DATE: May 3, 2016

SUBJECT: Cabin Air & Bleed Air Contaminants

BOEING RESPONSE TO QUERY

Cabin air quality inside Boeing airplanes is safe. Extensive research on cabin air conducted by independent researchers, universities, industry and government agencies has repeatedly demonstrated that contaminant levels are generally low and that health and safety standards are met. However, we continue to work with scientists to improve our understanding of cabin environmental factors and study other potential technologies such as sensors and advanced filtering.

Boeing is supportive of scientific research being conducted in the U.S. by the FAA Center of Excellence for Airliner Cabin Environment Research (ACER), NASA's Vehicle Integrated Propulsion Research (VIPR) and the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) organization through research project 1262 that is measuring air quality and the potential for bleed air contaminants. We've also participated in EASA's Rulemaking and the UK Committee on Toxicology (COT).

Despite this established research to the contrary, a number of advocacy groups continue to promote the idea that exposure to trace levels of organophosphate contamination -- far below published standards -- presents a risk to human health. They are very vocal and, from time to time, the media picks up and publishes their stories. However, because the science has not changed, Boeing has not changed its position that cabin air is safe to breathe – a position that is firmly based on the reliable scientific data currently available.

ANSWERS TO ANTICIPATED QUESTIONS

Q1. Is cabin air safe to breathe?

Yes, cabin air is safe to breathe. Cabin air quality research conducted by independent researchers, universities, industry, and government agencies has consistently shown that cabin air meets health and safety standards and that contaminant levels are generally low. We continue to work with scientists to improve our understanding of environmental factors that influence the flying experience.

Boeing also supports scientific research on cabin air quality conducted in the U.S. by the FAA ACER, NASA's VIPR, and by the ASHRAE organization's in-flight research project 1262.

Q2. What are the possible ways engine oil contaminants can enter the cabin air environment?

There are basically three ways that engine oil contaminants can potentially enter the cabin.

(1) If oil is spilled in the vicinity of the inlet of the engines or the auxiliary power unit, (APU), or if an oil reservoir is overfilled, that may result in the engine or APU ingesting oil. If that happens, a portion of the ingested oil could enter the cabin.

(2) All turbine engines consume a small amount of oil during normal operation, and this oil can be exhausted from the back of the engine. As an aircraft taxis down the runway, it is possible that trace amounts of engine exhaust from the preceding aircraft could be ingested temporarily by the trailing aircraft. This depends upon distance between the aircraft and wind direction. This exhaust would be comprised primarily of exhaust gas combustion products, but it could also include traces of uncombusted engine oil.

(3) Finally, in rare instances, an oil seal inside an engine or APU may leak. If this happens, it is possible for oil contaminants to enter the cabin through the bleed air system.

In all of these cases, existing data supports our position that the contaminant levels associated with such events are much too low to present a health issue. This conclusion is supported by the reviews of existing data conducted by the UK Civil Aviation Administration (CAA, 2004), House of Lords Science and Technology Committee reviews (2000), Committee on Toxicology (COT, 2007) and more recent research conducted by ACER, ASHRAE Project 1262 (2012) and KLM in-flight research (2014). Current regulations and industry specification and design practices seek to minimize potential sources of bleed air contamination. Boeing and the aviation industry as a whole have been quite successful in achieving that goal, as the FAA's reviews of the Accident/Incident Data System (AIDS) and the Service Difficulty Reporting System (SDSR) databases have shown.

Q3. What kind of technology does Boeing use to supply outside air to the airplane cabin?

Boeing currently uses two types of technology to supply outside air to the airplane. Most aircraft in use around the world today use bleed air systems to ventilate and pressurize the cabin. Bleed air systems have been in use for many decades. In a bleed air system, a small percentage of the compressed air in the compressor section of the engine is diverted, or “bled,” off the engine upstream from the combustion chamber where fuel is added. Outside air is always entering the environmental control system and is constantly circulating in the cabin. One-half of the air supplied to the cabin comes from the bleed air system, and the other half is recirculated from the cabin itself. Before this recirculated air is returned to the cabin, it is drawn through HEPA filters which remove over 99% of any particulate matter that may be present.

The only modern jet aircraft that does not use bleed air to supply ventilation to the cabin is the Boeing 787 Dreamliner. The 787 uses electric compressors to feed the environmental control system, mixing fresh, outside air and HEPA-filtered recirculating air. The air in the cabin of a 787 is always circulating, just like it is in airplanes equipped with bleed air systems. Because the outside air supply does not pass through the engine compressors, no engine oil contaminants can enter the cabin if an engine oil seal leaks. However, as with all aircraft, the potential always exists that contaminants present in the air in the airport environment will be introduced into the cabin while the aircraft is on the ground.

Q4. How do you respond to claims that even low contaminant levels are dangerous?

Toxicologists who have evaluated worst case contamination scenarios and compared their results with existing occupational health thresholds have concluded that transient low level contamination of cabin air is not hazardous to cabin occupants. This is consistent with the reviews of existing data by the UK Civil Aviation Administration (CAA, 2004), House of Lords Science and Technology Committee reviews (2000), and Committee on Toxicology (COT, 2007). Boeing continues to support ongoing research being conducted by the ACER and by ASHRAE.

Q5. How many incidents have there been where engine oil contaminants have entered the cabin?

Cabin air contamination incidents are reported to regulatory agencies such as the FAA or EASA based on whether the pilot believes it could have a detrimental impact on the flight. FAA data suggest such events are rare; however, we understand that flight attendant union reports are more frequent. An FAA database indicates that 252 events were reported in the U.S. between Jan 1999 and Nov 2008 (from Service Difficulty Reporting System), an estimate of 2.7 events per 1,000,000 airplane departures. Boeing fully supports industry efforts to develop a consensus on reporting standards and data collection.

Q6. Can filters be installed in cabin air systems to block contaminants from entering the cabin?

All Boeing airplanes use HEPA-type filters to remove essentially all particles from the air that is re-circulated to the cabin. (On modern aircraft, cabin supply air is a mixture of about 50 percent outside air and 50 percent filtered/re-circulated air. Ventilation is continuous and air is constantly flowing in and out of the cabin.) However, HEPA-type filters are not effective against contaminants that are gaseous in nature. Aircraft rely on air dilution with clean outside air to dilute potential gaseous contaminants to levels that are safe and healthy. Boeing does provide gaseous filters for the recirculated air on the 787 and will offer it as a customer option on the 777X. Gaseous filters lower gaseous contaminants in the recirculated air.

Q7. Why are airplanes designed to use "bleed air" from engines if there is the possibility that contaminants will enter the cabin?

The ambient air outside the airplane at cruise altitude is very clean, cold (below -35º F), dry and low in partial pressure of oxygen, which is too low to sustain life. Consequently, the air at that altitude must be compressed to a density that is healthy for passengers and crew. Airplanes with a bleed air system use the airplane's engine compressors to accomplish the task of warming and pressurizing cabin air, providing a healthy and safety cabin environment. The air is taken from the engine compressors upstream of the combustion chamber where fuel is added.

Q8. Did Boeing design the 787 with a no bleed air system in order to prevent contaminants from entering the cabin?

No. Fuel savings and environmental performance are the primary reasons the 787 does not use an engine bleed air system. Recent advances in technology have allowed Boeing to generate pressurized cabin air without drawing bleed air from the engines. The 787 uses electrical compressors to compress the cold, low pressure air to the necessary temperature and pressure to provide a healthy and comfortable cabin environment at flight altitudes. This approach is more fuel efficient because it avoids drawing energy away from the engines.

Q9. Does Boeing plan to change existing airplanes to non-bleed systems? How about development airplanes?

No. Boeing does not plan to modify existing airplanes to incorporate a non-bleed system like that used on the 787. Existing airplane infrastructures are not designed for the 787's new technology. Attempting to retrofit the 787's electrical system architecture would require a wholesale redesign and recertification of all airplanes in the worldwide fleet. Both the 737MAX and the 777X are planned with bleed air systems.

Q10. Are contaminants from the engines odorless?

In the rare case where engine oil contaminates a bleed air system, there would most likely be an odor.

Q11. Why doesn't Boeing install sensors to detect cabin air contamination in its aircraft? Is it an issue of cost?

Boeing believes that air quality on airplanes is healthy and safe. However, we are always looking at ways to improve our products in a manner that enhances safety, comfort and value for our customers. We are aware of and support efforts under way to develop and evaluate the effectiveness and reliability of sensors to detect airborne contaminants of various types. Such technology must be demonstrated to be highly reliable before it can be safely incorporated on aircraft.

Q12. What is Boeing doing to prevent oil from leaking into the air supply on Boeing aircraft in service today?

Boeing is working with industry stakeholders to develop a consensus on data collection and supporting in-flight research to better understand the nature and cause of cabin air contamination events. We are also supportive of scientific research being conducted by ASHRAE (research project 1262), the FAA ACER, and NASA VIPR, all measuring air quality and assessing the potential for bleed air contamination. Boeing fully supports gathering additional data and continues to work with industry to minimize the frequency of contaminant events. In this regard, it will be important to continue to develop industry best practices when it comes to operation and maintenance. Boeing also continues to look at advanced technologies that improve airplane design and value, and the passenger's and crew's flying experience.

Q13. What is Boeing's response to the FAA Notice for Proposed Rule Making (NPRM) on "Bleed Air Cleaning and Monitoring Equipment and Technology" (Docket No. FAA-2012-0714) and what is NASA VIPR?

While we understand that bleed air cleaning and monitoring technologies are being developed by industry suppliers, at this time there are none that are fully aerospace-qualified to address engine oil thermal decomposition products during a rare engine upset condition. We are currently supporting the work of the FAA's ACER through the NASA VIPR 3 project.

VIPR testing includes a series of on-wing engine ground tests including "nominal" and "faulted" engine operating scenarios conducted on a C-17 Globemaster III aircraft equipped with P&W 2000 engines. Data will be collected over a range of power settings including quasi-steady-

state and transient operating conditions and will evaluate advanced sensors and algorithms. The project will, in part, evaluate advanced bleed air sensors and filtration technologies and conduct analyses of thermal decomposition products produced during a simulated engine upset condition.
Boeing is involved in VIPR 2 and VIPR 3, working collaboratively with team members from Pratt & Whitney, U.S. Air force, NASA (Glenn, Dryden, and Armstrong) FAA ACER, and other component suppliers.

Q 14 What's Boeing's response to the "A Dark Reflection" movie?

Boeing has not seen the movie, but media reports suggest that the movie's premise is that there is an aviation industry cover-up of facts that say that cabin air is harmful to crew and passengers. This is simply not true; there is no cover-up. The subject of cabin air quality has been thoroughly examined and discussed at international conferences and industry meetings for many years. Existing independent research and data support our position that cabin air is safe and healthy. Blue-ribbon panels also have stated, after comprehensive reviews of the scientific literature, that cabin air is not a health or safety issue (EASA Rulemaking in 2012, Committee on Toxicology 2007, FAA's ACER through ASHRAE project 1262 in 2012 and KLM in-flight research in 2014). It should be noted that the producer of the movie presented his material to the UK COT, EASA, and the ASHRAE committee. The material he submitted, and which presumably was used in making his movie, was found to be incomplete and his claims unjustified by the scientifically qualified reviewers.

Q15. What is your reaction to the recent media stories about the British coroner's report by Sheriff Stanhope Payne? It supposedly concludes that BA pilot Richard Westgate's death was due to 'aerotoxic syndrome'?

Boeing relies on scientific facts and data to make informed decisions and conclusions. Boeing will review the full coroner's report when it becomes available before making any comment. We will also be reviewing the UK CAA regulator and British Airways comments and analysis on the report. It is possible that the CAA will ask the UK COT or another independent researcher such as ACER for review and comment. Boeing will consider all this input before forming an opinion on the coroner's report.

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