organization, which was partially funded by the U.K. CAA, that represented air passengers and shippers. In 1986, the AUC urged the CAA to consider a simple and inexpensive smoke hood that would allow passengers a three-minute window of opportunity to escape from a burning aircraft on the ground.

"My concern is that the traveling public doesn't know about these wonderful devices [modern smoke hoods], which should be available for purchase in airport shops," said Dempster. "Airlines don't have to be penalized [by requiring smoke hoods]. Just let people carry [compressed gas] smoke hoods on the aircraft."

Dempster said that it would be a "grave mistake" to suggest further smoke-hood research is necessary, because aviation authorities might sieze this as a means to block airline passengers from using the smoke hoods of their choice [specifically those using compressed gas]. He said that there would be little thanks for such a recommendation.

"Not many people would thank you [Flight Safety Foundation if it suggested that further research is required] ... , least of all the regulators and the airlines when lawyers for the next lot of victims of toxic fumes justifiably turn their guns onto them," said Dempster. "Believe me, they're [lawyers are] standing by waiting for such an eventuality."[34]

Malcolm C. Keogh, a law partner in the firm of Pannone & Partners, said that he believes that in the United Kingdom,

the CAA is not protected legally from suit in court, unlike the FAA, for failing to perform its functions.

"According to the Civil Aviation Act of 1982, ' … it is hereby declared that the CAA is not to be regarded as the servant or agent of the Crown or as enjoying any status, privilege or immunity of the Crown ... ,'" said Keogh, who was a member of the legal steering committee that represented "virtually all the passengers involved in the Boeing 737" accident in Manchester.[35] "'It shall be the duty of the CAA to perform the functions conferred on it ... to further the reasonable interests of users of air transport services.'

Parat C Smoke Escape Mask

"Clearly, the CAA would currently argue that it considers that passengers' best interests are served by prohibiting them from using EUROCAE-65 [compressed gas] smoke hoods. I would argue that the very extensive research which has taken place, culminating in the thesis of Dr. E.J. Trimble, unequivocably demonstrates that smoke hoods would save lives. The inevitable conclusion of my argument is that if there should be another accident involving a British-registered aircraft where people die through asphyxiation in circumstances, which could have been prevented by the use of smoke hoods, the [U.K.] Civil Aviation Authority will bear full legal liability by reason of its breach of a clearly defined statutory duty."

A conference at the University of Oxford's Linacre College in England in March 1988, focused on the CAA's *Smoke hoods: net safety benefit analysis*. Some participants were critical of the report's research.

H.S. Park, a B.P. Ventures Ltd. statistician who attended the conference, concluded: "No consideration has been given to some factors which could be important when examining the safety benefit of smoke hoods. For example, only deaths have been considered. It is probable that smoke hoods improve, immediately and in the long term, the post-crash condition of survivors. In insurance claims, injuries can prove more expensive than death." [36]

The Royal Air Force Institute of Aviation and Forensic Pathology reported at the AGARD meeting that in an aircraft fire particulates can carry toxic materials into the lungs that may cause lung disease later in life and that "the potential hazard of smoke inhalation should not be underestimated. Survivors may feel well initially, but lung function may deteriorate rapidly in the 24 hours following exposure.

"The only effective way to prevent them [particulates] from entering the lungs is to filter them out."[7]

During the same 1988 conference, then recently retired chief of the FAA's Civil Aeromedical Institute's (CAMI) Biochemistry Research Aviation Toxicology Laboratory, C.R. Crane, Ph.D., said, "It is especially interesting that the only 'improvement' which is allowed to extend the time available for successful evacuation ... is the installation of fire-blocking layers!

"I would characterize the general model [used in the CAA's report] as one that would inadequately, if not incorrectly, represent the real world of aircraft fires. Furthermore, the parameters that serve as input for the predicting equations are so rarely available from accident investigation data — or are estimated with such poor precision and confidence — that one could get almost any answer he wanted by selecting the appropriate input values. There is, however, one trend in the predictions that does suggest, to this reviewer, some sort of systematic bias (either in the design of the equations or in the selection of the input values) and this is that the contribution from FBL [fire-blocking materials in the aircraft cabin] is consistently overestimated while that from PPBE [passenger protective breathing equipment] is underestimated."[37,38]

[In 1984, the FAA mandated that Part 121 aircraft be retrofitted with seat cushions that had a thin layer of highly fire-resistant materials. The fire-blocking layer would protect the foam core of the cushion. When foam burns, it not only spreads the fire but also emits lethal smoke, combustible gases and toxic gases.]

Crane acknowledged that developing an adequate model is difficult: "The fact that I have characterized the model under review as potentially inadequate (and even possibly flawed) does not also mean that I, or anyone else, have a better one to offer at this time. It is possible that more appropriate equations could be devised, but we cannot change the fact that historical data required for input into any equation are almost nonexistent. I would prefer no model over a poor model — no predictions over misleading ones."

J.H.B. Vant, Ph.D., chairman of the Aviation Study Group at the University of Oxford's Linacre College, reported on the results of a 1987 smoke-hood test in a paper presented at the 1989 AGARD conference. The test, which was conducted at Teesside Airport, was organized by a research team from Linacre College led by Vant; the CAA contributed personnel, equipment and money to the test, which was conducted in the spring season.

There were 765 volunteers, aged 18 to 50, who participated in nine simulated emergency evacuations from a Hawker-Siddeley Trident 3 airliner [capable of seating up to 180 passengers] in clear air and nontoxic theatrical smoke, with and without smoke hoods. British Airway's flight attendants who were familiar with the aircraft also volunteered and participated in the tests.

In his paper, "Smoke Hoods Donned Quickly — The Impact of Donning Smoke Hoods on Evacuation Times," Vant reported that to ensure that the "tests would gain acceptance" by the FAA, it was agreed "that the cabin crew's directions to don [the smoke] hoods would be as the falling smoke reached the top of the seat backs. ... This was likely to be the longest period of time passengers would tolerate smoke without donning [smoke] hoods."[39]

Duram Emergency Escape Mask

Nevertheless, many of the participants in the Linacre College test made some significant decisions of their own. The CAA's *Smoke hoods: net safety benefit analysis* noted, "No delay in donning was identified in the Linacre College trials because many of the test subjects put their [smoke] hoods on while the smoke in the cabin was building up, but before the evacuation [donning the smoke hoods] was commanded. This, it could be argued, is probably realistic. The CAMI trials [see "Clearing the Air About Smoke Hoods"] did not attempt to measure the donning effect."

Vant reported in his paper that the majority of the participants donned the smoke hoods within 10 seconds and that the "speed at which smoke hoods are donned is influenced by the motivation of the individual to don the equipment, the ease at which such equipment can be worn and the effectiveness of the instruction provided during the passenger briefing.

"It was observed that on donning smoke hoods in conditions of smoke a more orderly evacuation took place than in a condition of smoke without hoods. It is therefore concluded that the donning of the ventilated smoke hoods gave participants a feeling of protection from the smoke and the confidence they gained from this act brought about a more orderly evacuation."

Vant concluded that "the preoccupation of evacuation times, with and without smoke hoods, has led to the main point being missed. The tests show, as did those undertaken by the Federal Aviation Administration [see "Clearing the Air About Smoke Hoods"] that evacuation in conditions of smoke takes much longer and thus protection is necessary from smoke particles, toxic fumes and gasses for some passengers to survive."

Although the Teesside results supported smoke-hood use, some industry authorities questioned whether passengers' reactions could be anticipated in a real-life emergency. They said that human behavior is not predictable, and that a person unfamiliar with a smoke hood may not be able to use it correctly.

"That it [a smoke hood] is a device that has to be individually donned by each passenger indicates that there is a tremendous opportunity for differences in the time it takes [to don a smoke hood]," said Al Prest, Air Transport Association of America (ATA) vice president of operations.[40] ATA is an association of airlines that transport people, goods and mail between fixed terminals on regular schedules.

"We want people to get out of the airplane quickly, and we think donning a smoke hood will delay the process," said Prest. Anxiety, dexterity and motor skills could all lend a hand in delaying donning — and evacuation.

"It is far easier to motivate people to get up and to get out than it is to get involved with each person donning a smoke hood," Prest said.

Vant said the nature of air travel makes it imperative that passengers have access to protective devices.

"The airline industry tells passengers what to do, when to do it, where to do it," he said.[41] "Passengers are controlled, and in a small, confined space, that is not unreasonable. The problem with an aviation fire is it sometimes occurs without the people on the flight deck knowing about it. Protective equipment needs to by controlled by the passengers — the flight deck [crew] may not know what is going on."

Vant said that researchers face difficulties in obtaining factual and reliable information for evacuation models, although there are many unsupported accounts of what happens in aircraft fires. He said that he believed that smoke hoods will become more necessary as time passes — and air traffic increases.

"The danger always increases as traffic increases," he said, "Air [aircraft] fire has not disappeared."

Vant said that he carries a smoke hood when he travels. "Of course, I do [carry a smoke hood], as do all [U.K.] air investigation officers I know."

Vant, who participated in the 1988 conference at Linacre College, said that no model has been presented to replace the one used by the CAA's *Smoke hoods: net safety benefit analysis.* He said that is because of a lack of data, and that such data might not be available for some time.

Plus 10 Filter Breathing Unit

"[In an actual fire emergency] no one is around with a stopwatch; they are hightailing it out of there," he said. But the lack of a realistic model does not diminish the necessity of having smoke hoods on aircraft for passengers, according to Vant.

"Cabin smoke — two, three breaths and you fall over [incapacitated] and block the exit for everybody else," he said.

Vant said that the data base used in the CAA's report was flawed, and that as a result, the study itself was flawed.

"I would contend that this report that they [smoke hoods] will only save 'x number' of lives is defective," he said.

In January 1991, the Transport Committee of the British Parliament's House of Commons issued *Aircraft Cabin Safety,* a report that urged the use of smoke hoods and criticized the CAA for its apparent disinterest in them.

"We sense a lack of will on the part of the CAA, coupled with an attitude that either smoke hoods or watermist systems represent the answer," the committe's report said. "We have been convinced by arguments put to us by the Air Safety Group [a group of former aviation professionals, according to Victor Brennan, the British Embassy's civil air attaché in Washington, D.C.[42]] that 'smoke hoods and watermist systems go hand-in-hand.' But whilst the installation of watermist systems will take many years, smoke hoods could soon be made available."[43]

[Cabin watermist/water-spray systems use a dedicated onboard water supply to delay fire penetration and to limit the development of fire in a cabin. When the system is activated, water is sprayed into the cabin, lavatories, galleys, pressure bulkheads and other areas. (See "Cabin Water-spray System Promises Better Crash Survivability," *Cabin Crew Safety*, January/February 1992.)]

The Transport Committee added: "We see a pressing need for smoke hoods and are concerned by the CAA's apparent disinterest in them. Even if the CAA's stringent specification [see "Clearing the Air About Smoke Hoods"] is met, the Authority has given no firm commitment to make mandatory their carriage on U.K.-registered aircraft. ... We recommend the mandatory carriage by U.K.-registered aircraft of the best smoke hoods currently available. This should be implemented without further delay."

The CAA disagreed. Three months later, in April 1991, the CAA issued a report, *Improving Passenger Survivability in Aircraft Fires: A Review*, which remains its most recent decision on smoke hoods.

"The authority's view on passenger smoke hoods is that the subject cannot be viewed in isolation," said the CAA.[44] "If it is possible to prevent a fire, steps must be taken to do so. If a fire does start, then means must be provided to fight it and measures taken to ensure the best possible chances of survival following an accident."

The report cited the various steps to suppress or contain aircraft fires, which in turn had reduced the potential for smoke hoods to save "about one life per year worldwide, even on the unrealistic assumption that smoke hoods would

have introduced no additional delay in the evacuation. The more likely outcome is that delays in the evacuation would have led to the loss of eight or more lives per year."

The CAA said that its decision was not rooted in the technical design of passenger smoke hoods, but "mainly in the unpredictable response of untrained passengers to a strange piece of equipment in rapidly changing conditions that causes professionals to argue against the value of smoke hoods on transport aircraft."

The CAA said that each passenger-survivor in an aircraft accident "has to develop a strategy for his own survival. This strategy must not be unduly complicated, otherwise precious seconds will be lost. ... Do I put on a smoke hood or do I just get out as quickly as possible? It would only take a few passengers to hesitate over the question before a disciplined and orderly evacuation becomes disorganized and chaotic."

Other factors that weighed against smoke hoods, in the opinion of "professional safety specialists," said the CAA, were that:

- Passengers might be "lulled into a false sense of security once smoke hoods were donned" and stand erect, which would expose them to greater risk of higher temperatures, rather than get as low as possible;
- Evacuation time could be increased by impaired vision and communication;
- Aisles could be blocked by passengers who caused delays by assisting children and spouses to correctly don the smoke hoods;
- Training in donning smoke hoods should not be underestimated because "untrained people do the most improbable things"; and,
- Passengers will "forget about smoke hoods," based on aircraft ditchings where only 50 percent of water-flotation life-jackets have been used.

Fuji Ace Mark II Emergency Escape Mask

"In view of the risk that smoke hoods will jeopardize the evacuation process and may in some circumstances lead to increased loss of life, the Authority has concluded that it should not require the carriage of passenger smoke hoods in U.K. transport aircraft even if one [a smoke hood] were to be available which met the specification. Furthermore, it should discourage any airline from doing so voluntarily.

"The Authority is concerned that in a crash situation, with passengers experiencing shock and perhaps panicking, any delay in putting on a smoke hood, particularly by parents of young children or partners helping each other, would reduce the benefit [of smoke hoods]. It would only require one or two people to get into difficulty with their smoke hoods, for the whole evacuation to be in jeopardy. This, the Authority feels, is an unacceptable safety risk and it is for this reason that it has decided not to require the provision of passenger smoke hoods in British-registered aircraft."

The AAIB's Trimble disagrees: "In adopting the posture that these [smoke hoods] would delay evacuation, they [the CAA] have damned the whole approach from here to eternity."

Brennan said that the CAA will not be mandating cabin water-spray systems because they are not cost beneficial. He added that "one of the reasons that we [the CAA] didn't go for smoke hoods was because we thought cabin water-sprays were a better bet. I think it's a debate [about smoke hoods] that will go on and on. It's not the answer that people who have an interest in these things [smoke hoods] want to hear."

"Now it would be impossible for the U.K. to mandate something unilaterally at this point. It would have to be with the JAA [Joint Aviation Authorities].

"We're back to square one," said Brennan.

Vant said that he agreed with Trimble that authorities may have locked themselves into a position against smoke hoods, and that they would be politically embarrassed if they reversed their decision. [Vant is also a research consultant to the business school at The Robert Gordon University and supervised Trimble's thesis.]

Vant said that the problem began when the CAA regulators decided to pursue cabin water-spray systems, instead of smoke hoods, as the better safety benefit in aircraft cabin fires.

"Now they are in the situation where they have to go back and say that what they had proposed in the beginning was right all along. They would give anything for someone to give them a way out," he said.

But the CAA's Denis Warren, in an article published in a 1992 issue of the FAA's now-defunct *Aviation Safety Journal*, wrote: "In reality there will inevitably be some delay caused by the donning of smoke hoods and the evacuation will be slower. The analysis shows that if this is taken into account, there would be a reduced benefit overall, and in some accidents additional loss of life was likely.

"Worse still, if some passengers had donned their [smoke] hoods and others [had] not, some of the latter may try to get back to their seats to fetch theirs, effectively blocking the aisle and stopping evacuation."[45]

Sarkos also warned against delays: "The role of the passenger is to get the hell out of the airplane as quickly as possible using the nearest available exit. Smoke hoods could potentially be a counterproductive measure.

Provita Smoke Hood

"In a lot of accidents, they have enough problems getting out of the airplane without donning something that is foreign to them."

But he acknowledged that the issue of smoke-hood use will remain emotionally charged for some time. "I have never encountered a more controversial subject [in aircraft fire safety]," Sarkos said.

Vant, who has access to the fire simulator at the Fire and Emergency Center in Montrose through the Aviation Study Group at Linacre College, said that the simulator model is about the size of a Chinook helicopter fuselage. [The Chinook helicopter's interior is 30.5-feet (9.3-meters) long and has a mean width of 7.5 feet (2.3 meters).[46]] Vant said that the center is owned by a consortium of offshore oil companies, and that they use the fuselage model to train people how to escape from burning helicopters.[47]

The model, which is in a barren area, can be tilted, and there are steel seats inside it. During a fire simulation, kerosene fuel can be pooled around the model. When the fuel is ignited, the model becomes hot and smoky, and a vastly more realistic environment than allowed in government evacuation tests.

Vant offered this solution to end the controversy about smoke hoods: "Put the FAA and the CAA guys in my simulator. That might change their minds." ♦

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