Evaluating Aircraft Air Cabin Quality

By Carlos R. (Chuck) Miró & J.E. Cox, Ph.D., P.E.

The transportation sector has unique considerations for space conditioning. One of the more challenging is conditioning the space in aircraft. At an altitude of 35,000 ft (10.6 km), the outside environment is –70°F (–57°C) with air pressure of 2.6 psia (18 kPa) (which will not sustain human life). The environmental control system, in addition to providing thermal comfort, must first provide and maintain a safe pressure (oxygen) level for occupants.

Governmental requirements specify altitude limits for aircraft without oxygenation capabilities. This 8,000 ft (2.4 km) level can be exceeded for brief periods of time for weather situations, etc. Oxygenation (providing sufficient oxygen levels for breathing) is provided through the aircraft's air-conditioning and pressurization system.

A seminar at ASHRAE's annual meeting in Minneapolis on Aircraft Air Cabin Quality, sponsored by ASHRAE Technical Committee (TC) 9.3, Transportation Air Conditioning, described the unique challenges of aircraft space conditioning.

Aircraft Systems

David Space of Boeing described design considerations for commercial aircraft. Typically, the comfort control and ventilation system for the occupied compartments receives fresh air at 50°F to 70°F (10°C to 21°C) from a bleed-air arrangement from the engine intake (prior to the combustion chamber). Conditioned air is supplied through a plenum and distributed through a system designed for a ceiling-to-floor primary airflow pattern. The system minimizes compartment airflow in the forward/backward directions as a measure to minimize exposure to odors and disease agents emanating from occupants. Air is exhausted generally at the rear of the aircraft to offset the amount of fresh air intake.

High-efficiency particulate air (HEPA) filters are used. The filtering system in newer aircraft is moving toward a 99.97% efficiency level. This level is comparable to the level required in the critical-care areas in hospitals.

Because of the presence of higher levels of ozone (high-altitude and high-latitude conditions), ozone converters are important considerations.

In-Flight Data

Determination of potential air contaminants of commercial aircraft in flight under normal airliner operating conditions was the subject of an ASHRAE-sponsored research project. Early results were reported by Dr. Niren Nagda of ENERGEN Consulting. Data collection was conducted on 10 normal airline flights. Monitoring equipment was used on all portions of the flight i.e., ascent, cruise and descent.

Data are being analyzed and processed (which includes among other factors pressure corrections). Specialized techniques were required because of the very low relative humidity (RH) levels in the bleed air system (about 0.5% RH). The relative humidity in the passenger cabin was about 9%.

Measurements included cabin air conditions and conditions in the bleed air (fresh air plenum) system. The data show that the bleed air and the cabin air conditions were similar. Nagda reviewed the data for the various chemicals monitored. He particularly noted two results. Concentrations of ethanol (from human sources) were higher than expected as were concentrations of methylene chloride (from unknown sources).

In general, "no surprises have been found in the cabin and bleed air findings." This ASHRAE research will provide the first "published" real-time, measured data.

The UV Option

Robert J. Hall of the United Technology Center reported on studies on the application of ultraviolet (UV) light (photon illumination) to air purification. HEPA filters attack particulates, but UV can attack gaseous contaminants such as volatile organic chemicals (VOCs) and microorganisms. Hall indicated that a UV purification system can increase in-flight removal effectiveness by 75% and can increase ground-level removal effectiveness by 50%. Tests have shown UV effectiveness against tuberculosis agents.

The installation of a UV purification system adds weight that is equivalent to a single passenger. A UV system uses about 5 to 6 W per passenger. Maintenance involves changing the lighting elements at 10,000-hour intervals.

UV technology and other contaminant removal measures can reduce the amount of bleed-air (fresh air) needed. Reducing the amount of bleed air requirements will improve engine efficiency.

ASHRAE Proposed Standard

ASHRAE is developing a new standard "Air Quality within Commercial Aircraft (SPC 161P)." The purpose of the proposed standard is to define the requirements for air quality in air-carrier aircraft and to specify methods for measurement and testing for compliance.

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