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Hidden, Smoky Fire in MD-87 Aft Cabin Forces Emergency Evacuation After Landing

All the passengers and crew members evacuated the aircraft at the gate without injury, but the fire would have posed a far greater safety threat if the fire had occurred in flight, the official Danish accident report said.

FSF Editorial Staff

The Scandinavian Airlines System (SAS) McDonnell Douglas MD-87 was taxiing to its assigned gate at Copenhagen Airport Kastrup in Copenhagen, Denmark, when a flight attendant in the aft cabin detected a faint smell of electrical smoke after electrical lights near her lit brightly and then dimmed before they self-extinguished. She alerted the lead flight attendant (purser), who immediately contacted the first officer.

Smoke continued to develop in the cabin as the aircraft was parked at the gate. The flight attendant in the rear of the aircraft opened the aft cabin door and lowered the aft ventral stairway. The lead flight attendant opened the left forward cabin door and ordered the jet bridge to be brought to the door. All 79 passengers and six crew members evacuated the aircraft without injury in the Nov. 24, 1993, accident. A fire that subsequently erupted substantially damaged the fuselage skin and destroyed the aft cabin interior of the aircraft. A fire fighter was seriously injured when he lost his oxygen mask while extinguishing the fire.

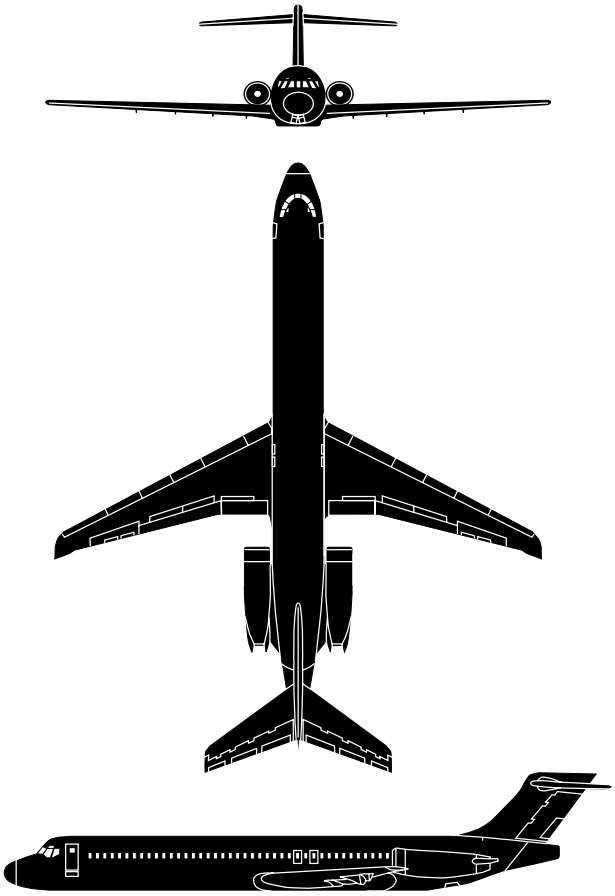
The Danish Aircraft Accident Investigation Board (AAIB), in a report released in October 1996, concluded that factory-installed wires "were routed in such a manner that they became pinched between the aircraft structure (intercostal) and a recirculation fan duct installed on a partition. [Intercostals are short longitudinal structures that join adjacent aircraft fuselage frames or ribs.]

"The pinching resulted in chafing of the wire insulation, which led to metal-to-metal contact between the wires and the intercostal and to wire-to-wire contact. Arcing and sparking caused a V-shaped erosion and burn spot on the intercostal. Continued arcing and sparking resulted in ignition of the cabin sidewall insulation material, [that] eventually developed into a fierce … uncontrollable fire which subsequently destroyed the aft part of the cabin interior and a major part of the aircraft structure."

The AAIB report said that a postaccident inspection of three other SAS MD-87s "revealed a number of serious faults and unsatisfactory conditions in the factory-installed electrical wiring for the right-hand aft stowage closet." The report added that the "routing of the unprotected and slack wires (across the inboard-facing flange of the intercostal) jeopardized the safety of the installation [because] pinching, rubbing and [wire insulation wear] was a potential risk/hazard."

The report noted that the cabin configuration "with a stowage closet, a galley, a partition and a lavatory installed in the right-hand and left-hand side of the aft cabin [Figure 1, page 3] is unique to the aircraft delivered to SAS."

The aircraft was on its fourth leg of the day when it landed at 1745 hours local time. The aircraft's first leg was from Madrid, Spain, to Barcelona, Spain. The second leg was from Barcelona to Copenhagen. The accident crew was assigned to fly the remaining three "shuttle" flights between Copenhagen and Stuttgart, Germany. The fourth-leg landing in Copenhagen was "described by both pilots and the cabin crew as being normal," the report said.



McDonnell Douglas MD-87

The MD-87 is a short-fuselage variant of the MD-80. The MD-87 first flew in 1986 and can accommodate 130 single class passengers or 109 passengers in a mixed class configuration. It is equipped with two Pratt & Whitney JT8D-217C turbofan engines and has a maximum takeoff weight of 63,503 kilograms (140,000 pounds).

The MD-87 has as normal cruising speed of 0.76 Mach and a standard range of 2,372 nautical miles (4,395 kilometers).

Source: *Jane's All the World's Aircraft*

The cockpit crew and the flight attendants remained in constant contact until the evacuation. The purser informed the first officer of the problem at 1751, according to the cockpit voice recorder (CVR). The first officer asked, "Shall we carry out an emergency evacuation?"

The aft flight attendant then contacted the cockpit crew directly on the interphone. The first officer answered the call and repeated out loud what the flight attendant said so as to keep the captain informed. The flight attendant said that she smelled "electrical burning" and that there is a "smoke screen down here, but it's nothing wild, you know."

At 1752, the first officer told the flight attendant, "You know what, we are at the gate in just a second." The flight attendant replied, "Yes, yes, yes no panic here." A few seconds later she added: "But then again, there is some smoke down here by now." The first officer responded, "We are taxiing into the gate just now."

The amount of smoke in the cabin continued to increase. At 1754 the captain called the apron tower, requested fire-fighting equipment and told the purser to "let [the passengers] out now."

At 1755 the first officer told the captain that "we have quite a lot of smoke in the back" as the smoke alarm sounded for the third time. The captain replied, "Look out for the chimney effect."

The report said that after the aircraft was parked, "the crew turned off the generators, shut down the engines and selected emergency power ON. The ground engineer who met the flight routinely connected the external power supply. While he was doing so the captain, who had opened the sliding window, attracted the engineer's attention and asked him to go to the aft stairway and check for smoke."

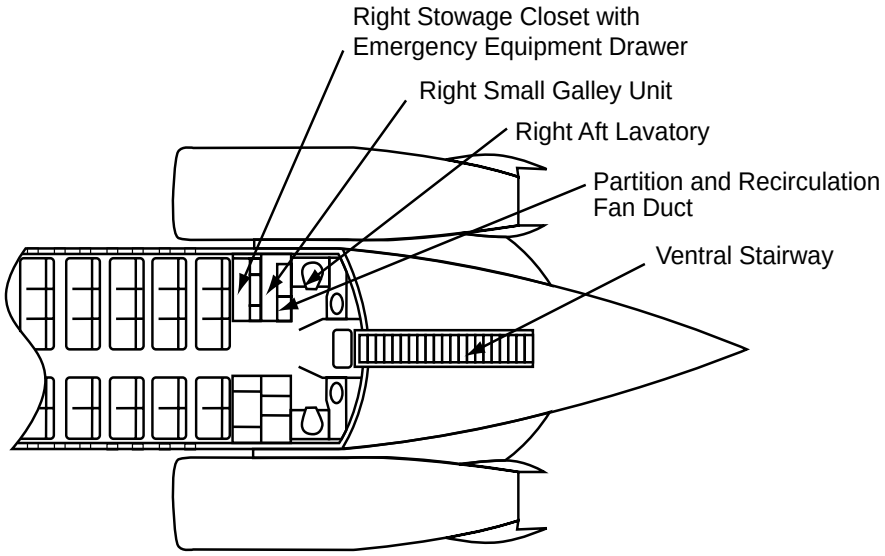
As the jet bridge was brought into place, passengers began to evacuate, the report said. "When the smoke alarm sounded, the [purser] realized that since standing passengers obscured her view of the aft cabin, an expeditious disembarkation was required. Thus, via the public address system the [purser] announced, in a firm way, that due to smoke in the aft cabin the passengers were to leave the aircraft in a hurry, leaving their hand luggage behind. At about the same time the [aft flight attendant] opened the aft cabin door and let down the aft ventral stairway in order to expedite the disembarkation."

The ground engineer entered the cabin using the aft stairway but was forced to exit because of the dense smoke. He did not see flames in the aft cabin area or outside around the lower aft cargo compartment, the report said.

Smoke extended from the ceiling to the level of the passenger-seat backs when the captain left the cockpit. As the captain prepared to check the main cabin to make sure that everyone had exited the aircraft, he attempted to open a sealed package containing a smoke hood, the report said. "[After failing] to open the sealed package properly, he just bent down under the smoke cover and ran through the aft cabin and back again, thereby making sure that the cabin was empty." [For a thorough discussion of smoke hoods as survival aids in aircraft fires, refer to the *Cabin Crew Safety* issue referenced under "Further Reading from FSF Publications."]

The report continued: "The captain then continued outside the aircraft and went directly toward the aft end to check whether or not the fire vehicle had arrived. He observed a large 'glowing' area on the fuselage skin just above the right-hand

Aft Cabin Configuration, Scandinavian Airlines System (SAS)
McDonnell Douglas MD-87



Source: Danish Aircraft Accident Investigation Board

Figure 1

engine, but did not ... [see] any ... fire/rescue activities. The captain went straight back to the cockpit where he ... emphasized to the apron tower the urgent need for assistance from the fire and rescue services. The captain then turned all electrical power (ground power and emergency power) OFF, and left the aircraft via the forward left-hand cabin door. On the ground ... he ordered the ground engineer to remove the external power supply plug from ... the aircraft."

At 1755:43, the apron tower activated a full-scale fire alarm, which alerted county services along with airport-based fire and rescue equipment, the report said. The first fire-fighting vehicle arrived on the scene at 1758, and the full airport fire detachment was at the scene at 1801. The fire was extinguished at 1815.

The report said that the fire "destroyed major parts of all of the equipment installed in the [aft right-hand side of the cabin]. The extreme heat development destroyed the fuselage skin and structure over a large area on the aft right-hand side of the aircraft. Additionally ... seats, partitions, galleys, lavatories and paneling were severely damaged by smoke and heat. This ... damage extended as far forward [as the] cockpit and cockpit equipment. The underfloor equipment and compartments were severely damaged by soot and residue from fire-fighting agents, which ... had drained down through the cabin floor to the bottom of the aircraft."

The aircraft, built in early 1988, was not subject to the more stringent U.S. Federal Aviation Authority (FAA) cabin interior flammability standards required for transport aircraft manufactured after August 1988, the report said.

[The FAA has twice introduced requirements, defined in the U.S. Federal Aviation Regulations (FARs) Part 25.853, concerning heat-release standards for cabin interior materials. Standards that went into effect on Aug. 20, 1988, were succeeded by more stringent standards that went into effect on Aug. 20, 1990.

[But those standards applied only to the cabins of aircraft built after the rules went into effect or to cabin interiors that were completely refurbished.[1]]

The FAA Technical Center in Atlantic City, New Jersey, U.S., also conducted tests on two oxygen generators removed from the forward cabin of the accident aircraft to determine whether "heat-related discharge of the generators installed above the last row of seats in the right-hand side had acted as torching fuel to the fire, thereby intensifying it," the report said. Tests determined that the discharge of oxygen from the generators "had only a minor effect" on the fire.

[Chemical oxygen generators produce breathable oxygen for the emergency masks to be used by passengers and crew members in the event of a sudden, unexpected cabin decompression. Designed to function safely when properly installed and used for their intended function, chemical oxygen generators can be dangerous under other circumstances. When transported as cargo, they are classified by the FAA as

Photo: Danish Aircraft Accident Investigation Board

Fire in the aft cabin of an SAS McDonnell Douglas MD-87 burned through the fuselage adjacent to the right engine, at Copenhagen Airport Kastrup, Nov. 24, 1993.

hazardous materials and are subject to strict rules for handling and shipment.

[Oxygen generators carried in a cargo hold are suspected of causing a fire that resulted in the May 1996 fatal accident to a ValuJet McDonnell Douglas DC-9-32. The generators were mislabeled by the shipper, a maintenance contractor, in a way that made it appear that they had been discharged and were therefore inert. During the climb after takeoff from Miami, Florida, U.S., the flight crew notified air traffic control that there was smoke in the cabin and cockpit. Approximately nine minutes after takeoff, the DC-9 impacted a Florida Everglades swamp, killing all 110 people on board.]

The SAS captain, 50, held an airline transport pilot (ATP) certificate and had logged 9,551 flying hours, of which 8,953 were in type. The first officer, 36, held a commercial pilot certificate and had logged a total of 2,634 hours, of which 2,409 were in type. The purser, 49, had a total of 14,663 hours in the cabin.

The report said that the cockpit and cabin crew "reacted firmly and professionally throughout the scenario. The fact that the smoke developed after the aircraft had landed and was taxiing on the outer perimeter close to the assigned gate gave the cabin crew the opportunity to prepare for and initiate an expeditious disembarkation of the passengers. ... The cabin crew's quick response and firm reaction ... resulted in a smooth disembarkation without any sign of panic.

"The AAIB and the CIT [SAS company investigation team] concur fully with the entire crew's decision not to waste time and effort in locating the origin of the smoke/fire and subsequent fire fighting, but rather to concentrate on the task of getting the passengers safely out of the cabin."

The investigation found the origin of the fire in two electrical wires that provided 115-volt alternating current (AC) to a utility plug in the right stowage closet, and 28-volt AC to lights in the stowage closet and the emergency drawer at the bottom of the closet, respectively. The wires (L1156AM18 and M504D16) were found to have a slack of about 10 centimeters to 15 centimeters (four inches to six inches) for a distance of about 45 centimeters to 55 centimeters (18 inches to 22 inches) between supports and "became pinched between the inboard-facing flange of [an intercostal] and the recirculation fan duct because of a lack of provision for clamping or other means to secure the wires," the report said.

"Normally, wire groups or bundles should not exceed 1.27 centimeters (0.5 inch) in deflection between support points … ," according to the FAA, the report said. "This measurement may be exceeded provided [that] there is no possibility of the wire group or bundle touching a surface that may cause abrasion."

Over time, the two wires had been "subjected to chafing where they were pinched ... [which] occurred when the aircraft was going through phases of flight ... takeoff, climb, cruise, descent, approach and landing.

"Slight movement of the stowage closet, galley unit and partition created the possibility of chafing wire insulation and eventually also wearing through the inner insulation blanket on the intercostal. This resulted in a situation where it became possible for the bare wires to make contact with not only each other but also with the intercostal."

Evidence that the wires had arced, fused and ignited was provided by "a distinct erosion mark on the inboard-facing flange of the intercostal" and "fresh, deep scuff marks on top of the fiberglass recirculation fan duct," the report said. "The erosion mark and the scuff marks were in alignment."

The report said that while the aircraft underwent "routine 12,500-flight-hour [level-IV] maintenance, some 'nonroutine' work, such as AD [airworthiness directive] notes, SBs [service bulletins] and ... TOs [technical orders] was carried out ... .

"To comply with inspection work of the upper fuselage fasteners ... removal of the cabin interior, [including] aft service units, partitions, sidewall panels and insulation blankets, was required. [Nevertheless,] the work requirements did not specify any inspection of the wiring installation in the aft part of the cabin. It is therefore not possible to confirm whether or not the arced and fused wires ... were damaged by chafing at the time when the aircraft was undergoing the first major disassembling of the cabin interior for inspection and maintenance purposes."

Two days after the accident, the SAS engineering department issued a control TO calling for the inspection of electrical wires in the aft right-hand cabin area. "The inspection was complied with on the company's 58 aircraft without significant findings," the report said. Follow-up level-IV inspections of three other MD-87s were conducted as they became due for level-IV inspections in 1995.

During these inspections, the "AAIB and CIT members decided to take the opportunity to inspect the factory installation of the stowage closet wiring on these aircraft. On all three aircraft the same wire installation over [the intercostal] was evident. The wires were installed with the same magnitude of slack, and in all cases were lying tight or pinched between the intercostal and the recirculation fan duct. However, no direct chafing or destruction of the wire insulation had occurred."

The report said that level-IV inspections of the three SAS MD-87s conducted during 1995 (two in January and one in June) revealed the following:

Photo: Danish Aircraft Accident Investigation Board

Fire that began on the right side of the SAS McDonnell Douglas MD-87 spread to the left side (shown here) and destroyed the aft cabin, at Copenhagen Airport Kastrup, Nov. 24, 1993.

- "On all three aircraft an inappropriate routing of the two wires in question was discovered. ... The wires were only fastened to the inboard-facing flange of the intercostals by way of common tape"; and,

- " ... On one of the aircraft inspected, a yet more inferior installation of the two wires was discovered. ... It was found that the two wires were routed up the fuselage side in a rather unusual manner, apparently not supported by the usual tie-mounts." The report said that the wires were "lying ... directly on the fuselage structure [for some distance], going through the insulation blanket via an unauthorized cut/slit in the blanket. At places the wires were held loosely in place [with] tape."

The AAIB concluded: "Considering that this was the first time that the cabin interior was disassembled to such an extent since the interior was installed at the factory, it is reasonable to assume that during production of the aircraft, installation of the tie-mounts was evidently forgotten or neglected.

"Consequently the installation of [the two wires] in this particular aircraft must, with regard to craftsmanship, inspection and final inspection, be considered of dubious standard, resulting in an installation left with a number of potential places for serious rubbing and chafing of the wires." The report said that this installation was a "serious threat to flight safety" that "should have been detected at least during the manufacturer's final inspection."

The report said that in addition to the hazard of pinching and slack in the wires, it is difficult to confirm whether the wires are in a safe or unsafe position following installation of service units in the aft right-hand side of the cabin. "Moreover, should an ignition at or near the intercostal junction occur, it would be impossible to reach [the] fire [location] with the available extinguishing equipment carried in the cabin."

The AAIB report said that a "number of corrective actions were implemented with the intention of securing a safe installation of the stowage closet wiring," with the first action being taken during the repair of the accident aircraft. McDonnell Douglas issued a service rework drawing (SRD) to be used in the repair and modification of the aircraft. The SRD, issued on May 30, 1994, was also the basis of Service Bulletin (SB) 24-151, which was issued on Sept. 29, 1994.

"However, as the inspection revealed serious safety-related errors in the routing of the stowage closet wiring, errors that were not covered by SB 24-151," the SAS engineering department issued a new technical directive (TD) in January 1995 outlining these deficiencies, the report said. McDonnell Douglas issued a revision to SB 24-151 in July 1995, the report said.

As inspection of the three MD-87s progressed, the report said, discovery of additional wiring problems made the revision to SB 24-151 "inadequate, as the text insufficiently ensured a

Cockpit Voice Recorder Transcript
SAS McDonnell Douglas MD-87
Copenhagen Airport Kastrup, Nov. 24, 1993

Time	Source	Content
1751:06	**CA1**	The CA [cabin attendant] sitting on the aft jump seat reports that the lights above her went out during landing and now it smells rather burnt.
	FO	Shall we carry out an emergency evacuation?
		[At this time the cockpit received a call direct from the CA2 on the interphone, the FO answered the call and repeated the information from CA2 aloud, making sure the PIC heard everything.]
1751:20	**CA**	Now there is smoke development down here in the right lavatory.
	FO	Now there is smoke development in aft lavatory.
	PIC	Is there smoke development?
	FO	How bad is it?
	CA2	Not too bad, it smells burnt, starting to develop smoke down here in the right lavatory.
1751:45	**FO**	OK, I think you and I will maintain this telephone connection with each other.
	CA2	Yes, yes.
	FO	If it gets worse, you'll inform us, so we can take some —
	CA2	Much smell of electrical burning, right.
	FO	Much smell of electrical burning, OK.
	CA2	Yes, and I can see that there is starting a smoke screen down here, but it's nothing wild — you know.
	FO	But it smells really electrically ... electrical burning.
	CA2	Very electrical yes, and it was my lights above me that went out in a very unusual way during the landing. They lit up brightly and then back down before they went out.
	FO	The light went out during landing, first up then down again.
1752:20	**FO**	You know what, we are at the gate in just a second.
	CA2	Yes — yes — yes no panic here.
	FO	I will maintain the telephone line open — right.
	CA2	Yes— yes but then, there is no panic, not at all.
	CA2	But then again, there is some smoke down here by now.
	FO	We are taxiing into the gate just now.
1752:52	**CA2**	Have you disconnected all the switches for down here and so on?

	FO	No not yet —
	CA2	OK.
	FO	How much smoke just now?
	CA2	It's smoking quite a bit by now.
	FO	It's smoking quite a bit.
	FO	You know what, we are shutting down and then we'll take the generators.
	PIC	You know what, should we not go ahead and take the generators off.
	CA1	Why don't we open the door as soon as possible?
	FO	Yes indeed.
1753:27	**PIC**	[Addressing the ground engineer] Enter through the aft stairway, because we have a small problem that there is some smoke by the aft stairway — go to the aft stairway — then we'll open the aft stairway.
	PIC	Can you tell them to open the aft stairway?
	FO	CA down the back — would you open the aft stairway.
1753:48		[Sound of smoke alarm]
	CA2	The lavatory —
	PIC	Parking (ATWR) from 666.
	ATWR	Yes.
1754:05	**PIC**	We are parked at 24, could we have a fire vehicle over here. We have some smoke in the aft cabin.
	ATWR	You'll get it.
	FO	That was a good idea then we are ahead of it.
	CA1	How is she down there?
	FO	I don't know.
	CA1	Should we take the Pax [passengers] out?
1754:21		[Sound of smoke alarm]
	PIC	Just let them out now.
	FO	Just let them out.
1755:12	**PIC**	[Call to ATWR] Are the fire vehicles on the way out here —
	FO	We have quite a lot of smoke in the back by now.
1755:20		[Sound of smoke alarm]
1755:27	**PIC**	Look out for the chimney effect.
1755:28		[Sound of smoke alarm]
1756:29	**FO**	Smoke in the back —
1756:31	**FO**	Smoke in the back —
1756:42	**PIC**	Emergency power.
		[End of recording]

PIC = Captain
FO = First officer
CA1 = Purser
CA2 = Cabin attendant 2
ATWR = Parking
[ ] = Editorial insertion

Source: Danish Aircraft Accident Investigation Board

safe accomplishment of the modification rework." The report added that "instructions in SB 24-151 (R1) were misleading, as some safety items were left out of the text, and some of the suggested items were substandard."

The report also said that inspection of the three aircraft revealed that "a significant amount of dust was discovered … behind sidewall paneling, service units (storage closets, galleys and lavatories) and especially inside the ventilation grilles … at floor level.

"The accumulation of dust was of a magnitude … to consider the dust to be a potential source of fuel for a fire … . The [value] of fireproof and fire-retardant insulation and soundproof materials will be considerably diminished with accumulation of highly flammable dust on and around them."

The three MD-87s were modified in accordance with both the McDonnell Douglas and the SAS TD, the report said. The FAA approved SAS's modifications in April 1995, pending a second revision of SB 24-151. The FAA granted SAS approval to continue its inspection and modification program based on its TD. SAS's engineering department issued another TD in September 1995 to include items not found in SB 24-151 (R1).

The AAIB was informed on March 25, 1996, by SAS's major maintenance and overhaul base in Oslo, Norway, that modifications to all the company's 16 MD-87s had been completed, the report said.

While praising the crew's conduct, the AAIB noted that the accident would have posed significantly greater safety risks if the fire had occurred in flight. The AAIB stressed the "importance of awareness of and immediate action to any unusual smoke development during flight and on [the] ground. Any sign or smell of ... smoke should always be considered a very serious threat to safety, as the time from recognition to actual flames, as in this case, can be extremely short.

"To emphasize this point, but without drawing any hypothetical conclusions, the AAIB believes that it would have been very difficult, if not impossible, to extinguish the fire on board [the accident aircraft] had the fire occurred in the air ... [because] of the place of ignition (behind the stowage closet and galley) ... and the rapid damage and burn-away of the air conditioning and ventilation ducting in the cabin ceiling, which would have allowed lots of air to be blown directly on ... [the] fire."

The report also noted that the captain's first call for a fire-fighting vehicle "was precautionary and rather casual. However, when he made his second request, after personally having inspected the outside of the aircraft, it was an urgent call for the assistance of the fire brigade. On both occasions the captain called the apron tower, but at no time was a state of emergency declared."

Because an emergency was not declared, several procedures related to aircraft accidents were not followed, the report said. "The AAIB inspector on duty was not contacted until about 1-1/2 hours after touchdown. He was then contacted by an airport supervisor and not as expected by air traffic control (ATC) as required ... . Though the apron tower activated the major fire alarm, the situation was apparently considered to be 'just a lavatory or a galley fire' in an aircraft parked at the gate with no passengers or flight crews involved. Therefore, ATC was not alerted to the seriousness of the situation."

The AAIB also expressed concern about the smoke-alarm system on board the aircraft. Postaccident interviews with cabin crew members revealed that the smoke-alarm signal under normal, and especially under stressful conditions "could very easily be mistaken for [the emergency evacuation signal], a signal activated by the cockpit crew ... ."

The report added: "The smoke alarm sounded at least twice during the evacuation ... [and] the sound of the alarm did not unsettle the cabin crew or the disembarking passengers. However, the [aft flight attendant], who at this time was very actively engaged in the disembarkation, shouting in an authoritative voice, 'Emergency, evacuate hurry, leave your hand luggage,' at first interpreted the smoke alarm as being the evacuation signal activated by the cockpit crew."

In 1991, an unnecessary emergency evacuation of an SAS Boeing 767 parked at a Copenhagen Airport Kastrup gate was spurred by a misinterpretation of the smoke-alarm signal, the report said.

The AAIB recommended that SAS evaluate the "acoustic signals for emergency evacuation and smoke alarm in [its] aircraft and consider modifications of these acoustic signals where needed to [ensure] the correct interpretation of and correct response to" such signals.♦

Reference

1. U.S. General Accounting Office (GAO). A*viation Safety: Slow Progress in Making Aircraft Cabin Interiors Fireproof*. Report no. GAO/RCED-93-37. January 1993.

Further Reading from FSF Publications

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ACCIDENT PREVENTION

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