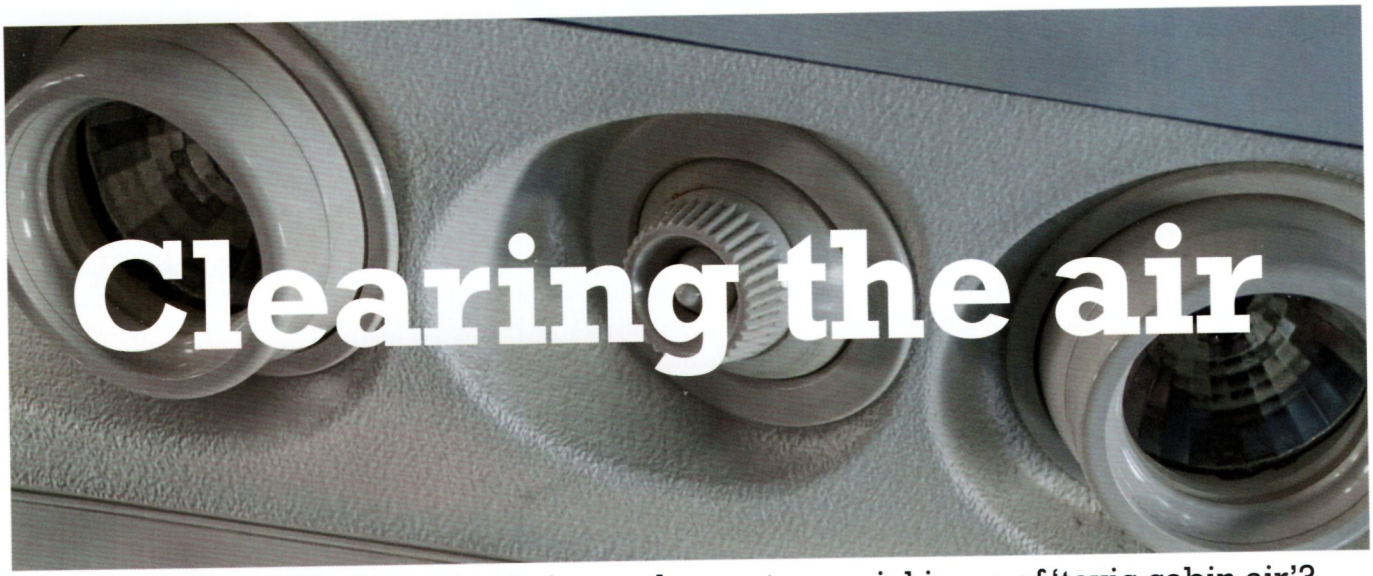

Clearing the air

Is there now a technological solution to the controversial issue of 'toxic cabin air'? DAVID LEARMOUNT reports on how one UK airline is aiming to trial a new bleed air filter – but will it make a difference?

> IT IS DAILY BECOMING MORE DIFFICULT TO WRITE OFF CABIN AIR CONTAMINATION AS MEDICALLY INSIGNIFICANT IN THE FACE OF SOME RECENT HIGH PROFILE AIRBORNE EVENTS

The recent decision by a major British airline to trial specialist filters for engine bleed air in its fleet has turned the spotlight yet again on the controversial issue of cabin air quality. At the same time it signals the potential for an imminent solution to a problem that has haunted the industry for decades.

The airline is easyJet, and the filter manufacturer is US-based Pall Aerospace. EasyJet explains its rationale for taking part in the trial with Pall: 'We hope to identify and reduce incidents of unusual smells and fumes in the cabin.' The carrier comments: 'These are rare events but, when they occur, they can cause flights to be delayed which disrupts our passengers.' EasyJet explains that it is definitely going ahead anyway with upgrading its Pall HEPA (high efficiency particulate absorber) cabin air recirculation filters 'to get rid of smells faster' and will be working with the filter manufacturer in 2018 to develop a fumes detection system, which 'will be able to identify smells from specific sources'.

Finally, easyJet says that it is 'developing a new filtration system with Pall which filters external air before it comes into the cabin – a trial is planned in 2019'. The latter statement is just another way of describing a bleed air filter.

Bleed air filtration system

Pall Aerospace says it has every confidence that a fully certificated, retrofittable bleed air filtration system will be on the market by 'late 2018'.

If Pall's claims for the equipment's effectiveness, commercial viability and maintainability are borne out, the commercial availability of cabin air quality assurance measures for the first time is likely to make the arguments for their use compelling. In the late 1980s United Airlines made the decision unilaterally to fit Pall Aerospace HEPA filters for recirculated cabin air. This proved a marketing winner when the airline was able to advertise that its cabin air was healthier and soon HEPA filters for cabins became universal. despite the fact that they were optional.

Dr David Stein, Pall's Head of Strategic Marketing, explained that the HEPA filters were later upgraded by most airlines to deal with airborne volatile organic compounds (VOC), including bacteria. He pointed out that, when smoking onboard was finally banned and the seating density in economy cabins increased, suddenly passengers could smell unpleasant odours that tobacco smoke had previously masked, so the cabin air recirculation filters were able to improve the air quality noticeably.

Engine bleed air supplied to the cabin was still not filtered at source, however. In 2008, Pall developed bleed air filtration systems for the cockpit air in DHL Boeing 757 freighters. These were early 757s that had more regular 'fume events' than most types. The events were caused by engine oil vapour from faulty oil seals getting into the 757's bleed air and, therefore, its cockpit and cabin. Pall's new filters worked so effectively that DHL recorded 'a significant decrease in crew complaints and flight disruptions'. DHL had made the decision to act when crews had complained of damage to their health.

Stein points out that the successful bleed air filter for 757 cockpits has an EASA supplemental

Aerotoxic Association

type certificate and describes it as a 'first generation version' of the whole-aircraft system that is under test with easyJet today.

Speaking at the Global Cabin Air Quality Executive's mid-September International Aircraft Cabin Air Conference (IACAC), held at Imperial College, London, Stein told delegates that the Pall bleed air filter system being trialled has reached the 'post-feasibility' stage of its development and is expected to be certificated by 'the third or fourth quarter of next year'. He did not provide a price for retrofitting the system but said its weight when fitted was about 100kg and time between filter changes is anticipated to be 5,000 hours, which is approximately once every aircraft maintenance C-check.

New facts emerge

New scientific papers on cabin air contamination presented at the 2017 IACAC reinforce the case for some form of bleed air filtration. Although the dispute continues to rage about exactly how much harm exposure to oil-contaminated engine bleed air does to crew and passenger health, the claims that it causes no harm whatsoever have more or less ceased, replaced by discussion about airline duty of care to passengers and crew – particularly crew because of the risk of repeated exposure.

A significant study about the exposure of crews to low levels of engine or hydraulic oil contaminants in bleed air was presented at the September conference. Researched at Cranfield University, the study points out that low levels of pyrolised organophosphates from engine lubricating oil are inevitably and continually present in bleed air. Engine oil seals – both labyrinth and mechanical oil seals – act to contain the lubricant supply to the engine shaft bearing but they depend for effectiveness on a low level of oil flow through them. In terms of engine oil consumption this planned leakage is negligible but it is essential and continuous. Meanwhile, the engine designers originally assumed that high air pressure would prevent oil leakage into the compressor chamber. The report demonstrates that they were wrong about that.

This matters, because aero engine lubricating oil – an entirely synthetic fluid, not a mineral oil – contains organophosphate additives (tricresyl phosphate) that are highly effective anti-wear agents but also a neurotoxin. Their toxicity is proclaimed on the containers in which they are supplied.

The Cranfield study, carried out by cabin air expert Dr Susan Michaelis, published the following conclusion: 'Low-level oil leakage in normal flight operations is a function of the design of the pressurised oil and bleed-air systems. The use of the bleed-air system to supply the regulatory required air quality standards is not being met or being enforced as required.'

In the slipstream of past developments

The industry has in the past dealt with bleed air contamination differently. In October 1955, Henry Reddall of North American Aviation presented a paper to the Society of Automotive Engineers in Los Angeles. It was entitled 'Elimination of engine bleed air contamination'. Industry reaction to the issue was as follows. In 1954 Boeing's Dash 80 – which became the 707 – was designed with turbo-compressors for cabin air pressurisation. So was the Douglas DC-8 in 1958, the Convair 880/990 in 1959 and the Vickers VC10 in 1962. Boeing began using engine bleed air for cabin pressurisation when the 727 series was introduced in 1964 but, when

rXu Zheng

it introduced its 787 series in 2011, it returned to pressurising the cabin by alternative means.

Pall's development of a potentially viable bleed air filter is particularly significant now because it is daily becoming more difficult to write off cabin air contamination as medically insignificant in the face of some recent high profile airborne events.

In terms of scale, a bleed air fume event over Canada on 24 October 2016 is notable because it involved an Airbus A380 but similar events over the years have been recorded on all types large and small, except the 787. In the A380 case, British

ROYAL AERONAUTICAL SOCIETY

Toxic cabin air – the view from the RAeS Aerospace Medicine Group

The RAeS Aerospace Medicine Group acknowledges the concerns of aircrew and passengers regarding the potential adverse health effects of contaminated bleed air. However, the evidence that this poses a chronic health risk has not been proven. Most fumes in the cabin events are not bleed air events and therefore not related to seal failures etc. It is important to remember that HEPA filters remove particulate matter including dust, allergens and microbes but the removal of VOCs requires more advanced techniques including adsorption and catalytic oxidation.

In response to a paper published online in 2017[1], five of the largest international aerospace medical associations, including the RAeS, responded to the Editor[2] highlighting that over the past two decades several major studies of cabin air have been carried out internationally and none have identified levels of toxic substances approaching clinical significance. Since the long-term effects being reported by individuals do not appear to be explained by toxins in cabin air, other causes must be sought.

It is recognised that the fumes from bleed air events may result in acute symptoms, such as irritation of the eyes and the respiratory system and represent a flight safety hazard: hence the need for pilots to don their masks should such an event occur. A bleed air filter would potentially protect, or at least mitigate, pilot exposure to such irritant fumes during bleed air events. The cost and efficacy of any such protection would have to be assessed in light of any hazard.

[1]www.euro.who.int/__data/assets/pdf_file/0019/341533/5_OriginalResearch_AerotoxicSyndrom_ENG.pdf?ua=1

[2]www.euro.who.int/en/publications/public-health-panorama/correspondence/aerotoxic-syndrome-a-new-occupational-disease/letter-to-the-editor

Airways Flight 286 en route from San Francisco-London was over Saskatchewan when it was forced to divert to Vancouver with a fume event that incapacitated at least eight crew members, forcing them to go onto oxygen. When it landed all three pilots and 22 cabin crew were taken to hospital and many of them were unfit for work months later, according to their union, Unite. The condition of the passengers is unknown. There has been no formal inquiry by British authorities into the event and BA was left alone to deal with it. BA says the aircraft's flight back to London was uneventful.

The Charlotte incident

Individual airframes sometimes become notorious for fume events but remain in service for years, with no follow-up by the authorities because engineering examination often comes up with the 'no fault found' (NFF) verdict. An example is N251AY, a US Airways Boeing 767-200. On 16 January 2010 it operated a flight from St Thomas, US Virgin Islands, to Charlotte, North Carolina with 174 passengers and seven crew on board. During the flight the cabin crew noticed an unpleasant smell in the cabin and the pilots suffered headaches, sore throat and eye irritation. By the time they were managing the approach to Charlotte they began to feel groggy and had difficulty in concentrating but they landed the aircraft safely. During the en-route phase the pilots had messaged base to request medical attendance on arrival.

The event has been confirmed by US Airways but is not recorded by the FAA or the National Transportation Safety Board as a notifiable incident. Crew blood tests on arrival confirmed high levels of carboxyhaemoglobin All the symptoms persisted for days and the feeling of fatigue never left the pilots. They eventually had their aircrew medical clearance rescinded and lost their licences.

In March the same year, the US Association of Flight Attendants reported that eight pilots and cabin crew members, including all but one of the crew on the St Thomas-Charlotte flight on 16 January 2010, did not return to work and that there had been at least three known fume events on N251AY at about that time. The only fault the airline reported it found was leaky rear door seals which, arguably, could have allowed engine fumes into the cabin on the ground but the AFA says it doubts that explains what actually happened.

US Airways reported that it had carried out a borescope check on N251AY's engines but reported 'NFF'. Dr Michaelis points out, however, that there did not have to be a fault for oil seal leakage into the compressor to take place. Her Cranfield study explains that oil seal leakage is lowest during stable flight phases like cruise but in transition phases, such as start, spool-up, throttle-back, or whenever the power is varied, the pressure distribution and thermal equilibrium is disturbed and a fume event can occur even when there is no bearing or oil seal fault. Hence the frequency of NFF reports from the engineers after post-fume-event inspections.

Fume event reports

Recorded fume events known to have caused sensory impairment and incapacitation of pilots and cabin crew are numerous but listing them all is of limited use because the stories are all remarkably similar and none has led to an actual crash. Nevertheless, if airlines had access to a commercially viable means of preventing or mitigating bleed air fumes, they would almost certainly adopt it.

Indeed in 2009, at a press briefing at the Society's London headquarters, BAE Systems and medical systems manufacturer Quest International launched a cabin air filtration system for the BAe 146 and Avro RJ series. Unfortunately it did not prove as effective in an airborne environment as it had in a hospital.

Meanwhile, Pall may not exactly be trumpeting its promised development of a viable bleed air filter but there are a lot of people out there with high hopes for it.