



50%

A The cabin air on commercial aircraft is typically supplied by two sources – 50% from recirculated air and 50% bleed air taken from the compressor section of the engines or APU

The Air We Breathe

Paul E Eden discusses the state of the art technology in cabin environmental control systems

When the Boeing Model 307 Stratoliner entered service in 1940, it opened a new era in which airliners could potentially fly above terrain and weather, improving safety, efficiency and passenger comfort – the key enabling technology was cabin pressurisation.

Pressurisation and cabin air quality are managed by the environmental control system (ECS). At its most basic, the ECS receives engine bleed air and conditions it to maintain cabin pressure and sustain a comfortable, breathable atmosphere for passengers and crew. Boeing's 787 is the exception, its ECS drawing air from ram air inlets, not the engines.

The industry has become very good at cabin pressurisation but has

struggled with the occasional entry of contaminants into cabin air on the ground. These 'fume events' may have long-term health consequences for crew and they are sufficiently common that frequent flyers will almost certainly have experienced them and know how unpleasant they can be.

A recent European Committee on Standardisation (CEN) technical report detailed recommendations for preventing fume events, including installing filters to prevent fumes from entering the cabin or to mitigate their effect. The report has caused pressure on EASA to address the issue properly, while some ECS suppliers are already ahead of the game.

David Conrad, vice president, business development at Oxnard, California-based PTI Technologies, explains the challenge of fume events and how PTI is working to prevent them.

1 “The cabin air on commercial aircraft is typically supplied by two sources – 50 per cent recirculated air and 50 per cent bleed air taken from the compressor section of the engines or APU. The 50 per cent from bleed air contains contamination that may include hydraulic fluids, engine oils, pyrolysis products, multiple types of volatile organic compound – VOCs – and particulates, as well as ozone.”

In response, PTI Technologies has developed integrated filter technology, initially applied to fuel tank inerting systems and now to bleed air filtration for ECS. “We’ve tested these filters at temperatures up to 250°C [500°F] and challenged the filter with contaminants including toluene, engine oils, valeric acid, ozone and propylene glycol. Our test results are very positive, and we are working to deliver integrated bleed air filters to airframe OEMs for testing.”

The company is also developing filter systems for recirculated cabin air. Standard HEPA (high-efficiency particulate absorbing) filters remove impurities but are unable to capture gases. Conrad reports market-leading performance in trials with HEPA filters with activated charcoal imbedded into their weave for gas removal.

Other 'fume removal' options on the market include BASF's dual-mode Deoxo convertor, which uses catalyst technology to break down ozone and VOCs into oxygen, carbon dioxide and water. Interestingly, David Yokota, Senior Director, Air Management Systems, Honeywell Aerospace, also reveals: “We are actively working on solutions to fume events, but we are not yet in a position to provide details.”



2

HEPA filter

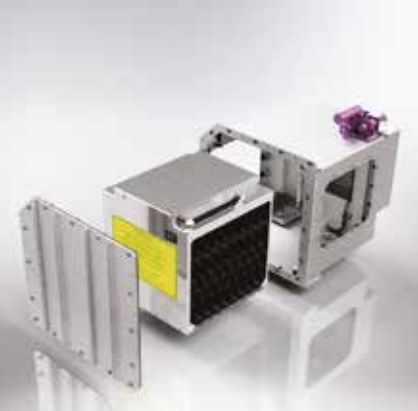
Air filtration in aircraft ECS drew particular attention in the wake of Covid-19, with a focus on the ability of HEPA filters to remove microscopic airborne particles – including viruses – from recirculated cabin air. PTT's Conrad explains: "It is vital to minimise the quantity of harmful particles circulating through the cabin and cockpit. Viruses, pollen, bacteria and microscopic dust can contaminate cabin air and trigger responses in humans, including runny nose, watery eyes and sneezing.

"For this reason, recirculated air flows through HEPA filters, which are otherwise used in medical environments. These trap more than 99.9% of airborne particles and bio-contaminants, down to 0.3mm. A well-maintained, high-performance HEPA air filtration system is important for the creation of a healthy and comfortable atmosphere for passengers and crew."

Covid-19 particles tend to be between 0.1mm and 0.5mm in size, suggesting that a sizeable proportion should pass through a HEPA filter. But the virus enters cabin air in respiratory particles released from passengers and crew as they breathe, speak and cough, and these are usually between 0.9mm and 1.0mm in size. Meanwhile, it is accepted that an N95 mask will protect medical personnel against Covid-19 and these masks trap 95% of particles that are 0.3mm or greater in size. A HEPA filter is equivalent to an N100 mask, trapping 100 per cent of similarly sized particles.

There is also a strong argument for cabin air humidification, especially in less densely occupied premium sections, both

4



for passenger wellbeing and its potential to cause 'clumping' of virus particles. Peter Landquist, VP senior advisor sales at CTT Systems, says: "It is proven that humidity plays an important role in reducing the risk of viral infection. When humidity is low, our mucus membranes dry, weakening our first line of defence against viruses. I believe filtration and humidity are very important and that both are required." Cabin air is otherwise very dry, since little water vapour occurs naturally at altitude.



3

More densely loaded cabin areas have higher humidity levels, typically around 12 per cent, because more people are breathing out water vapour, but first class may be as low as 5 per cent; levels below 20 per cent in the built environment are considered suboptimal.

Landquist describes how CTT's system combats these effects: "The cabin humidifier is installed in the air supply ducts for the cabin zone to be treated. Two or three units are usually sufficient to cover first and business class. The humidifiers automatically activate at cruise altitude, increasing cabin humidity to 22 per cent, and deactivate as descent begins. Thanks to air recirculation, the added humidity 'spreads' to the economy cabin, typically increasing humidity there to around 18 per cent."

Increased cabin humidity also means condensation, which may cause corrosion, electrical failures and add weight through pooling. For this reason, CTT's cabin humidification system includes zonal dryers.

Sound and weight

Diehl Aviation produces a range of ECS components and its VP corporate communications, Guido van Geenen, expands on two specifics – noise and sustainability. Cabin sound levels are an important factor in passenger comfort and air conditioning systems create a significant element of cabin noise. Van Geenen explains: "Airliners must meet very high acoustics requirements and delivering very good sound insulation without negatively affecting airflow is a major challenge for air conditioning system design." The key is in the careful choice of materials, including noise attenuating composites.

Those same materials have a role in sustainability. "Virtually every gram counts on board an aircraft," van Geenen says. "Saving weight means saving fuel, and Diehl Aviation has inevitably applied its high standards for lightweight component technology to air conditioning ducting. Our Particle Foam Air Outlet, for example, combines novel materials and a jointing method developed in-house to ensure new levels of efficiency and weight reduction.

"Air outlets made from granulated foam plastic and air ducts in thermoplastics offer many benefits in lightweight construction and manufacturing processes. Once testing of this new, automated technology is complete, our customers will be able to profit from its benefits."

More than eight decades since the Stratoliner introduced pressurised commercial air travel, the industry is still evolving technologies that have made ECS an important component in the passenger experience. New challenges such as Covid-19, our expanding understanding of passenger physiology and sustainability are continuing to drive innovation in systems as essential as they are taken for granted. ☺

1 & 3. Diehl Aviation's air mixer unit and air distribution piping are made with efficiency and weight reduction in mind. Photos: Diehl Aviation. **2 & 4.** CTT Systems' zonal dryers work to reduce problematic condensation, while its cabin humidifiers maintain optimal levels for passenger wellbeing and comfort. Photos: CTT Systems.