Air Safety Week, Vol. 14 No. 17

April 24, 2O00
Washington. *D.C.*

Potential In-Flight Fire Events **Occur Daily; Many in Inaccessib1e Areas**

"Crews don't have the diagnostic tools to locate the sources of *smoke and fire."*
Jim Shaw, line pilot and manager,
Air Line Pilots Association in-flight project

DAYTONA BEACH, Fla. – If a pilot's greatest fear is an in-flight fire, aircrews in the U.S**.** airline industry are facing this frightening specter an average of three times a day. In one out of every three of these cases, pilots were sufficiently concerned to execute a precautionary landing.

More than 960 smoke and in-flight fire events were recorded in 1999. They triggered more than 350 unscheduled landings. In many cases, evidence of electrical arcing was discovered. After routine repairs, the aircraft were returned to service. Even if these events were trivial, although many were not, safety was affected. According to Jim Shaw, manager of the in-flight fire project for the **Air Line Pilots Association** (ALPA), the rate of one unscheduled landing per day compromises safety. "Every day there's at least one pilot and crew landing at an airport they are not familiar with," he declared. Shaw presented his findings at the **Society of Automotive Engineers** (SAE) "Advances in Aviation Safety" symposium.

Even at half the rate, Shaw's numbers are staggering. They result from a compilation of Service Difficulty Reports (SDRs) in the first 10 months of 1999 *(see box at right).* To he sure, this period of time covers the months following the Sept. 1998 fatal crash of **Swissair** Flight 111, in which out-of-control electrical fire on the accident MD-11 is the primary suspect. Pilots, sensitized in the wake of the Swissair disaster, may have been landing their aircraft with unusual alacrity at the first whiff of a strange smell or the distinctive odor of an electrical malfunction. The dread is universal, as evidenced by a recent article in a Canadian publication for bush pilots (*see box at left).*

Many events not reported

Pilot anxiety may be only a partial explanation. Shaw offers another, more chilling point: even though the SDR database represents the richest lode of such information, it may represent a significant undercount of actual events. For example, one SDR report cited "several air returns with smoke odor" (e.g., unscheduled landings) for the affected airplane. In addition, under U.S. regulations concerning Immediate Notification (49 CFR 830.5), operators are required to submit reports of in-flight fires, irrespective of the outcome. However, smoke without fire is not a reportable event, despite the folk wisdom "where there's smoke there's fire." Consequently, the **Federal Aviation Administration's** (FAA) incident database contained only about 1/7th the number of reports Shaw discovered it the SDR database. Of 155 SDR-reported events that necessitated an aborted takeoff, return to the block, emergency descent or unscheduled landing, only 21 such cases were found in the FAA incident database for the same time period.

For these reasons, Shaw believes his tally represents "minimum numbers,'' and that the actual count "can reasonably be presumed" to be greater.

Sam Holoviak, a pilot who also is a member of ALPA's central air safety committee, observed with the vivid memory of personal experience, "The sound of a popped circuit breaker raises the hair on the back your head." With this observation in mind, highlights of Shaw's findings should raise hair on the backs of many heads:

* **High numbers**. An average of about 100 smoke and fire-related events is being recorded per month, or roughly three per day. An SDR database search based on entering the words "Smoke and not False Warning" for the *Nature of Condition*, and the words "insulation or wiring, and char or burn or short" in the *Summary* turned up 964 events over the 10 months from Jan1, 1999 to Nov. 2, 1999. Only 12 reports mentioned "fire," but flames in a hidden area (e.g.. behind a panel under the floor) would more likely be recorded as "smoke."

* **High temperatures**. Most events involved high temperatures: 578 out of the 964 total. A high-temperature event was subjectively defined as one involving reference to smoke from a solid material or an electrical overload, short, bearing seizure, or whatever resulting in a popped circuit breaker. A second category involving air contamination was defined as a possibly combustible event involving smoke or mist appearing to result from leakage of oil or hydraulic fluid into the ducting (i.e., an "air contamination event."). Some 60 percent of the events met the "high temperature" definition.

* **Mostly electrical.** Of 392 events that were categorized, more than 300, or 80 percent, related to aircraft electrical systems and components. For example, an overheated and smoking fluorescent light ballast was logically coded as an electrical malfunction. On the other hand, smoke wafting out of an air duct was not automatically presumed to be electrical in nature. In order of descending frequency, the following abridged list of failures illustrates the range of reports:

Description	Count	Description	Count
Fan	68	Connector	12
Wire	48	Circuit breaker	8
Light	*27*	Battery charger	4
Coffeemaker	17	Control panel	3

With 60 reports citing wiring, wire-harnesses and connectors, some 11 percent of the high temperature events were associated with wiring faults *(see box at right).*

***** **Mostly unprotected.** About 380, or 66 percent, of the 578 high temperature events occurred in or near the cabin, galley, lavatories and cockpit (including 50 high temperature events in the electronics and equipment, or E&E, bay immediately below the cockpit). Of course, these are the areas where electrical systems tend to concentrate, so the failure density correlates with equipment density. Significantly, these also are the areas, excepting the lavatories, where neither built-in fire detection nor suppression is provided.

***** **Mostly uncontrollable.** "If the crew didn't know where the smoke was coming from, they didn't have access or controllability," Shaw observed. By this measure, he concluded, "Control of the event, even at a minimal level, was possible by the crew in less than 40 percent of the events, and access of sonic kind was possible in less than 20 percent." It is his belief that the best locations for in-flight smoke and fire detection and suppression are "in the inaccessible areas of the fuselage."

"The crews don't have the diagnostic tools to locate sources of smoke and fire," Shaw maintained. Although not mentioned at the SAE symposium, the inability to control smoke/fire events is by no means restricted to U.S. and Canadian skies. In 1993 a smoldering electrical fire ignited by a short circuit on a Swissair DC-9 completely filled the cockpit with dense, acrid smoke. The pilots were barely able to see through the windscreen, and at one point resorted to "wagging" the checklist in a vain attempt to disperse the smoke as they made an emergency landing at Munich. In its report of this case, the **German Aircraft Accident Investigation Branch** (FUS) suggested the use of an "inflatable viewchannel" so crews in such circumstances could see their instruments and gain at least a limited view through the windscreen *(see ASW, June 14, 1999, p. 10).* Such a device, known as the Emergency Vision Assurance System (EVAS), is now on the market *(see ASW, Dec. 21, 1999, p. 8).*

***** **Making it worse.** In most cases, when crews reset popped circuit breakers they made the situation worse. Shaw found 12 events that reported the circuit breakers were reset. In eight of those cases, additional smoke, arcing, or damage occurred. In the remaining four cases, a serious malfunction had occurred and resetting the breakers injected the possibility of further damage. Although the number of reset circuit breaker cases is not that great, they lend weight to the recent ALPA recommendation that circuit breakers should not be reset for all but the essential systems needed to get the airplane safely on

the ground *(see ASW, March 6, p. 10).*

Shaw's findings suggest much more in the way of corrective action. Better reporting discipline is needed to improve the quality of the data. Smoke events should he added to the current requirement to report in-flight fires. This action, Shaw believes, would mitigate "the significant under-reporting of smoke events."

A complete rethinking

Shaw and other like-minded individuals who have studied the hazard posed by in-flight smoke and fire have a number of solutions in mind. At the SAE symposium they presented a menu of actions to plug vulnerabilities and to improve needed defenses against catastrophe. Their ideas include:

*** Better detector placement.** Capt. Ken Adams, another member of ALPA' s safety committee, believes a step as simple as placing detectors in each of the main air conditioning ducts would greatly assist pilots in isolating the source of smoke, enabling them to better differentiate between "aerosolized" oil leaking into the air conditioning system and the potentially greater hazard posed by an electrical fire *(see expanded comments of Capt. Adams in ASW, Nov. 1, 1999, p. 3).*

*** Full coverage.** Shaw believes coverage needs to be expanded. "We can't keep living in the Stone Age. We need detection and suppression throughout the aircraft," he urged. Priority should be placed on inaccessible areas of the fuselage.

* **Better detectors.** Presently, even in locations on the aircraft where smoke and fire detectors have been placed, the industry is plagued with a high false alarm rate. Tom Cleary, a fire researcher with the **National Institute of Standards and Technology** (NIST), has found in his work that the smoke detectors in aircraft cargo compartments have a false alarm rate of about 100 to 1. This ongoing epidemic of false alarms undermines pilot confidence in the smoke detection equipment and certainly complicates their decision-making. However, Cleary believes that new technology offers the promise of reducing the false alarm rate by "at least" a factor of 10, as evidenced in recent NIST research *(see box, page* 4). The techniques include improved signal processing to eliminate spurious signals, to compensate for "baseline drift" and to diagnose faults in the detector itself. The integration of photoelectric ionization, smoke, and carbon monoxide detectors also will contribute to that tenfold reduction in false alarms.

Cleary believes the airline industry will find the new detector affordable. After all, it's being developed under the auspices of the **Department of Housing and Urban Development** (HUD) for low-income housing, he observed.

*** Better suppression.** New water-mist technology under development by the **U.S. Navy** to protect its warships may find application in the airline industry. According to Dr. Fred Lawson at the Naval Research Laboratory, "Water mist is better than Halon." Described as "God's gift to firefighters," Halon production has been banned as a result of its impact on global warming, and the airline industry is searching for a substitute. Lawson believes that a new, extremely fine misting technology ("Which does not feel wet to the touch") may be the answer.

In trials aboard the U.S.S. Shadwell, an amphibious warship converted to test vessel, Lawson said a mere 20 gallons of water converted to mist can kill a fire in a 60,000 cubic foot machinery space. The mist, he said, "Brings down a totally untenable situation dramatically." Lawson recounted that the water mist reduced the temperature from 9000 F to about 1200 F "within seconds."

He dismissed the fear often expressed by airline industry officials that the water mist would foul the functioning of vital electronics. On the Shadwell, Lawson said, "A 30-minute exposure posed little or no hazard to energized switchboards, motor controllers or electric motors."

Adams believes the existing potable water supplies on an airliner may be more than adequate for a water-mist fire suppression system to protect the presently unprotected cabin area. A full-up system of detection and suppression would weigh on the order of 200 pounds. The Navy will be testing a prototype water-mist system in the cabin of a retired B737 early next month (system performance will be duly reported in this publication).

• **Better access**. Adams pointed out that fires can propagate behind panels. Indeed, one such fire occurred behind the flight engineer's panel on a **Delta Airlines** [DAL] **L-1011** enroute from Hawaii to

California late 1998 *(see ASW, July 12, 1999, p.3).* The flight crew could see the flames behind the narrow seam of the metal cover but could not squirt fire-suppressing chemical from the hand extinguisher into the interior. Adams believes that access ports to insert extinguishers could be installed, enabling crews to apply extinguishing agent without having to waste time with screwdrivers or fire axes opening panels.

The need for such emergency fire extinguishing ports is growing, Adams maintained. More electrical components are migrating into the cabin area "Little closets with avionics stuffed in them" he said. Adams recalled the recent case of a 767 on a Trans-Atlantic flight where the electronics in one of these closets overheated, and the crew was forced to divert to a precautionary landing in Ireland.

- **Better procedures.** According to Holoviak, instances of in-flight smoke and fire need to be treated "as equal to the complete loss of one engine on a twinjet." The procedures, he said, should be designed to "get the aircraft pointed in the right direction immediately" for landing.

Emergency checklists, Adams declared, "should be designed to relieve the crew of troubleshooting, focus on emergency diversion, depower to essential items, and land as soon as possible." As an example, the first three items on the Delta 767-400 smoke/fire emergency checklist consist of: (1) don masks, (2) establish communications, (3) begin the divert.

With respect to depowering flight essential systems, Bill Sell, an engineer with German circuit breaker (CB) manufacturer **E-T-A Elektrotechnische Apparate GmbH,** suggested a simple system of standardized color-coding. The breakers for critical circuits, he suggested, could be colored red. "If it pops, you know immediately a flight essential circuit is affected," he said.

"You could put a colored cap over the button, or use a simple insert, e.g., color code the rating label" on the CB, Sell explained. In other words, the red-coded CBs would help pilots to "sweat the red stuff" as it were. The color-coding, Sell believes, would be a boon to pilots, who are "under pressure anyway" when the CBs start popping.

- **Better design.** Over the longer term, improved electrical system design would help harden airplanes against the ravages of electrical fires. There should be no 'single point" failures, Shaw maintained. "Separation of the captain's and the first officer's instrument power wires should be ensured," he said. Overall, he argued, "No single wire bundle failure should result in loss of a significant amount of electrical systems." *» Shaw, e-mail jdshaw@compuserve.com; Adams, e-mail kmuleadams@csi.com; Sell, e-mail wrnfsell@aol.com «*

April Shower of Directives Suggests Electrical Design Flaws for MD-11

The list of actions to correct electrical system deficiencies in **MD-11** aircraft continues to grow, presenting operators with an increasing burden of repairs.

In its latest spate of activity, the Federal Aviation Administration (FAA) published eight airworthiness directives on a single day last week. All of them dealt with various aspects of the aircraft's electrical system *(see box at right, with keywords in bold).* It would seem that the airplane's electrical system is being rebuilt a piece at a time. In the latest round, operators are faced with the problem of scheduling work to satisfy compliance times of six months or one year.

The latest batch of ADs follows 15 that were issued in February, and one issued earlier this month on the cockpit map lights *(see ASW March 6, p. 4, March 27, p. 12, and April 10, p. 6).* All of these ADs appear to be an outgrowth of the Sept. 1998 fatal crash of a Swissair MD-11 at Halifax. An electrical fire is suspected. The latest batch of 8 ADs brings to 55 the number of ADs issued in the roughly 20 months since the crash. That's five times the number of ADs published on the MD-11 over the 20 months before the crash.

As in the February flurry of Ads, April's shower of activity hints at an original equipment design fault (incompatible CB's and connector ratings). If that flaw escaped FAA notice during certification, the oversight is now neatly camouflaged by airworthiness directive. The FAA was asked if further ADs can he expected; an answer was not provided by our press time.

THE STARK FINDINGS IN BRIEF

"We found a high number of smoke and fire events that resulted in unscheduled landings or were not controllable or accessible by the crew." Jim Shaw

Lessons learned:

- A very high number of smoke or fire events occur on transport aircraft in the US and Canada – 964 over 10 months.
- 478 were high-temperature events, vastly outnumbering nearly 400 reports of air contamination (possibly combustible).
- A detailed look at 392 high temperature events showed that 80 percent involved electrical systems and components.
- In the overwhelming number of cases, the crew had limited ability to recognize, gain access to, or to control the malfunction.
- The resetting of tripped circuit breakers with internal or external short circuits generally made things worse.
- There is an average of more than one unscheduled landing a day due to smoke or fire based only on Service Difficulty Report (SDR) data.
- The SDR database under-reports the significance of the problem.

Source: Shaw