Airborne transmission and ventilation

SET: 21 October 2020

For information no action required.

EVERY JOURNEY MATTERS

Airborne transmission: what do we know so far?

This paper sets out our:

- current understanding of aerosol transmission of COVID-19 and
- proposed next steps to ensure that we continue to manage this risk as effectively as possible on the TfL network.

Engineering and SHE regularly review latest Government, PHE and SAGE guidance, as well as best practice advice from HVAC industry bodies (national & international) and the wider transport industry and other relevant COVID-19 research.

What do we know so far?

- The possibility of aerosol transmission of COVID-19 (SARS-CoV-2) (outside of aerosol generating procedures in healthcare) has been formally acknowledged by WHO.
- It is possible that aerosol transmission plays a role in super spreading events. Super spreading events are characterised by high secondary attack rates and tend to occur in poorly ventilated indoor spaces.
- Good ventilation of indoor spaces will dilute and remove virus in the air.
- People should not spend long periods of time in poorly ventilated spaces with others ~~people~~.

Airborne transmission: what do we know so far? (continued)

- Cloth face coverings are likely to have some benefit in reducing risk, face shields/visors are unlikely to be an effective control.
- Encourage face covering in addition to increased ventilation, social distancing and hand hygiene to interrupt transmission.
- No firm evidence to show that the virus is spread through heating, ventilation and air conditioning (HVAC) systems.
- Current Government guidance and associated industry advice on HVAC systems within buildings is to consider how ventilation air flow can be maintained and the amount of fresh air supply increased:
    - This could include opening windows or doors (unless they are fire doors, have environmental or operational restrictions),
    - leaving ventilation equipment switched on to improve circulation, or
    - keeping air cooling/conditioning units running continuously.
- No evidence of COVID-19 has been found in air samples on the Underground or bus network: Imperial College sampling on 23 September (results in Appendix 1). Next sampling will be carried out on 21 October.

SAGE Recommendations: managing airborne transmission risk

SAGE Environment & Modelling Group's paper on the "Role of Aerosol Transmission in COVID-19" (August 2020) set out a number of recommendations which are relevant to TfL:

- Steps should be taken to ensure good ventilation in all buildings. Priority should be given to spaces where ventilation is absent or inadequate, those where there are several people in close proximity for a period of 30 minutes or more and those where an infectious person is more likely to be present.
- Particular attention should be paid to planning for winter to ensure that spaces can be effectively ventilated without significantly compromising the thermal comfort of occupants.
- Greater use of cloth face coverings should be encouraged in indoor environments with poor ventilation or when large numbers of people congregate to reduce the risk of super spreading events. There is a need for further research to understand the best strategies for controlling airborne transmission risk. Research to understand the influence of air conditioning units on different particle sizes would be valuable.
- There is a need for further research to understand the effectiveness of face shields/visors as a mitigation measure.

Buses: recommendations of the UCL report

Modifications to the assault screens such that the speech holes are covered and the gaps around them to be no more than 5 mm wide (based on the UCL Assault Screen Study, Appendix 2). All vehicles were fully operational in this condition by June 2020.

Avoid recirculation of air between the saloon and the driver's cab, so that the air in the cab is kept separate to the passenger saloon in terms of the air supply. Affected vehicle Heating, Ventilation and Cooling systems were identified and disabled by May 2020. This work aligned with the recommendation to improve vehicle assault screens.

Modifying the ventilation system so that the driver has their own system that is separate from the passenger saloon and draws air from an outside source of fresh air. In order to ensure safe CO_2 levels inside the cab, the cab ventilation system must provide high standards of indoor air quality. 1800 vehicles were modified to meet this recommendation by early August 2020. **Opening the window in the driver's cab until these ventilation systems are adapted.**

Buses: recommendations of the UCL report

Return to front door boarding and operate boarding procedures such that both front and middle door are open to increase ventilation on the bus. This was achieved following the implementation of the driver assault screen improvements.

The saloon area should be considered in more detail to analyse the risk and personal exposure to passengers (in conjunction with other areas measures such as social distancing, masks etc). In the interim saloon windows should be encouraged to be open to aid ventilation. This work on the passenger area is now underway. Physical testing, computational fluid dynamics analysis and research are estimated to conclude by late 2021. The interim advice to customer is to keep windows open.

Passengers have been requested to wear suitable face coverings whilst using public transport until further research can be completed on the effectiveness. This is was implemented on 15 June 2020

In the medium-term, targets for Indoor Air Quality (IAQ) standards on public transport are being developed and adopted. This is required internationally and TfL is working to ensure this is considered during development of new vehicle standards.

London Underground stations and operational buildings

The existing HVAC systems in London Underground (LU) buildings (stations, operational buildings and ancillary facilities) ensure there's an adequate supply of fresh air available. The majority of our systems have filtration built in, appropriate for the LU environment – designed to remove dust and dirt particles from the air. These are periodically inspected and maintained as part of our existing facilities maintenance regime, which is in itself based on industry best practice guidance.

Across LU buildings, we have many different types of HVAC systems in operation, due both to the age of the network and the different technologies available when we built our stations and infrastructure – so solutions that can be adopted in one location may not work in another. With this in mind, we ask colleagues to take a common-sense approach and do what is practically possible in their work area. The Engineering team has given advice to the different LU teams where requested.

Other TfL modes (LO, DLR, taxis, etc.): TfL recommendations on implementing ventilation standards in buildings in non-public areas have been shared with all other modes and franchises.

London Underground trains I

All London Underground trains use pressure ventilation systems, except for the newest S Stock trains that provide services on the Metropolitan, Circle, District and Hammersmith & City Lines. Pressure ventilation systems bring fresh air into the train carriages from outside the train on a continuous basis – forcing staler air out through natural gaps in the carriages around doors and through end windows and open saloon ventilators.

All trains have some form of saloon ventilators that also allow air in and out of the carriages. These are all currently locked in an "open" position and have been for a number of years.

Driver's cabs for all LU trains have separate external ventilation or air conditioning systems (dependent on the rolling stock) to the air in the passenger saloon areas. This is with the exception of the S stock trains under certain defect conditions.

London Underground trains II

Our newest S Stock trains have HVAC systems and through gangways with high fresh air ventilation rates.

All LU trains are designed to open doors on the correct side at every platform. This results in a theoretical air change rate of 20 air changes per hour, so the air inside the carriages gets replenished very frequently. In practice the figure will be higher than this, likely in excess of 30 changes per hour due to other ventilation mechanisms – saloon ventilators, R/S door drop-light windows, natural air leakage through door gaps, train or mechanical ventilation induced airflow from outside the train forced into the carriage etc. This figure substantially exceeds the minimum requirements of applicable recommendations.

All trains are currently regularly cleaned using chemical anti-viral coating cleaners (VirusGuard, Zoono, etc.).

Note that modifications to the LU fleet would be a significant undertaking given the volume involved and accompanying assurance required to carry this out safely.

TfL buildings

Across the TfL Head office portfolio we have a wide range of HVAC systems in operation supporting the larger TfL office hubs and our leased office towers. Government and industry guidance (CIBSE, Refcom, REHVA etc.) regarding improvements that could be made on HVAC are being followed, with this under continual review.

Current mitigations include the following:

- Ventilation systems in Head Office buildings have been optimised to ensure the maximum fresh air supply is provided to all areas wherever possible.

- Given the widely varying occupancy profiles in different buildings, the Building Management and other control Systems are kept under constant review, with the most appropriate control strategy adopted to suit the current circumstances

- Natural ventilation is used where applicable.

Conclusion and TfL's next steps

The information and evidence on airborne transmission continues to emerge.

Proposed next steps:

1. Developing our understanding of ventilation in our operational buildings:

- Prioritised survey on all non-public areas for all our assets on London Underground
- Asset Operations and Engineering to assess what modifications can practically be made
- Tender returns have been received 16/10/20 for the first batch of prioritised sites, with a programme for this and further batches to be developed.

2.COVID-19 sampling and research:

- Support independent sampling tests (airborne & contact surfaces) of public-area assets to demonstrate continued success of control measures
- Support the various research streams
- Request from [redacted] from Centre for Transport Studies, UCL for a decommissioned tube carriage for aerodynamic research.

3. Assurance:

- **C**omms: colleagues and customers – reduce complacency through reminders.
- Importance of ventilation, keep doors and windows open where possible in addition to "hands, face, space."

Appendix 1: COVID-19 sampling: Imperial College pilot study

September Results: All swabs and air samples were negative – no COVID found. This is despite sampling 18,000L of air in stations – vastly in excess of the amount of air a person would breathe in that time.

Aims and objectives

- To collect samples across surface and LU to test for COVID-19 on the network
- To collect data as representative as possible of real customer journeys on busy sections of the network
- To inform the design of a larger study to collect samples across more areas of the network

Methods

- Researcher travels from Waterloo to Euston on Northern Line, then Euston to Paddington on 205 bus
- Takes swab samples at hard surfaces e.g. grab handles
- Takes air samples, sampling 300L/minute of air (on average someone exercising hard breathes less than 100L/minute so this is a large sample volume)

Testing procedure

	Air sampling	Swab sampling
1	Waterloo, on concourse between Bakerloo and Northern Line, for 1 hour	Escalators, oyster readers
2	In carriage along journey from Waterloo to Euston	Grab handles on carriage
3	Euston station at 'half' concourse, near ticket machines, for 1 hour	Escalators, oyster readers
4	205 bus top deck from Euston to Paddington	205 bus push buttons, handrails

Next steps

- Current pilot will run the same experiment monthly for the next three months
- Liaising with UCL, DfT/PHE/Network Rail and other transport providers to feed into other testing programmes (TfL is the first to conduct air sampling. Swab sampling is being done on rail and buses nationwide and has been negative to date)
- Consider how we can best share this information with our colleagues and our customers
- Use experience gained from pilot to design phase 2 testing incorporating more areas of the network, more frequent sampling and different sampling modes where appropriate