

Airborne transmission and ventilation

SET: 3 March 2021
For information no
action required.



Paper Recommendations

SET is asked to:

- 1) Note the paper on Airborne transmission and ventilation for information, with no request currently put forward.

This paper sets out our:

- 1) Current understanding of aerosol transmission of COVID-19 and
- 2) Proposed next steps to ensure that we continue to manage this risk as effectively as possible on the TfL network.



Airborne transmission: what do we know so far?

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?

- Aerosol transmission of COVID-19 (SARS-CoV-2) (outside of aerosol generating procedures in healthcare) was formally acknowledged by WHO in July 2020.
- Ventilation has been identified as a key factor in mitigating against the risk of aerosol transmission, particularly of indoor spaces, but this needs to be applied as part of a hierarchy of controls (Face, hands, space, ventilation), alongside the use of face coverings, social distancing, sanitisation of common contact surfaces and hand hygiene to interrupt the known transmission mechanisms
- 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.



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

- Face coverings are beneficial in reducing risk, face shields/visors are less likely 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 subject to an adequate supply of mechanical/natural ventilation being provided to the room in parallel.
- No evidence of COVID-19 has been found in air samples on the Underground or bus network: Imperial College sampling from September through to December 2020 (results in Appendix 1).



SAGE Recommendations: managing airborne transmission risk

SAGE Environment & Modelling Group's paper on the "Role of Aerosol Transmission in COVID-19" (August 2020) and the subsequent update (December 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.



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 CO₂ 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. The remaining vehicles already had separate systems.

Window stickers are being applied and stand out ibus messaging plays regularly, advising passengers to keep windows open for ventilation and to ensure they wear their mask correctly over their nose and mouth



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 are required to wear suitable face coverings whilst using public transport. 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, which aligns with the current Government guidance to mitigate against aerosol transmission. 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 based on industry best practice guidance. Improved ventilation fault response durations have been implemented with ventilation faults now attended to within 4 hours and fixed within 48 hours. This is supplemented by daily fault triage by the LU asset operations Mechanical team

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. Ventilation FAQ's have been published on the Corona virus sharepoint site to further support colleagues. The Engineering team continues to give advice to the different LU Asset Operations teams where requested.

Other Rail modes: TfL recommendations on implementing ventilation standards in buildings in non-public areas have been shared with all 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 including both the saloon and drivers cabs, 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

2.COVID-19 sampling and research:

- Support independent sampling tests (airborne & contact surfaces) of public & non public area assets to demonstrate continued success of control measures
- Support the various research streams

3. Assurance:

- Continue with comms: 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 at TfL phase 2

Background

- TfL commissioned Imperial college to collect samples across surface and LU to test for COVID-19 on the network, starting September 2020
- Phase I focused on a simulated passenger journey, repeated monthly
- Phase 2 is split into two workstreams:
 - Workstream 1 continues the simulated passenger journey
 - Workstream 2 adds air and surface sampling of staff areas

Methods – phase I

- 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)
- Extremely sensitive lab tests are used to give the best chance of detecting any virus



Phase I testing procedure

Sample number	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

Phase I results – all samples negative in 2020

Experiment date	Air sampling	Swab sampling
September 2020	Negative (no COVID found)	Negative (no COVID found)
October 2020	Negative (no COVID found)	Negative (no COVID found)
November 2020	Negative (no COVID found)	Negative (no COVID found)
December 2020	Negative (no COVID found)	Negative (no COVID found)



More information on sampling methodology

The BBC filmed the October 2020 sampling run which can be viewed at <https://www.bbc.com/news/health-54649463>



Appendix 1: COVID-19 sampling at TfL – Phase 2

Phase 2 workstream 1 – simulated journey

- The same journey from workstream 1 is sampled monthly
- The hour-long sample on the concourse has been removed
 - Other sampling experience indicates the concourse is an extremely unlikely place to detect coronavirus – the focus going forward is on sampling the air around where a real customer may be
 - A customer is not likely to stand motionless on the concourse for an hour

Phase 2 workstream 1 – results

Experiment date	Air sampling	Swab sampling
January 2021	Negative (no COVID found)	Negative (no COVID found)
February 2021	Results pending	Results pending
March 2021	Results pending	Results pending
April 2021	Results pending	Results pending

Phase 2 workstream 2 – staff area sampling

- Staff areas across the network will be sampled, including:
 - Tube
 - Bus
 - Trams
 - Maintenance
 - Victoria Coach Station
- The focus will be on the most heavily used staff areas, which can safely and effectively be sampled
- Not all staff areas will be sampled but the researchers aim to gain a good overview of representative staff areas across different parts of the TfL network
- Researchers will take surface swabs from the area being sampled, and will run air sampling while doing so to search for any coronavirus in the air
- Each area will be sampled once. If a positive result is found the area will be deep-cleaned and a further sampling session scheduled to ensure no coronavirus remains.

Phase 2 workstream 2 – results

- This document will be updated with results as they become available



Appendix I: COVID-19 sampling at TfL – Phase 2

Discussion

- It is encouraging that extensive sampling has not revealed Coronavirus on surfaces or in the air on the London transport network
- **More detailed analysis of these results is expected from the Imperial College Team in early 2021**
- The results have been negative despite significantly increased transmission and prevalence of COVID-19 in the community in London

Q&A

- How can the swab results all have been negative when COVID rates are so high?
 - COVID is primarily transmitted from person to person. This can be when one person breathes the air of someone who has COVID, or if they touch their face after shaking hands with someone who has COVID.
 - COVID can survive on surfaces and we mitigate against this with an extensive cleaning regime. The results seem to indicate that this has been effective so far. TfL will continue to look for ways to develop and improve the cleaning regime to make sure the transport network is safe
- How can the air sample results have been negative when COVID rates are so high?
 - The air samplers we used draw enormous quantities of air over their filters. The results were negative because the lab could not detect COVID on those filters. It's important to note that the sampling machine was observing social distancing throughout the experiment – even though it was in busy areas, on escalators, concourses, tubes and buses, it did not spend any significant time in close proximity to other people during its journey. People on the journeys with the sampler were also wearing face masks
 - This shows the huge importance of social distancing and wearing face masks on the transport network – if a sampler doing the breathing of several people didn't get any COVID into it, the same would likely be the case for a person doing the same journey

Contacts

Study lead for TfL, Paul McGovern, Senior Lead Occupational Physician – [REDACTED] [@tfl.gov.uk](mailto:[REDACTED]@tfl.gov.uk)

Samantha Phillips, Head of Occupational Health and Wellbeing – [REDACTED] [@tfl.gov.uk](mailto:[REDACTED]@tfl.gov.uk)

Other considerations

- What would have had to happen to detect COVID on the network?
 - If the air sampler had been coughed on by someone with COVID, or even if someone with COVID had stood close to the sampler without wearing a mask, we probably would have detected the virus.
 - If someone with COVID were not wearing a face mask, coughed into their hands and then touched a surface just before it was swabbed, we probably would have detected the virus.
- How should we use these results?
 - The risk of catching COVID-19 comes from being close to people who are infected
 - The transport network is safe but it's imperative everyone follows the rules – staying away from other people, observing hand hygiene and wearing masks
 - The risk is greater when you are close to other people (e.g. in rush hour). Keep your distance, especially if others are unable to wear masks because they are exempt.

