E-Jets Cabin Air Quality and COVID-19 Outbreak

General

This document is an informative technical report aiming to support Embraer operators to promote technical discussions with their authorities related to air quality on board due to the COVID-19 outbreak.

This document is not an Embraer assurance that precludes totally the chances of having any cross infection inside the aircraft cabin.

Aircraft Cabin Environment – Risk of Contamination

Since SARS outbreak in 2003, cognizant authorities have collected evidence that the risk of any communicable disease being transmitted on board an aircraft is low.

Scientific research has shown that there is little risk of any communicable disease being transmitted on board an aircraft, as the quality of aircraft cabin air is carefully controlled. (WHO, 2020)

These studies suggest low risk of transmission between passengers on board, possibly due to the lack of face-to-face contact, physical barriers of back seats and the direction of cabin air flow, from ceiling to floor (IATA, 2020a).

In comparison with many other confined spaces, the risk is probably lower in modern aircraft due to cabin air systems equipped with High Efficiency Particulate Air (HEPA) filters (IATA, 2020b).

What is discussed in the scientific studies?

The studies below present infection analysis using data from flights with contaminated persons on board:

- Schwartz, 2020: 15 hours flight from Wuhan to Toronto, with 350 passengers on board and one symptomatic COVID-19, none secondary case discovered so-far. All passengers were wearing masks during this flight. Also, the lack of secondary cases after prolonged exposure supports droplet transmission as the likely route of COVID-19 spread;
- Breugelmans, 2004: one confirmed SARS-infected pax flew from Hong Kong and then extensively in Europe. After 7 flights, no SARS transmission was shown among 110 passengers seated close to the infected passenger;
- Vogt, 2006: Among 1,766 pax on 7 US flights, 312 completed questionnaires and blood was collected from 127. Transmission of SARS was not observed, suggesting the risk of transmission is not amplified on board.

Based on the literature reviewed, it is possible to conclude that:

- In the great majority of flights investigated (Breugelmans, 2004, Vogt, 2006, Schwartz, 2020), almost none confirmed case of spread of SARS on board of aircraft cabin could be identified;
- In the asymptomatic phase of the illness, the individual is not coughing neither sneezing, so the spread risk might be lower.

Given the design of the cabin air management system, the implementation of strict hygiene protocols, and the use of masks by passengers and crew, the risk of cross infection inside the aircraft is considered to be low.

Note: SARS-CoV2 and SARS-CoV1 have similar aerosol and surface stability, as well as similar decay rates (Doremalen, 2020).

COVID-19 and expiratory droplets and the use of individual masks

When coughing, talking and sneezing, a person will atomize water droplets that are inside the respiratory system. Contaminants present in the expiratory tract of an infected person are carried outside and can be transmitted to other individuals via inhalation.

The main known infection routes of cross-infection are airborne and direct contact with contaminated surfaces (Olsen, 2003, Ferretti, 2020, Otter, 2016).

The most common expiratory droplets are between 4 and 8µm in size (see Figure 1). Particles of this size are filtered with HEPA with an efficiency greater than 99.9[1]%.

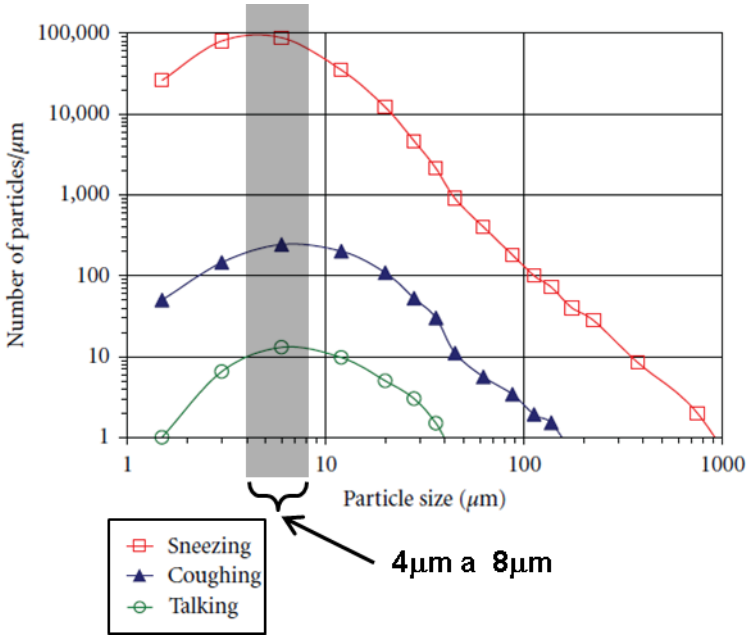


Figure 1: Droplet size distribution (adapted from Duguid, 1946)

SARS-CoV-2, the most recently discovered coronavirus, has an estimated size around 0.1µm. The HEPA filter efficiency for this particle size is also higher than 99.9% (Pall, 2020 and Safran, 2020).

Particles larger than 5 µm deposit on surfaces quickly, mainly due to the force of gravity (Connor, 2009). The smaller particles are carried by the airflow and are able to transport contaminants for longer distances (Tang, 2006).

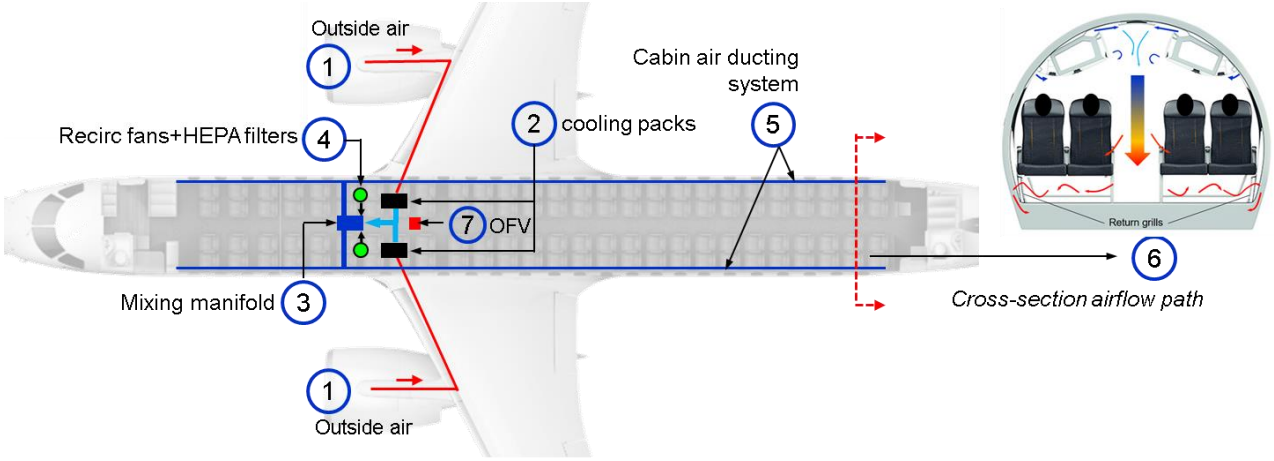
[1] 99.97% at *0.3mm DOP and 99.99% with sodium flame challenge*

Figure 2: The use of individual masks and their role in blocking expiratory droplets

The use of passenger individual masks is a very effective way of blocking any type of expiratory droplets, reducing cross-infection risks (Lei, 2013).

E-Jets cabin airflow overview

The schematic below summarizes the main components of the Environmental Control System (ECS) related to air quality and how this system works.



1) Outside air is taken from the engines;
2) The hot air is conditioned in the cooling packs;
3) The cooled outside air is mixed with recirculation filtered air in the mixing chamber at an approximate 50/50 ratio;
4) Particles including bio-contaminants (fungus, virus and bacteria) are retained in the HEPA filters;
5) Air is evenly distributed throughout the cabin by diffusers located near the overhead bins and exit the return grills located next to the floor;
6) The distribution throughout the cabin ensures a vertical cabin airflow, which minimizes air movement between cabin seat rows;
7) The outflow valve controls the cabin pressure by modulating the airflow from pressurized area to the outside environment.

Design key factors to minimize cross-infection on E-Jets

The Embraer E-Jets cabin air distribution system was designed to improve passengers comfort and cabin air quality. State of the art simulation tools and extensive testing were used to comply with, but not limited to, FAA, EASA, SAE and ASHRAE air quality standards.

The air distribution system is equipped with High Efficiency Particulate Air (HEPA) filters, the same technology used in hospital to trap pollutants, including Covid-19 viruses, with efficiency higher than 99.9%[2]

The outside air exchange rate inside the cabin is about 20 times per hour (30 times per hour when filtered recirculation air is included), which is reasonably higher than hospitals and typical buildings.

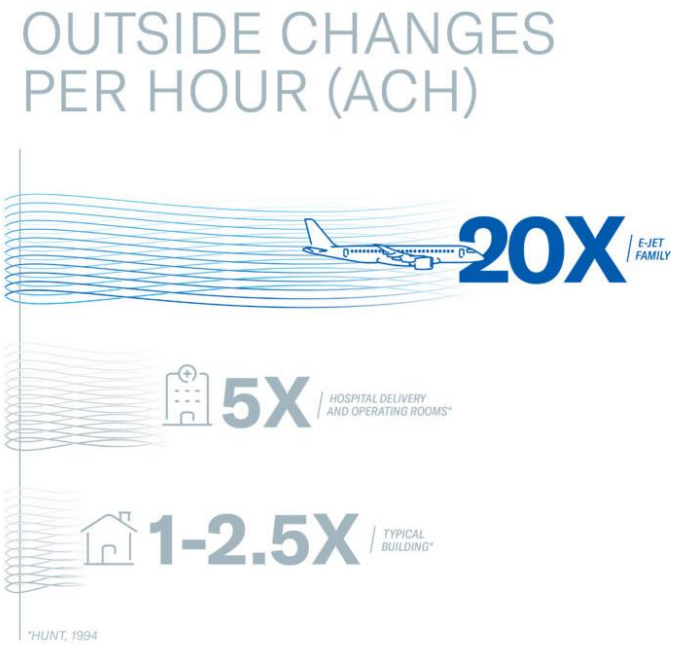


Figure 3: Outside air changes per hour in different indoor environment.

The cabin air conditioning system also minimizes cross infection between aircraft rows since the airflow passes through the passengers upper head position in the same cabin section (very low fwd/aft air movement).

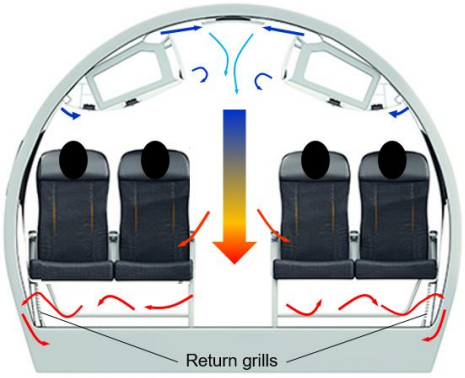


Figure 4: Airflow inside E-Jet cross-section

[2] 99.97% at *0.3mm DOP and 99.99% with sodium flame challenge*

Gasper as an additional air barrier

Previous studies have indicated the E-Jets gasper valve may act as an additional contaminant barrier, acting as an air curtain, to avoid airborne contaminants to be inhaled by occupants, if adequately adjusted to the occupant breathing zone.

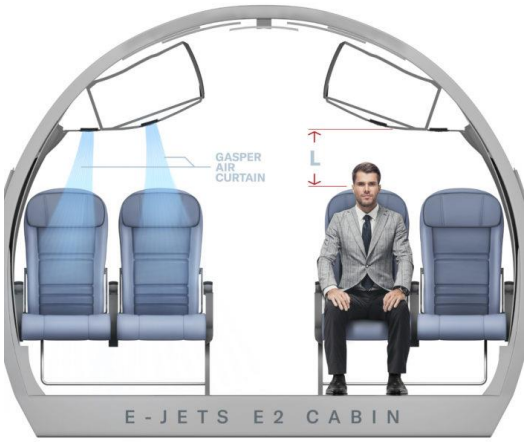


Figure 5: Gaspers as air curtain

The gaspers air protection effect is possibly high in the E-Jet cabin mainly because its proximity to the passenger upper head position (distance "L" in Figure 5).

Operational Information and Recommendations

The E-Jets reduced typical flight time (aprox. 1.5 hour) naturally minimizes risks of cross-infection.

According to IATA, mandating that airlines use empty seats to increase physical distance between passengers is not an effective health precaution on board of aircraft (IATA, 2020a).

Besides the recommendations from health and aviation authorities, as additional measures, Embraer suggests:

- Minimize cabin movements with trolleys and occupants to minimize air mixture/turbulence in the cabin;

- Operating with fully operational air conditioning packs, recirculation fans and outflow valve provides the best air quality for the occupants. Therefore, operators should consider minimizing dispatch with any of those components inoperative whenever possible.

- It is recommended to run the air conditioning system before the boarding process starts to exchange the cabin air.

Conclusions and Remarks

- Extensive review indicates low risk for on board contamination;
- Main contamination means are through exhaled droplets carried by airstream. In this case, ventilation has a significant effect on washing contaminants out;
- The use of personal masks on board minimizes dispersion of liquid droplets through exhalation;
- Airline procedures to identify and properly manage symptomatic passengers (before boarding and during flight) reduce the risk of on board contamination.

E-Jets cabin is considered a healthy environment for its occupants, assured by:

- Air quality and comfort driven design to meet the highest industry standards;
- High total air exchange rate: about 20-30 times higher than regular buildings and 5-6 times higher than hospitals;
- Recirculation HEPA filters may retain bio contaminants such as SARS-CoV-2;
- Typical short flights/distances naturally minimizes risks of cross-infection

It is also important to highlight the need for decontamination and disinfection of aircraft interior surfaces that passengers or crew may come in contact with, according to the published maintenance tasks and in the frequency required by local authorities.

Embraer recommends checking and following additional guidelines from aviation and/or health authorities.

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