FLIGHT SAFETY FOUNDATION
CABIN CREW SAFETY

Vol. 36 No. 2 *For Everyone Concerned With the Safety of Flight* March–April 2001

Timely Detection, Response Improve Outcomes of In-flight Fire Fighting

Interim recommendations by the Transportation Safety Board of Canada emphasize diversion and landing without delay, rapid in-flight fire fighting and reassessment of all aircraft crewmembers' capabilities for detecting and suppressing fires.

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FSF Editorial Staff

The Transportation Safety Board of Canada (TSB) in December 2000 issued five recommendations, which, in part, remind pilots and flight attendants of the limitations of in-flight fire fighting — especially the difficulty of fire detection and the brief time typically available for effective fire suppression. The interim air safety recommendations were developed during TSB's continuing investigation of the Swissair Flight 111 accident.[1,2]

The investigation has identified industrywide issues involving aircraft design, equipment, aircraft crew training, aircraft crew awareness, checklists and procedures for aircraft crews to systematically detect, locate, assess, control and suppress an in-flight fire within some areas of the fuselage of transport category aircraft, TSB said.

"In the case of [Swissair Flight] 111, approximately 20 minutes elapsed from the time the crew detected an unusual odor until the aircraft [struck the water], and about 11 minutes elapsed between the time the presence of smoke was confirmed by the crew and the time that the fire is known to have begun to adversely affect aircraft systems," TSB said.

TSB reviewed 15 other transport aircraft accidents since 1967 in which in-flight fire spread rapidly and became uncontrollable. Flammability of materials, crewmember access to areas within the aircraft, smoke/fire-detection and -suppression equipment, emergency procedures and training were among the areas studied.

"Fire suppression for the pressurized portion of an aircraft is provided by hand-held fire extinguishers," TSB said. "Hand-held fire extinguishers are mandatory in such spaces as the cockpit and galleys. By design, hand-held fire extinguishers are most effective against small fires, at limited range (up to three meters [9.8 feet]). Where access is relatively easy — such as exposed galley areas — existing procedures and training using hand-held fire extinguishers have proven to be adequate. However, where the source of the smoke/fire is not obvious, or access to the area is difficult, the situation can become hazardous very quickly."

In contrast with accessible galley fires, flight attendants would have difficulty using hand-held fire extinguishers to suppress some fires, such as a fire in the attic areas[3] or in the electrical and electronic equipment compartment (E&E bay) of a large commercial aircraft, TSB said.

"The quantity and location of these fire extinguishers depends on the passenger capacity of the aircraft," TSB said.[4] "The effectiveness of hand-held fire fighting equipment depends on the size, type and location of the fire, on how accessible the fire is, and on crew training."

TSB said that accident data show that occurrences involving odor, fumes or smoke that do not develop into in-flight fires are not unusual. Nevertheless, if an in-flight fire develops, anecdotal data show that the time required to control or to suppress the fire typically is very brief. (See "Elapsed Time After Fire Detection Averaged 17 Minutes," page 3.)

"Both the TSB review and an FAA [U.S. Federal Aviation Administration] study indicate that odor/smoke occurrences rarely develop into uncontrolled in-flight fires.[5] The TSB review of [Swissair Flight] 111 and other in-flight fire occurrences has shown that where an in-flight fire continues to develop, there is little time between detection of the fire and the loss of aircraft control," TSB said. "These data indicate that, in situations where there is an in-flight fire that continues to develop, the time from detection until the aircraft [struck water or terrain] varied from five [minutes] to 35 minutes. It must be anticipated that aircraft systems will be affected, either as a direct result of the fire, or as a result of emergency procedures such as the depowering of electrical buses." (See "Transportation Safety Board of Canada Cites Fire-related Accidents," page 4.)

Recommendations Reiterate Simple Fire Fighting Lessons

Lessons summarized from TSB's explanation of its recommendations include the following:

- Pilots and flight attendants must be aware that time is a primary factor in the successful identification and control of an in-flight fire. "Inadequate appreciation for how little time is available to detect, analyze and suppress an in-flight fire" reduces the probability of success, TSB said;

- Troubleshooting procedures are most effective if they eliminate the source of the odor/smoke *before* a fire begins or if they result in the suppression of a fire in its earliest stage. After a fire has reached the self-propagating stage — able to spread without continuous reignition from the source — further troubleshooting to eliminate the source will not be sufficient to extinguish the fire;

- Step-by-step procedures to locate and to control in-flight fires, or to troubleshoot odor/smoke from an unknown source, should not delay decisions by pilots to divert/prepare for an emergency landing;

- Flight attendants may not be aware of the extent to which emergency procedures rely on the crewmember/passenger senses of vision, hearing and smell to detect smoke or fire in nondesignated fire zones.[6] An assumption exists that people can detect smoke/fire in nondesignated fire zones during much of a flight. Nevertheless, a fire may ignite and propagate without human detection;

- Crewmembers should be aware that highly efficient aircraft ventilation systems typically have filters that remove combustion products produced by small fires, enabling some fires to burn without early detection by cabin occupants;[7]

- Inaccessible spaces exist within the fuselage of many transport aircraft and are not addressed by regulations governing designated fire zones (powerplants, auxiliary power units, lavatories and cargo areas that have known ignition sources and fuel sources).[8] Such nondesignated fire zones do not have automatic smoke/fire detection and suppression equipment that are required in designated fire zones,[9] yet may contain wiring, insulation, debris or other materials that can sustain smoke or flames; and,

- Accident reports have shown that an apparently controllable fire may deteriorate rapidly into an unrecoverable situation.

Methods of In-flight Fire Fighting Must Be Compatible, Coordinated

A comprehensive in-flight fire fighting system[10] should integrate and coordinate all aspects of fire response, including aircraft design, certification of materials, accessibility to vulnerable areas of the aircraft for fire fighting within the pressure vessel (pressurized portion of the fuselage), fire-detection and fire-suppression equipment, in-flight fire fighting procedures, and training and equipment for pilots and flight attendants, TSB said.

Recommendation A00-16 said, "Appropriate regulatory authorities, in conjunction with the aviation community, [should] review the adequacy of in-flight fire fighting as a whole, to ensure that aircraft crews are provided with a system whose elements are complementary and optimized to provide the maximum probability of detecting and suppressing any in-flight fire."

TSB's principal concerns regarding the fire fighting system are lack of integrated training and lack of crewmember access to some vulnerable areas of aircraft.

Elapsed Time After Fire Detection Averaged 17 Minutes

From data on 15 in-flight fires that occurred between January 1967 and September 1998, the Transportation Safety Board of Canada (TSB) calculated an average time of approximately 17 minutes between when an in-flight fire was detected and when the aircraft was ditched, the crew landed the aircraft, or the aircraft struck the ground or water. (Table 1 shows times from first detection used in this calculation.) To more accurately represent the scenario of the Swissair Flight 111 accident, the sample used for calculations excluded accidents in which the aircraft was landed successfully.

The review focused on fires in commercial transport aircraft with a maximum takeoff weight (MTOW) of more than 50,000 pounds (22,680 kilograms). Included in the review were any fires inside the fuselage (cargo compartment, cabin and/or cockpit); not included in the review were engine fires, wheel-well fires and explosions (bombs).

TSB said that fuselage fires that resulted in an accident were rare events; the few relevant examples spanned 31 years.

Data sources included Airclaims, Aviation Safety Network, International Civil Aviation Organization, U.S. National Aeronautics and Space Administration Aviation Safety Reporting System, U.S. National Transportation Safety Board and TSB.♦

Table 1
Elapsed Time From First Detection of Fire[1]
Selected Accidents, 1967–1998

Aircraft Type	Date	Time From First Detection (Minutes)
Antonov AN-12	Jan. 14, 1967	<10
British Aerospace BAC-111	June 23, 1967	<10
British Aerospace Caravelle	July 26, 1969	26
British Aerospace Viscount	May 6, 1970	<10
Ilyushin IL-62	Aug. 14, 1972	<15
Ilyushin IL-18	Aug. 31, 1972	<20
Boeing 707	July 11, 1973	7[2]
Boeing 707	Nov. 3, 1973	35
Boeing 707	Nov. 26, 1979	17
Boeing 737	Sept. 23, 1983	<20
Tupelov Tu-134	July 2, 1986	<20
Boeing 747	Nov. 26, 1987	19
McDonnell Douglas DC-9	May 11, 1996	<5
Antonov AN-32	May 7, 1998	<20
McDonnell Douglas MD-11	Sept. 2, 1998	20

[1]Time elapsed between when an in-flight fire was detected and when the aircraft was ditched, the aircraft was landed or the aircraft struck the ground or water.

[2]Approximate number.

Source: Transportation Safety Board of Canada

"Current aviation requirements and standards stipulate that aircraft crews must be trained to fight in-flight fires; however, the TSB found that within the industry there is a lack of coordinated cabin [crew] and flight crew fire fighting training and procedures to enable crews to quickly locate, assess, control, and suppress an in-flight fire within the fuselage of aircraft," TSB said. "The [TSB] is also concerned that aircraft crews are not trained or equipped to have ready access to spaces within the fuselage where fires have the potential to ignite and spread."

TSB Urges Consideration of Additional 'Fire Zones'

A thorough review must be conducted to determine what additional areas within the aircraft fuselage should be designated as fire zones; those areas then must be equipped with fire-detection and fire-suppression systems, TSB said.

"Presently, the requirements for built-in smoke/fire-detection and -suppression systems are restricted to those areas that are not readily accessible, and in which a high degree of precaution must be taken," TSB said. "The built-in [fire-]suppression features are either automatic, as in lavatories, or controlled from the cockpit, as in powerplants. In each case, the extinguishing agent must consist of an amount and nature tailored to the types of fire most likely to occur in the area where the extinguisher is used.[11] There are no requirements for built-in smoke/fire-detection and -suppression systems in the remaining areas of the pressurized portion of the aircraft."

Recommendation A00-17 said, "Appropriate regulatory authorities, together with the aviation community, [should]

Transportation Safety Board of Canada Cites Fire-related Accidents

Five interim air safety recommendations issued by the Transportation Safety Board of Canada (TSB) in December 2000 included the following brief descriptions of accidents reviewed in the context of TSB's continuing investigation of the Swissair Flight 111 accident:[1]

- July 11, 1973 — "After reporting an in-flight fire, [the crew of] a Boeing 707 made a forced landing. The aircraft came to rest on its belly as it continued to burn. The investigation revealed that of the 134 people on board, 123 suffered fatal injuries due to smoke inhalation. The investigative agency's report recommended enhancements to smoke and heat detection throughout the aircraft, including areas behind the false ceiling. The report also called for improvements in crew communication and the operating instructions dealing with fire emergencies to enhance crew response during in-flight fire." (Bureau Enquêtes-Accidents, France)

- Aug. 19, 1980 — "Approximately seven minutes after takeoff, the crew of [a Lockheed] L-1011 received an aural warning indicating smoke in the aft cargo compartment. When the aircraft landed, some 20 minutes later, the fire had penetrated the cabin. All 301 [people] on board perished in the fire. The investigative agency recommended, in part, the use of fire-blocking materials to control fire propagation, changes to crew emergency training and a review of the operator's standard operating procedures and emergency checklists." (Accident Investigation Authorities, Saudi Arabia)

- Oct. 16, 1993 — "Approximately 10 minutes after takeoff [the crew of the McDonnell Douglas] MD-81 experienced smoke of increasing intensity in the cockpit overhead panel. The aircraft crew was unable to locate the source of the smoke and requested a return to their departure airport. Investigators discovered a failed emergency power switch which created a smoldering electrical fire. Additionally, it was determined that the emergency checklist procedures failed to eliminate the smoke." (German Federal Bureau of Aircraft Accidents Investigation)

- Sept. 5, 1996 — "At Flight Level 330 [33,000 feet] the flight crew of a McDonnell Douglas DC-10F were alerted to smoke in the cabin cargo compartment when smoke detectors activated. After a successful landing and evacuation, the fire continued to burn and eventually destroyed the aircraft. The origin or propagation was never determined." (U.S. National Transportation Safety Board)

- Jan. 9, 1998 — "While in cruise, a Boeing 767 experienced abnormal warnings on the flight deck instrumentation accompanied by tripping of circuit breakers. The flight was diverted, and although the landing was successful, smoke appeared at the forward end of the passenger cabin. Investigators determined that the circuit breakers tripped as a result of electrical arcing/thermal damage to a wire bundle located in the [electronic equipment] compartment. The investigation concluded that metal contamination was present on the wire bundle and probably assisted the onset of arcing." (U.K. Air Accidents Investigation Branch)

- Nov. 9, 1998 — "The flight engineer of a Lockheed L-1011 observed smoke, sparks and a small flame emanating from an overhead circuit-breaker panel. Although the fire was successfully suppressed, multiple systems failures occurred during the descent. The investigation revealed that a circuit breaker had popped after arcing to an improperly installed wiring clamp. The arcing ignited dust and combustible debris at the back of the circuit-breaker panel." (U.S. National Transportation Safety Board)

- Nov. 28, 1998 — "A Boeing 747 returned to its departure airport after an apparent fault associated with an [electronic equipment] compartment cooling-system ground-exhaust valve. Investigators discovered several arced wires in a small wire harness associated with the exhaust valve. Insulation-blanket cover material had subsequently ignited and was consumed by fire." (U.K. Air Accidents Investigation Branch)♦

Reference

1. Transportation Safety Board of Canada (TSB). "Interim Air Safety Recommendations, In-flight Firefighting, Occurrence No. A98H0003TSB." Report no. A 15/2000. Dec. 4, 2000; updated Feb. 7, 2001. Swissair Flight 111, a McDonnell Douglas MD-11, struck the water near Peggy's Cove, Nova Scotia, on Sept. 2, 1998, during a flight from John F. Kennedy International Airport in New York, New York, U.S., to Geneva, Switzerland. All 229 occupants were killed; the aircraft was destroyed. The investigation by TSB is continuing.

review the methodology for establishing designated fire zones within the pressurized portion of the aircraft, with a view to providing improved detection and suppression capability."

TSB said that nondesignated fire zones to be reconsidered might include, but are not limited to, the following:

- "[E&E] bays (typically below the floor beneath the cockpit and forward passenger cabin);
- "The areas behind interior wall panels in the cockpit and cabin areas;
- "The areas behind circuit-breaker [panels] and other electronic panels; and,
- "The [attic] area."

TSB cited several reasons for recommending a reconsideration of fire zone designations.

Most transport category aircraft contain electrical wiring and electrical components, for example, that have the potential, under certain conditions of failure, to produce heat that could ignite flammable materials even though materials used in aircraft must conform to specific criteria for fire-resistance, TSB said.[12]

"There are many spaces, including some large areas, within transport category aircraft that are seldom inspected and that can become contaminated with [combustible] dust, debris and metal shavings [that could contribute to fire propagation]," TSB said. "The present detection [capabilities] and suppression capabilities in those nondesignated fire zones of the aircraft fuselage are inadequate. … Furthermore, any attempt at smoke/fire suppression in these areas would require direct human intervention using hand-held fire extinguishers."

Odor, Smoke From Unknown Source Requires Fast Response

TSB said that industry standards should be consistent in training flight crews to prepare for landing the aircraft without delay when odor/smoke from an unknown source is detected.

The many successful outcomes experienced by pilots and flight attendants in responding to odor/smoke occurrences may lead to incorrect assumptions about the time available or the seriousness of an occurrence.

"Within the aviation industry, there is an experience-based expectation that the source of odors/smoke will be discovered quickly and that troubleshooting procedures will 'fix the problem.'" TSB said. "Although in-flight fires like that aboard [Swissair Flight] 111 are rare, the TSB review shows that in a situation where an in-flight fire continues to develop, there is a limited amount of time to land the aircraft. [This] accident raised awareness of the potential consequences of an odor/smoke situation, and the rate for flight diversions has increased as a result. Some airlines have modified their policies, procedures, checklists and training programs to facilitate timely diversions and rapid preparations to land immediately if smoke from an unknown source appears and cannot be readily eliminated. … While such initiatives reduce the risk of an accident, the [TSB] believes that more needs to be done industrywide."

Recommendation A00-18 said, "Appropriate regulatory authorities [should] take action to ensure that industry standards reflect a philosophy that when odor/smoke from an unknown source appears in an aircraft, the most appropriate course of action is to prepare to land the aircraft expeditiously."

Reasons why flight crews might not follow this practice, however, include corporate culture, commercial pressure, inconvenience, passenger comfort and safety concerns about initiating an emergency descent, diverting to an unfamiliar airport or exceeding aircraft operating limitations, TSB said.

Design of Emergency Checklists Should Minimize Delay Factors

The design of some emergency checklists inherently may prevent flight crews from accomplishing critical procedures as quickly as possible, TSB said.

"In circumstances where the source of odor/smoke is not readily apparent, flight crews are trained to follow troubleshooting procedures, contained in checklists, to eliminate the origin of the smoke/fumes," TSB said. "Some of these procedures involve turning off electrical power and/or isolating an environmental system. Completing such checklists takes time, increasing the chances that a specific heat source could ignite a fire."

The design of the smoke/fumes checklist, for example, should enable appropriate troubleshooting procedures to be completed quickly and effectively.

"By design, an indeterminate amount of time is required to assess the [effect] of each action," TSB said. "It can take a long time to complete the checklist, including troubleshooting actions. … There is no regulatory direction or industry standard specifying how much time it should take to complete these checklists. The longer it takes to complete prescribed checklists, the greater the chance that a fire will become uncontrollable."

Recommendation A00-19 said, "Appropriate regulatory authorities [should] ensure that emergency checklist procedures for the condition of odor/smoke of unknown origin be designed so as to be completed in a time frame that will minimize the possibility of an in-flight fire being ignited or sustained."

In-flight Fire Fighting Procedures Require Periodic Review, Update

TSB recommended a review of in-flight fire fighting standards in the industry to expedite the process of assessing smoke/fire and gaining control of the situation. The review should include specific plans for fighting fires in locations that are not readily accessible.

"There has been little or no training provided for aircraft crews on how to access areas behind electrical [panels] or other panels, attic areas or E&E compartments," TSB said. "Typically, present designs do not incorporate quick-access openings or other such means to facilitate access to these areas."

The review also should include a comparison of pilot training and flight attendant training regarding fire fighting methods in the cockpit and in the cabin, TSB said.

"Although aircraft crews are trained to fight in-flight fires, there are no requirements that cabin [crews] and flight crews train together, or that they be trained to follow an integrated fire fighting plan and checklist procedure," TSB said.[13] "For example, neither flight crews nor cabin crews are trained to fight in-flight fires in the cockpit. Several operators contacted by the TSB indicate that flight crews and cabin crews do not receive training specific to fighting fire in the cockpit. The division of roles and responsibilities between the flight [crews] and cabin crews with respect to who will be combating an in-flight fire in the cockpit is not clearly identified in manuals and company procedures."

Recommendation A00-20 said, "Appropriate regulatory authorities [should] review current in-flight firefighting standards including procedures, training, equipment and accessibility to spaces such as attic areas to ensure that aircraft crews are prepared to respond immediately, effectively and in a coordinated manner to any in-flight fire."

Fire-related modifications to aircraft, systems and procedures have been prompted by specific failures identified in one or more accidents, TSB said.[14]

"[Nevertheless,] aircraft [design changes] and equipment design changes aimed at providing better fire fighting measures have sometimes been made in isolation from each other," TSB said. "Furthermore, there has not been a recognized need either to train aircraft crews for fire fighting in all of the nondesignated fire zones, or to design aircraft so as to allow quick and easy access to these [zones] for fire fighting purposes."

The five interim recommendations were issued to encourage regulators and the industry to develop specific solutions, TSB said.

"The safety deficiencies identified so far by the [TSB investigation of the Swissair Flight 111 accident] are being aggressively addressed by government and industry," TSB said, and monitoring of responses to these recommendations will continue.[15]♦

[This article, except where specifically noted, is based on Transportation Safety Board of Canada *Interim Air Safety Recommendations: In-flight Firefighting, Occurrence No. A98H0003TSB.* Report no. A 15/2000. Dec. 4, 2000 (updated Feb. 7, 2001).]

Notes and References

1. Transportation Safety Board of Canada (TSB). "Interim Air Safety Recommendations: In-flight Firefighting, Occurrence No. A98H0003TSB." Report no. A 15/2000. Dec. 4, 2000 (updated Feb. 7, 2001). TSB said that Swissair Flight 111, a McDonnell Douglas MD-11, struck the water near Peggy's Cove, Nova Scotia, on Sept. 2, 1998 during a flight from John F. Kennedy International Airport in New York, New York, U.S., to Geneva, Switzerland. All 229 occupants were killed; the aircraft was destroyed. "Approximately 53 minutes after takeoff, as the aircraft was cruising at Flight Level 330 [33,000 feet], the crew noticed an unusual smell in the cockpit," TSB said. "Within about three and a half minutes, the flight crew noted smoke and declared the international urgency signal 'Pan Pan Pan' to Moncton Air Traffic Services (ATS). [Swissair Flight 111] was cleared to the Halifax airport from its position 58 nautical miles to the southwest. While maneuvering in preparation for landing, the crew advised ATS that they had to land immediately and declared an emergency. Approximately 20 minutes after the crew first noticed the unusual smell, and about seven minutes after the crew's 'emergency' declaration, the aircraft struck the water near Peggy's Cove, Nova Scotia, fatally injuring all 229 occupants. … The aircraft crashed into the ocean, and all fire damage occurred in flight. The investigation (A98H0003) has identified extensive fire damage above the ceiling in the forward section of the aircraft extending about 1.5 meters forward and five meters aft of the cockpit bulkhead."

2. Bouchard, Benoit; Gerden, Vic. "Transportation Safety Board of Canada: Interim Air Safety Recommendations." Speech, Dec. 4, 2000. TSB Chairman Bouchard said that in March 1999, TSB issued four preliminary air safety recommendations about the recording capacity and power supply of flight data recorders. In August 1999, TSB issued two preliminary air safety recommendations about thermal acoustical insulation blankets and the related flammability test criteria, and two safety advisory letters about the condition of wiring in aircraft and overheating of flight crew reading lights. Bouchard said, "We do not know yet what started the fire [on Swissair

Flight 111] and our investigation of that aspect continues."

3. TSB defined the attic as the "area between the crown of the aircraft and the drop-down ceiling."

4. U.S. Federal Aviation Regulations (FARs) Part 25.851(a).

5. U.S. Federal Aviation Administration (FAA). "Smoke in the Cockpit Among Airline Aircraft." FAA Report. October 12, 1998.

6. TSB cited U.S. National Transportation Safety Board (NTSB) Aviation Accident/Incident Database report no. DCA83AA028, which said that the flight crew first detected smoke approximately 11 minutes after the related circuit breakers tripped. NTSB. *Air Canada Flight 797, McDonnell Douglas DC-9-32, C-FTLU, Greater Cincinnati International Airport, Covington, Kentucky. June 2, 1983.* Aircraft Accident Report no. NTSB/AAR-86/02. On June 2, 1983, Air Canada Flight 797, a McDonnell Douglas DC-9-32, was destroyed by fire after an in-flight lavatory fire was detected during a regularly scheduled international passenger flight from Dallas, Texas, U.S., to Montreal, Quebec, Canada, with an en route stop at Toronto, Ontario, Canada. Twenty-three passengers were killed; three passengers received serious injuries, 13 passengers received minor injuries; and two passengers and five crewmembers were not injured. NTSB said that while en route at Flight Level 330, the cabin crew discovered a fire in the aft lavatory. After contacting air traffic control and declaring an emergency, the crew made an emergency descent and ATC vectored the flight to the Greater Cincinnati International Airport, Covington, Kentucky, U.S. The aircraft was landed at the airport.

   NTSB said, "As the pilot stopped the airplane, the airport fire department, which had been alerted by the control tower of the fire aboard the incoming aircraft, was in place and began firefighting operations. Also, as soon as the airplane stopped, the flight attendants and passengers opened the left and right forward doors, the left forward overwing exit and the right forward and aft overwing exits. About 60 [seconds] to 90 seconds after the exits were opened, a flash fire engulfed the airplane interior. While 18 passengers and three flight attendants exited through the forward doors and slides and the three open overwing exits to evacuate the airplane, the captain and the first officer exited through their respective cockpit sliding windows. However, 23 passengers were not able to get out of the plane and died in the fire." NTSB said, in its final report, that the probable causes of the accident were "a fire of undetermined origin, an underestimate of fire severity and misleading fire-progress information provided to the captain." NTSB said, "The time taken to evaluate the nature of the fire and to decide to initiate an emergency descent contributed to the severity of the accident."

7. FAA. "Development and Growth of Inaccessible Aircraft Fires Under In-flight Airflow Conditions." Report no. DOT/FAA/CT-91/2. Feb. 1991.

8. FARs Parts 25.854, 25.855, 25.858, 25.1181, 25.1195, 25.1197, 25.1199, 25.1201, 25.1203, and 121.308.

9. FAA. "U.S. Airlines Install Fire Detection and Suppression Systems." News release, March 19, 2001. FAA said that U.S. air carriers complied with its March 19, 2001, deadline to retrofit transport category airplanes with fire detection and suppression systems. FAA said, "Most widebody passenger airplanes already had fire-detection and [fire-]suppression systems in inaccessible cargo compartments. The FAA's Feb. 17, 1998, final rule required that the remainder of the passenger fleet be retrofitted within three years. In addition, approximately 300 all-cargo airplanes were required to have detection systems and a means to shut off air flow to the cargo compartment. Out of 3,483 airplanes affected by the FAA's rule, 3,154 will have been retrofitted by the end of [March 19]. A total of 264 airplanes will remain in maintenance until the installation work is complete. Some operators have either made business decisions not to operate the aircraft or cannot meet the deadline, leaving 65 airplanes on the ground."

10. TSB said that "in-flight firefighting" includes all procedures and equipment intended to prevent, detect, control or eliminate fires in aircraft. These include, but are not limited to, material flammability standards, accessibility, smoke/fire-detection and -suppression equipment, emergency procedures and training.

11. FARs Part 25.851(a).

12. FARs Parts 25.853, 25.855, and Part I of Appendix F of FARs Part 25.

13. Canadian Aviation Regulations (CARs) Standards Section 725.124; FARs Part 135.331; Joint Aviation Requirements (JARs) 1.965; and International Civil Aviation Organization (ICAO) Annex 6, Article 9.3.1.

14. TSB said that specific improvements were made to fire detection and suppression in lavatory areas and cargo areas following the Air Canada Flight 797 accident and following the ValuJet Airlines Flight 592 accident. NTSB. *Aircraft Accident Report: In-flight Fire and Impact With Terrain, ValuJet Airlines Flight 592, DC-9-32, N904VJ, Everglades, Near Miami, Florida, May 11, 1996.* Report no. NTSB/AAR–97/06. Aug. 19, 1997. On May 11, 1996, ValuJet Airlines Flight 592, a Douglas DC-9-32, struck terrain in the Everglades about 10 minutes after takeoff from Miami International Airport, Florida, U.S. Two pilots, three flight attendants and all 105 passengers were killed. The aircraft was destroyed. NTSB, in its final report, said, "the probable causes of the accident, which resulted from a fire

in the airplane's class D cargo compartment that was initiated by the actuation of one or more oxygen generators being improperly carried as cargo, were (1) the failure of SabreTech [a maintenance contractor] to properly prepare, package and identify unexpended chemical oxygen generators before presenting them to ValuJet for carriage; (2) the failure of ValuJet to properly oversee its contract maintenance program to ensure compliance with maintenance, maintenance training, and hazardous materials requirements and practices; and (3) the failure of the [FAA] to require smoke-detection and fire-suppression systems in class D cargo compartments."

15. Gerden. Gerden heads the TSB investigation of the Swissair Flight 111 accident.

Further Reading from FSF Publications

Koenig, Robert L. "Canadian Report of Airliner Evacuations Cites Six Safety Recommendations." *Cabin Crew Safety.* Volume 30 (July–August 1995).

FSF Editorial Staff. "Improperly Installed Electrical Wiring Causes In-flight Fire and Leads to Loss of Control by Learjet Crew During Attempted Emergency Landing." *Accident Prevention.* Volume 53 (June 1996).

FSF Editorial Staff. "Chemical Oxygen Generator Activates in Cargo Compartment of DC-9, Causes Intense Fire and Results in Collision With Terrain." *Accident Prevention.* Volume 54 (November 1997).

FSF Editorial Staff. "In-flight Fire Prompts Recommendation for Review of Wiring Standards." *Aviation Mechanics Bulletin.* Volume 46 (May–June 1998).

FSF Editorial Staff. "Vigilance in Aircraft Galley and Services Procedures Preserves Margin of Safety." *Cabin Crew Safety* Volume 34 (January–February 1999).

Blake, David. "Project Assesses Flight Attendants' Abilities to Fight In-flight Fires in Cargo Compartments." *Cabin Crew Safety.* Volume 34 (September–October 1999).

FSF Editorial Staff. "Flames in Overhead Luggage Bin Prompt Extra Training for Flight Attendants on In-flight Fire Fighting." *Flight Safety Digest* Volume 19 (January 2000). 32.

FSF Editorial Staff. "Direct Communication Between Flight Crews, ARFF Incident Commanders Can Reduce Injuries." *Airport Operations* Volume 26 (November–December 2000).

U.S. National Transportation Safety Board. "Safety Study: Emergency Evacuation of Commercial Airplanes." *Flight Safety Digest.* Volume 19 (December 2000).

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