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Cabin-air Contamination Briefly Incapacitates Crew

Although the source of contamination was not identified, the Swedish Board of Accident Investigation said that the quality of the cabin air was of "crucial significance" when the captain and first officer suddenly suffered nausea and dizziness during descent. Earlier that day, cabin crewmembers told the pilots about other symptoms experienced aboard the aircraft.

FSF Editorial Staff

On Nov. 12, 1999, at approximately 1900 local time, the captain and copilot (first officer) of a British Aerospace (now BAE Systems) BAe 146-200, operated by Braathens Malmö Aviation, were incapacitated temporarily by nausea and dizziness during descent from 15,000 feet to land at Malmö/Sturup Airport, Sweden. The scheduled passenger flight had originated in Stockholm. The two pilots, a purser, two flight attendants and 68 passengers were not injured; the aircraft was not damaged. The crew was conducting the third of three flights of the day, each with a flight time of approximately one hour.

The Swedish Board of Accident Investigation (SHK), in its final report, said that the cause of the incident was "the pilots becoming temporarily affected by probably polluted cabin air" and that "the quality of the cabin air was of crucial significance." Nevertheless, SHK was unsuccessful in attempts to identify chemical contaminants that caused the symptoms and to identify a technical fault, the report said.

The airline industry worldwide has a strong interest in determining the causes of such sudden impairments of crewmembers, the report said (see "U.S. Report Prioritizes Issues in Cabin-air Contamination," page 2).

"This interest concerns both the possible damaging influences to health during prolonged exposure to poor air quality and acute impairment of performance capability of crews during transitory exposure to temporarily polluted air," said the report. "There are quite a number of reports about incidents that threatened the safety of flight in that the pilots were suddenly affected. … Some of the incidents have been associated with the smell of oil, other odors or smoke in the cabin. In other cases, such indications have been absent."

Based on a review of the operator's emergency procedures and training for pilots and flight attendants, the report said, "SHK has not found any clear instructions about how the crew shall act if anyone onboard is suddenly affected by contaminated air that neither [has an odor] nor is discernible visually."

The report said that the following events occurred on the day of the incident:

- The purser experienced "an unpleasant feeling of fainting" one time during the first flight when standing after bending down to retrieve articles from a cabinet.

U.S. Report Prioritizes Issues in Cabin-air Contamination

Priorities for future research on cabin-air contamination — from sources outside the aircraft, inside the aircraft and from the environmental control system (ECS) — have been recommended to the U.S. Department of Transportation in a December 2001 report by the U.S. National Academy of Sciences. Past studies and incident reports involving commercial transport aircraft during normal operating conditions and abnormal operating conditions were factored into the recommendations, the report said.

The Committee on Air Quality in Passenger Cabins of Commercial Aircraft, which prepared the report, ranked hydraulic fluids, engine oils and their heat-related degradation products as air-quality characteristics of moderate concern "because the potential severity of their [health] effects is high, but the likelihood of exposure to them at high concentrations is believed to be low." By comparison, reduced partial pressure of oxygen and elevated ozone concentrations in the cabin environment should be given high priority in research, the report said. Airborne allergens, carbon monoxide, infectious agents and pesticides also were ranked as air-quality characteristics of moderate concern. Carbon dioxide, deicing fluids, relative humidity and nuisance odors (odors that cause annoyance or irritation of mucous membranes in the nose from sources that are common in public-transportation vehicles, such as foods, odor-producing personal products, human biological effluents and cleaning materials) were ranked as air-quality characteristics of low concern.

The report said, "During nonroutine events, contaminant exposures result from the intake of chemical contaminants (e.g., engine lubricating oils, hydraulic fluids, deicing fluids and their degradation products) into the ECS and then into the cabin. … No exposure data are available to identify the contaminants in cabin air during air-quality incidents, but laboratory studies suggest that many compounds are released when the fluids mentioned above are heated to the high temperatures that occur in the bleed-air system [which provides outside air flow through the aircraft engines to the ECS]. … Furthermore, no published studies describe quantitative measurements of air quality under abnormal operating conditions."

The engine oils and hydraulic fluids typically used in commercial aircraft contain several organic substances — some known to be toxic if ingested in sufficient amounts — that have been studied separately, but these substances typically have not been studied as formulated for aircraft use, the report said.

"No data have definitively linked exposure to these compounds with reported effects in cabin occupants," the report said.

Future cabin-air surveillance programs and research programs should include efforts "to estimate the frequency of nonroutine operations in which serious degradation of air quality occurs" and to determine the potential toxicity of selected contaminants, the report said.

Citing laboratory measurements of degradation products from lubricating oils and hydraulic fluids subjected to high temperatures, the report said, "Simple calculations illustrate that only very small quantities of oils need to be [changed chemically by heat] under conditions that occur in the bleed-air system to exceed commonly accepted health standards. … However, the components released into the passenger cabin during air-quality incidents and their possible concentrations cannot be determined from the [laboratory] experiments … [and] no available exposure data identify the contaminants present in cabin air during an air-quality incident."

The report included a recommendation that the U.S. Federal Aviation Administration assess whether air-cleaning equipment is necessary and whether such equipment would be feasible for preventing air-quality incidents by removing particles and vapors from air supplied by the ECS.

Moreover, research should be conducted on "synergistic and interactive effects of exposure" of aircraft occupants, not only to specific contaminants but also to combinations of chemical contaminants and pesticides, reduced air pressure, low humidity and ozone, the report said.♦

[FSF editorial note: This article, except where specifically noted, is based on the Committee on Air Quality in Passenger Cabins of Commercial Aircraft, U.S. National Research Council, report, "The Airliner Cabin Environment and the Health of Passengers and Crew." 2002. The 326-page report contains tables, figures and appendixes.]

She told the flight attendants, who said that they had experienced similar sensations. No unusual odors were detected by the cabin crew. The pilots said, during a ground-stop discussion with the cabin crew in Malmö, that they had not noticed anything abnormal;

- During the second flight, one flight attendant stationed in the forward part of the cabin experienced "an odd pressure in the head, nasal itching and ear pain." The purser and the other flight attendant also felt discomfort and "the feeling of moon walk [abnormal sensation of body weight]." The pilots said, during a ground-stop discussion with the cabin crew in Stockholm, that they had not noticed anything abnormal, but discussed the possibility of a cabin-pressurization system fault. This possibility was not discussed with ground engineers (maintenance technicians); and,

- On the third flight, during climb after takeoff, the captain and the purser detected a momentary odor that the purser later said was like the odor of burned sulfur. The purser checked the coffee brewer and the lavatory; both were operating normally. Later in this flight, all cabin crewmembers experienced "more pronounced"

discomfort than what they had experienced on the earlier flights. One cabin crewmember felt "burning in the scalp," and an off-duty company pilot in the cabin told the cabin crew that he "sensed something peculiar about the air in the cabin."

Before leaving the cruising altitude of Flight Level 280 (28,000 feet) on the third flight, the captain began to feel "mild dizziness." A few minutes later, the copilot also felt ill, the report said. While descending through 15,000 feet for the approach to Malmö, the copilot "suddenly became nauseous and donned his oxygen mask" but after a few seconds of breathing oxygen, the copilot felt better and was able to continue his duties without difficulty, the report said. An estimated 10 seconds after the copilot began breathing oxygen, the captain also became "very nauseous" and donned his oxygen mask.

"The captain felt markedly dizzy and groggy for a couple of minutes," the report said. "He had difficulty with physiological motor response, simultaneity [ability to comprehend/integrate multiple stimuli being perceived at the same time and to perform related actions] and in focusing. Finally, he handed over the controls to the copilot. After having breathed oxygen a few minutes, even the captain began to feel better and thereafter, the pilots were able to accomplish a normal approach and landing on Runway 17 without problems."

The report said that the pilots had considered using an emergency checklist but did not use the emergency checklist, and the pilots did not declare an emergency to air traffic control. When the purser went to the flight deck to report that the cabin had been prepared for landing, she noticed that the flight crew was wearing oxygen masks.

"In his groggy state, the captain even had difficulty in grasping the purser's finger as acknowledgement of her clear [cabin-ready] signal," the report said.

Aviation safety investigators and researchers often have been impeded in their efforts to identify causal relationships between cabin-air contaminants and reported symptoms because few medical examinations of aircraft crewmembers have been conducted, the report said. The crewmembers involved in this incident did not receive medical examinations.

The report said that to help address this problem, Braathens Malmö Aviation developed procedures after the incident that require crewmembers to use a specific physician (or, if unavailable, the nearest medical facility) for medical examination and specific testing after air-quality incidents. Crewmembers also must notify the operator's flight chief or flight safety officer and must request that test results be provided to a physician affiliated with SHK.

Before the incident, all of the crewmembers believed that their health status was satisfactory for flight duty, the report said.

The BAe 146-200 is a four-turbofan, short-range transport airplane. The cabin air-conditioning system, pressurization system and deicing system use engine bleed air; the air-conditioning system also can use bleed air from the auxiliary power unit (APU).

The report said, "During the years the aircraft type has been in service, some operators have reported intermittent events when unpleasant smells were found to be coming from the air-conditioning system. The air in the cabin has been experienced as stale or smelling of oil. In order to overcome this problem, some aircraft have been retrofitted with catalytic converters, one on each engine within the bleed-air system. The incident aircraft was not equipped with catalytic converters. Among operators and crews of this aircraft type, it is a known phenomenon that even a slight internal oil leakage in one of the engines can be manifested in a distinct smell of oil in the cabin. When this happens, the cabin air can also assume a somewhat bluish tone."

The report said that the incident aircraft was maintained as required by regulations and that records did not show any reports about its air-conditioning system or any abnormal oil consumption before the flights on the day of the incident.

After the incident, the operator's maintenance staff found a minor external oil leak on the no. 2 engine, replaced the engine and conducted procedures to remove any oil that could have collected in air-conditioning packs. No odors or other cabin-air problems were detected during subsequent flight tests, and there were no further complaints about cabin air in the incident aircraft, the report said.

The operator also conducted an investigation of possible internal/external sources of cabin-air contamination, including deicing fluid, sanitation fluids, cargo, baggage, cleaning agents, fire-extinguishing equipment, and hydraulic equipment, the report said.

"Nothing in the investigation indicates that any of the investigated sources could have had other than a possible marginal significance in the discomfort the crew experienced," the report said.

SHK, the operator, the aircraft manufacturer and the engine manufacturer also developed a test protocol for airborne chemical contaminants (gases, vapors and aerosols) in the bleed air from the engine removed from the incident airplane; engine-run tests were conducted by the engine manufacturer, and the engine was dismantled and inspected.

The report said, "With the exception of the oil leak found by the operator and minor defects listed … no fault or abnormality could be found that could have explained a possible discharge of poisonous gases or substances into the bleed-air system."

The report said that the U.K. Air Accidents Investigation Branch (AAIB) was investigating an incident of pilot incapacitation — involving suspected cabin-air contamination in the same aircraft type — that occurred in November 2000. Based on other investigations and investigation of the November 2000 incident, AAIB in May 2001 recommended that the U.K. Civil Aviation Authority and U.S. Federal Aviation Administration work with the respective manufacturers to develop maintenance standards and modification standards to prevent the accumulation of oil byproducts in air-conditioning systems and specifically to prevent the contamination of cabin air in the BAe 146 and the Boeing 757.

AAIB had recommended in December 2000 that training for crewmembers of all jet transport aircraft incorporate the following actions, the report said:

- Don oxygen masks selected to 100 percent oxygen flow as the first response to suspicion of flight-deck air contamination, cabin-air contamination or pilot incapacitation;
- Engage the cabin crew in active monitoring of the flight crew under these conditions; and,
- Ensure that any crewmembers traveling as passengers in the cabin are informed immediately about the incapacitation of a member of the operating crew.

The SHK report recommended that the Swedish Civil Aviation Administration work with other civil aviation authorities to encourage the following:

- "Existing emergency checklists and emergency training programs [should be supplemented] regarding immediate steps to be taken when suspicion arises that the cabin air is polluted. The instruction for such occasions shall call for the immediate use of the oxygen mask selected to 100 percent [oxygen flow];
- "A plan of action [should be] developed for how crews and aircraft shall be handled directly after landing if an incident with polluted cabin air has occurred;
- "An international database [should be] established with factual information from flights where suspicion of polluted cabin air exists; and,
- "Research efforts [should be] initiated in regard to the characteristics of modern lubricating oils under very high pressure and temperature and their influence on the health of human beings."♦

[FSF editorial note: This article, except where specifically noted, is based on the Swedish Board of Accident Investigation report RL 2001:41E, *Incident Aboard Aircraft SE-DRE During Flight Between Stockholm and Malmö, M County, Sweden, on 12 November 1999*. Nov. 23, 2001. The 50-page report contains tables, diagrams and appendixes.]

Cabin Crew Safety

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