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Continuous Smoke in the Cockpit Continuing Hazard, Study Warns

Airliners are not required to be able to cope with continuous smoke in the cockpit, yet in-flight smoke and fire events occur at an average rate of one in every 5,000 flights, according to a new study.

Undertaken by aviation consulting firm **Morten Beyer and Agnew**, the study provides a timely overview of the hazard posed by in-flight smoke and fire. The study was co-authored by Nick Lacey, former head of flight standards for the **Federal Aviation Administration** (FAA) and Niels Andersen, an aeronautical engineer with an extensive background in flight deck technology.

Their report comes to a number of stark conclusions:

- In-flight smoke and fires continue to occur largely in inaccessible areas and compartments of transport aircraft.
- Certification procedures do not require aircraft manufacturers to test for smoke dispersal and evacuation during continuous dense smoke. "To our knowledge, FAA certified aircraft have never demonstrated the ability to disperse dense continuous smoke," the authors noted. "This has been a safety concern of airline pilot safety committees for over 30 years." *(See ASW, Dec. 21, 1998, p. 1)*
- The time taken for fire identification and suppression, while simultaneously maneuvering to land the aircraft – on the order of about 15 to 30 minutes – can lead to smoke migration, pilot confusion, obscured vision inside and outside the flight deck, and occasional conflagrations with catastrophic consequences.
- Based on existing safety reporting channels, Lacey and Andersen estimate that more than 1,000 in-flight smoke events occur annually, resulting in more than 350 unscheduled or precautionary landings – that works out to an average of one precautionary landing every day *(see box, above)*. The estimated rates of occurrence are as follows:

In-flight smoke events:	1 in 5,000 flights
In-flight smoke diversions:	1 in 15,000 flights

- Crews do not undergo realistic training, such as that practiced in the **U.S. Air Force** (USAF), for coping with smoke in the cockpit *(see box, p. 3)*

Despite the fact that continuous smoke is "reasonably probable," manufacturers are not required to demonstrate that their cockpit ventilation or other systems can deal with it. The relevant guidance is contained in FAA Advisory Circular (AC) 25-9A, issued in January 1994. The 1992 draft version of this document emphasized the continuous smoke problem and incorporated a requirement that crews must be

Smoke in the Cockpit

Two recent examples:

- **Sept. 18**, FH227 of **Big Sky**, Flight BSY2503, landed Runway 35L at Denver, Colo., exited at Taxiway M6 and declared smoke in the cockpit. Deplaned passengers and crew via stairs on the taxiway.
- **Sept. 19**, Beech 1900C of **Air Georgian**, Flight GGN7419, landed at Lester B. Pearson International Airport, Toronto, Canada. On flight from Dayton, Ohio, reported smoke in cockpit 20 NM south of Toronto. No emergency declared. *Source: ASW accident & incident tables. See additional smoke events 12 & 14 Oct. at p. 10*

Smoke in the Cockpit – Infrequent But High Consequence

The smoke hazard according to Paul Halfpenny:

"Although the probability of a fire that creates smoke in the cockpit is not high, it is a real number and must be considered. The results of loss of visual acuity by the crew can be disastrous as shown by various accidents: **Varig** B707 in 1983, **Air Canada** DC-9 in 1983, **ValuJet** DC-9 in 1996.

"Modern aircraft using two-man flight crews rely more heavily on electronics with a subsequent increase in probability of a component fire of equipment in or juxtaposed to the cockpit. Another probability is that of a terrorist attack that could fill the cockpit with a continuous source of smoke. This latter consideration has become a real hazard but defies rigorous probabilistic analysis.

"A continuous source of smoke, due to any kind of fire by itself or combined with any reduction in ventilation flow, or contamination of the ventilation flow with smoke – can have a serious effect on crew visual acuity unless some provisions are made to ensure instrument visibility."

Source: 'Smoke Hazards in the Flight Station,' Halfpenny, unpublished technical paper, July 2002 ■

able to see in the presence of continuous smoke.

The final version of this seminal guidance deleted the mandatory requirement to test against continuous smoke for certification purposes, recommending it but leaving such a test optional. Demonstrating the pilots' ability to see in the presence of continuous smoke became a function of the manufacturer's discretion:

"Although not mandatory, *if the applicant wishes to demonstrate protection from smoke generated by a continuous source in the cockpit*, smoke should be generated continuously. The crew should don protective breathing equipment and … activate any *optional* vision enhancement devices." (Emphasis added)

Of this significant change between the draft and final versions of the AC, Lacey and Andersen said in their paper, "We surmise that the manufacturers were conscious of the potential for costly redesign of bleed air systems, air conditioning packs, and outflow valves."

Separately, Lacey said of the continuous smoke problem, "Despite a clear FAA recommendation, manufacturers continue to ignore the issue."

Under current certification criteria, the cockpit is pumped full of smoke to the point where pilots cannot clearly see their instruments. Then the smoke is cut off, and the ventilation system must clear it within three minutes. Numerous experts have criticized the artificiality of this protocol, given the nature of fires in inaccessible spaces to spread, and the lack of fire detection and suppression in many of these same spaces.

One system now available, known as the emergency vision assurance system (EVAS), enables the pilots to see in the face of continuous smoke by physically displacing it with an inflatable clear plastic bubble *(see ASW, Dec. 21, 1998, p. 8).* This technology falls under the "optional" vision enhancement equipment mentioned in the AC.

Some carriers do not view it as optional, but an essential part of their contingency planning. For

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example, **JetBlue Airways** is installing EVAS in its entire Airbus A320 fleet.

Meanwhile, Lacey and Andersen come to a sobering conclusion:

> "In spite of the frequent occurrence of [in-flight smoke and fire] events, the fundamental design and certification of transport category aircraft environmental systems has remained unchanged since the introduction of jet transport aircraft. While measures are being taken to reduce the chances of fire and smoke by addressing circuit breaker protection, maintenance procedures, wiring and insulation materials, we can hardly conclude that the problems have been remedied."

Indeed, the problem may be worsening with the shift toward two-pilot crews and a greater density of electronics in the cockpit. Paul Halfpenny, a retired aerospace engineer and former vice chairman of the **National Academy of Sciences** (NAS) Committee on Airline Cabin Safety, a small fire can quickly lead to a dramatic reduction in the ability to see. Halfpenny calculated that rigid polyurethane foam burning at a rate of 5 grams per second reduces vision to less than 10 centimeters at maximum cockpit ventilation. Emergency depressurization would increase the visibility, but only for about 45 seconds (while the pressure equalizes). In other words, if the fire isn't extinguished and the smoke continues to be generated, the pilots cannot see vital instruments or out the windscreen to safely execute an emergency landing.

Halfpenny concludes that continuous smoke in the cockpit poses a real hazard *(see box, p. 2).* Of interest for extended-range twin engine operations (ETOPS), Halfpenny believes the likelihood of smoke in the cockpit is about three times greater than an in-flight engine shutdown (IFSD). Operators must demonstrate an IFSD rate of .02/1,000 hours or better in order to gain approval for ETOPS flights. That rate translates to a probability of one in 50,000. Lacey and Andersen found that diversions due to smoke in the cockpit occur 1 in every 15,000 flights. Thus, while the ETOPS approval process focuses on the likelihood of single-engine diversions, pilots actually flying these routes are more likely to face a smoke in the cockpit event rather than a failed engine. The two may not occur separately, since an engine failure, associated electrical and ventilation problems may occur simultaneously – forcing pilots into having to fly for three hours on one engine to the nearest airport while coping with smoke in the cockpit.

Lacey and Andersen's advice to airline executives – look hard at more realistic training and emergency equipment like EVAS to mitigate the risk of an in-flight smoke event or fire leading to loss of the aircraft. In other words, against the day when the ability to cope with continuous smoke is a mandatory part of aircraft design, operators are on their own. >> *Lacey, e-mail nlacey@MBA-consulting.com; Halfpenny, e-mail ax923@lafn.org* << ✈

'Pilots Are Never Exposed to Actual Smoke'

A brief case study in unpreparedness (extracts)

"Pilot training for smoke in the cockpit is limited to a classroom or computer-based study of the bleed air and air conditioning system. The crews practice the emergency procedures in the simulator by accomplishing the checklist actions … During these simulator sessions, pilots are never exposed to the actual smoke or to the migration patterns they are likely to experience, nor are they required to deal with potential compound emergencies – such as a cargo bay explosion – [causing] not only a rapid decompression, but also a partial electrical and instrumentation failure, along with smoke emanating from multiple sources.

"While it would be impossible to train for every combination of in-flight emergencies, it is our opinion that dense smoke could accompany many … situations that may be survivable – if the pilots are able to see well enough to continue to fly the aircraft:

- Detonation of an explosive device
- Uncontained engine failures
- Wheel well explosion
- Missile attack
- Smoke used to commandeer an aircraft during a hijacking
- Sabotage of aircraft environmental systems
- Countless sources of electrical malfunctions

"We have first hand experience with the United States Air Force (USAF) simulator training for in-flight fires on tanker and transport aircraft. Because of its combat mission, USAF takes the training of pilots in a 'dense smoke' environment to a higher level of realism.

"For example, USAF simulator training routinely puts crews through a cockpit electrical fire situation during a descent into a mountainous area. As the USAF crews accomplish their electrical fire checklist, they inevitably would become over-tasked and begin to make serious navigation and procedural errors or bungle the crew coordination necessary to combat the fire.

"We believe airline flight crews could benefit from guided discussions of some of these scenarios during their classroom and simulator training."

Source: Morten Beyer & Agnew ■