

**BURO HAPPOLD**

# Reopening Stories

# **Ventilation of theatres**



*Stephen Jolly, Duncan Campbell, Hakim Muhammad*

Please note that guidance is evolving. This presentation is based on information available at the date of preparation.

**20<sup>th</sup> October 2020**



# **Summary of current guidance on ventilation systems in the context of Covid 19**



***Or, "He shall not breathe infection in this air"***

Henry VI, Part II, William Shakespeare

# Understanding Impacts of Ventilation

- Understanding Covid-19 transmission
- Impacts of ventilation systems
- Understanding existing systems
- Practical Steps
- New Installations

# UNDERSTANDING COVID TRANSMISSION ROUTES

# Three identified routes of transmission

## Surface (fomite) contact

- Hand-to-hand contact
- Hand-to-surface contact
- Virus active for 2-3 days on surfaces

## Large Droplet, 1-2m close contact and airborne transmission

- Sneezing, coughing, Talking, Singing
- Droplet size  $>60 \mu\text{m}$

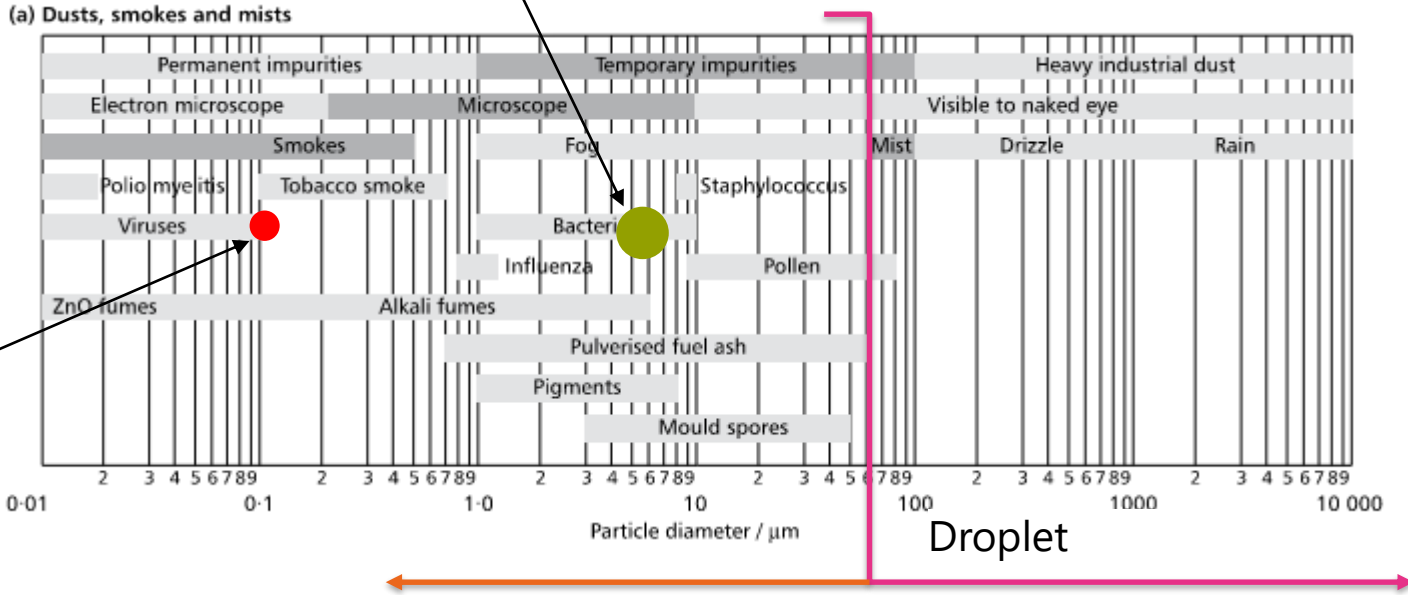
## Aerosol, long range airborne transmission

- Droplets evaporate
- Droplet size  $<60 \mu\text{m}$
- Virus active for 2-3 hours in indoor air
- Faecal transmission also identified path for aerosol transmission

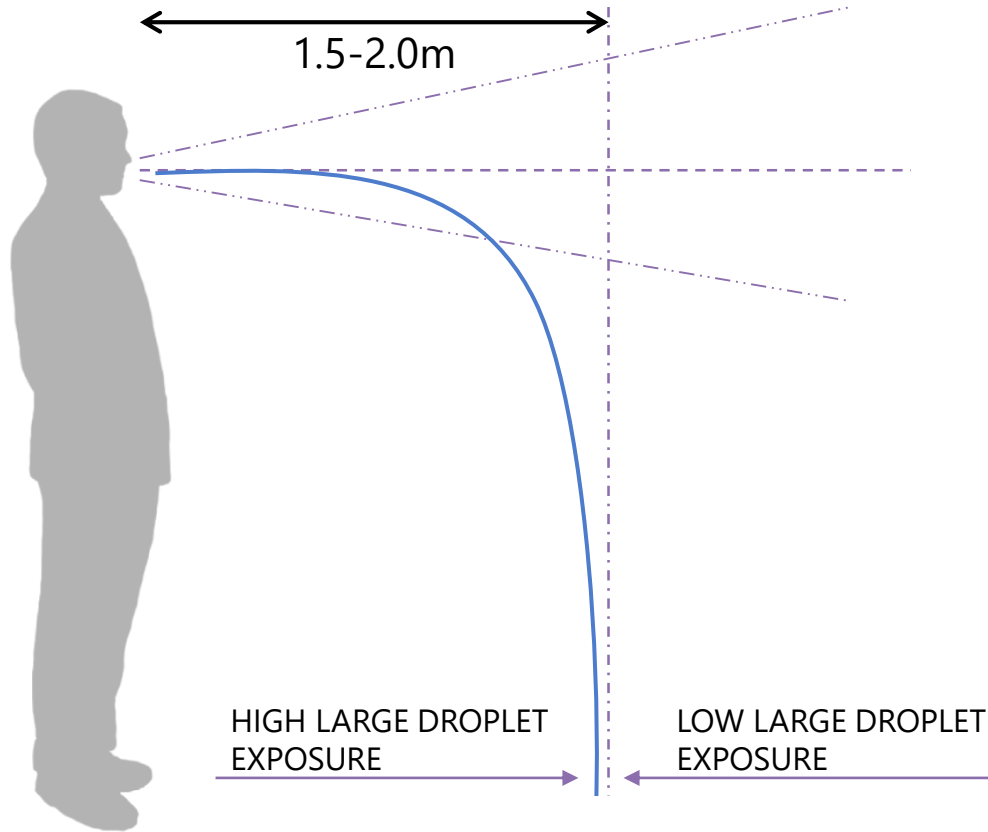
# Particle Sizes

Aerosol  
evaporated and  
suspended in air

Single  
Covid-19  
Virus

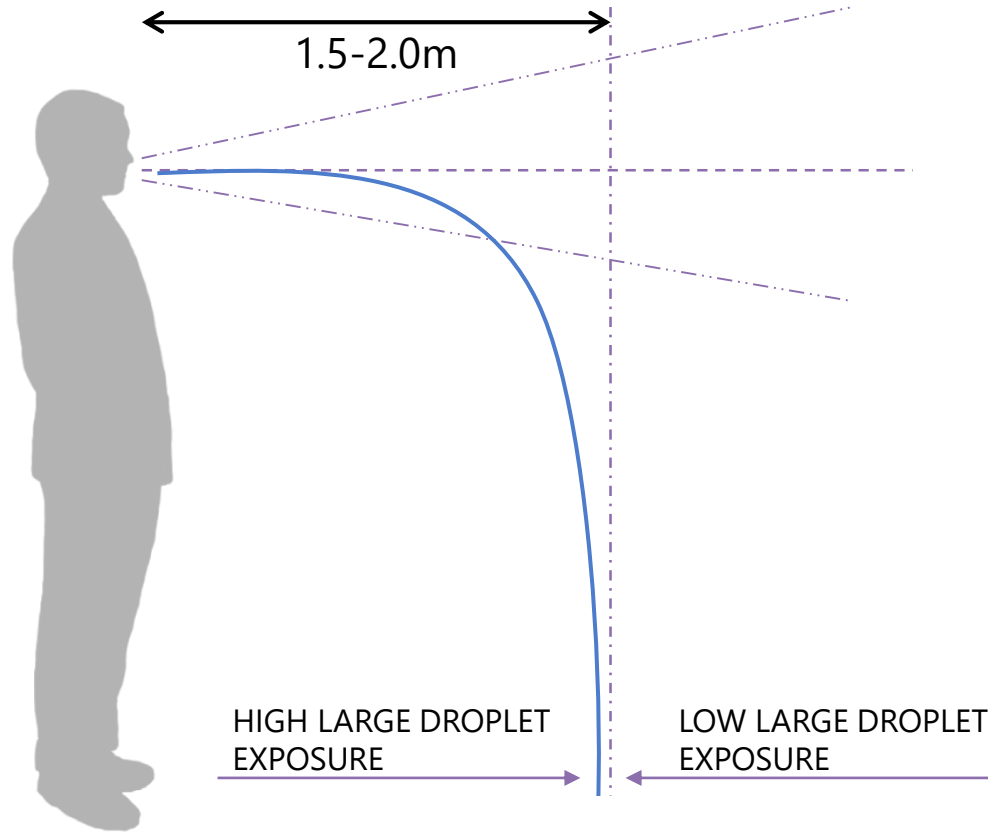


# Large Droplet Transmission



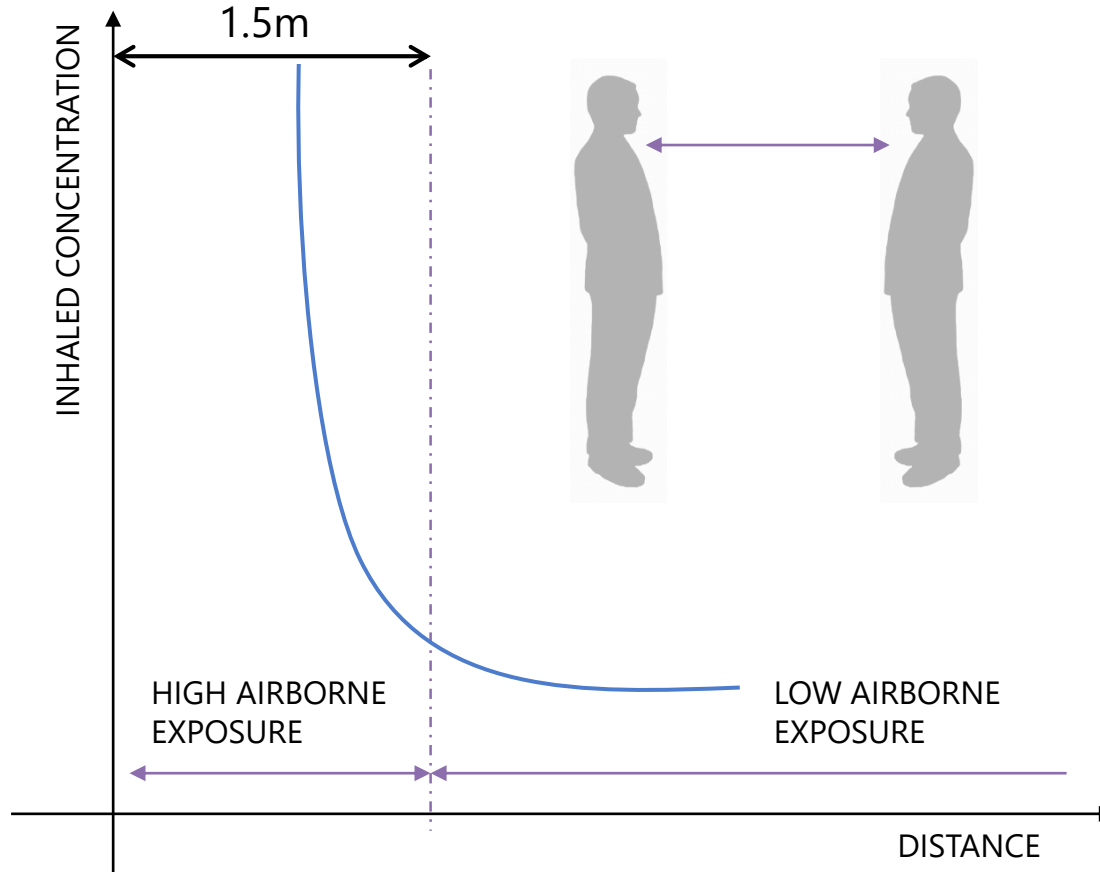


# Large Droplet Transmission

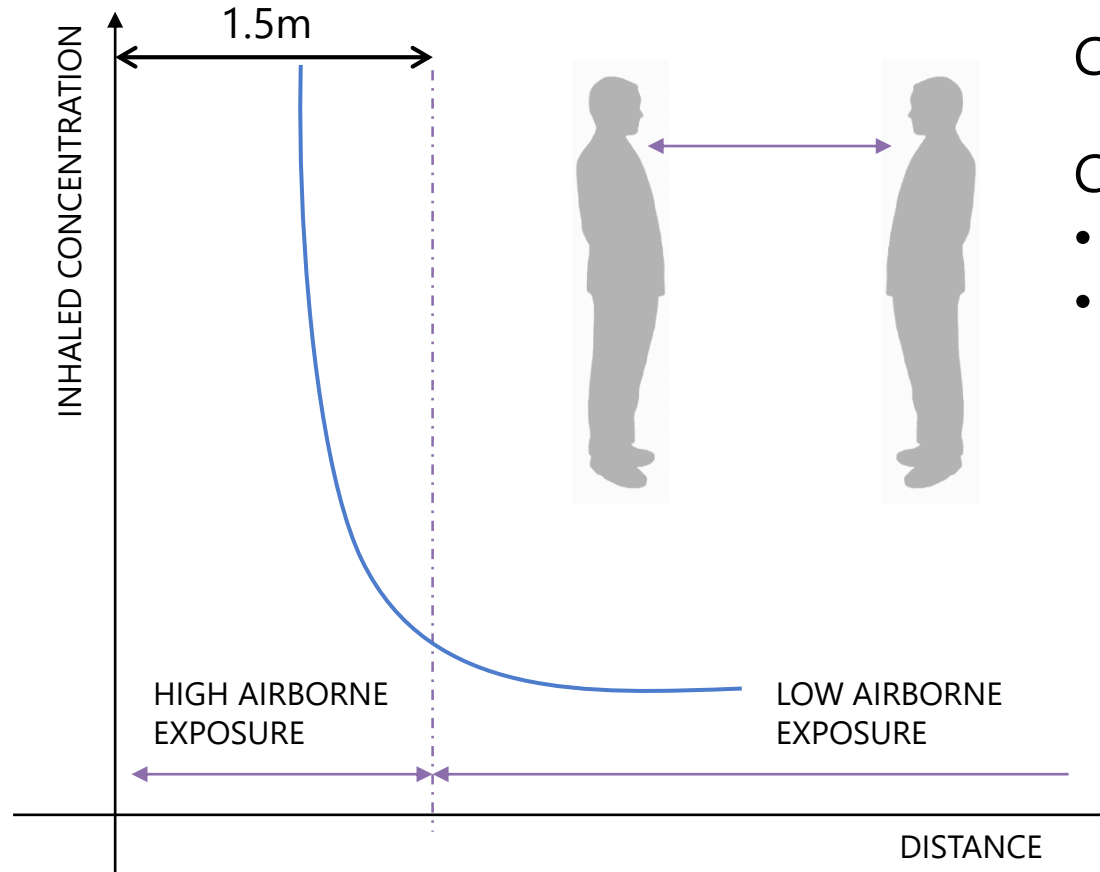


- ## Control with PPE
- Masks
  - Visors
  - Physical barriers

# Aerosol Transmission



# Aerosol Transmission



Control with distancing

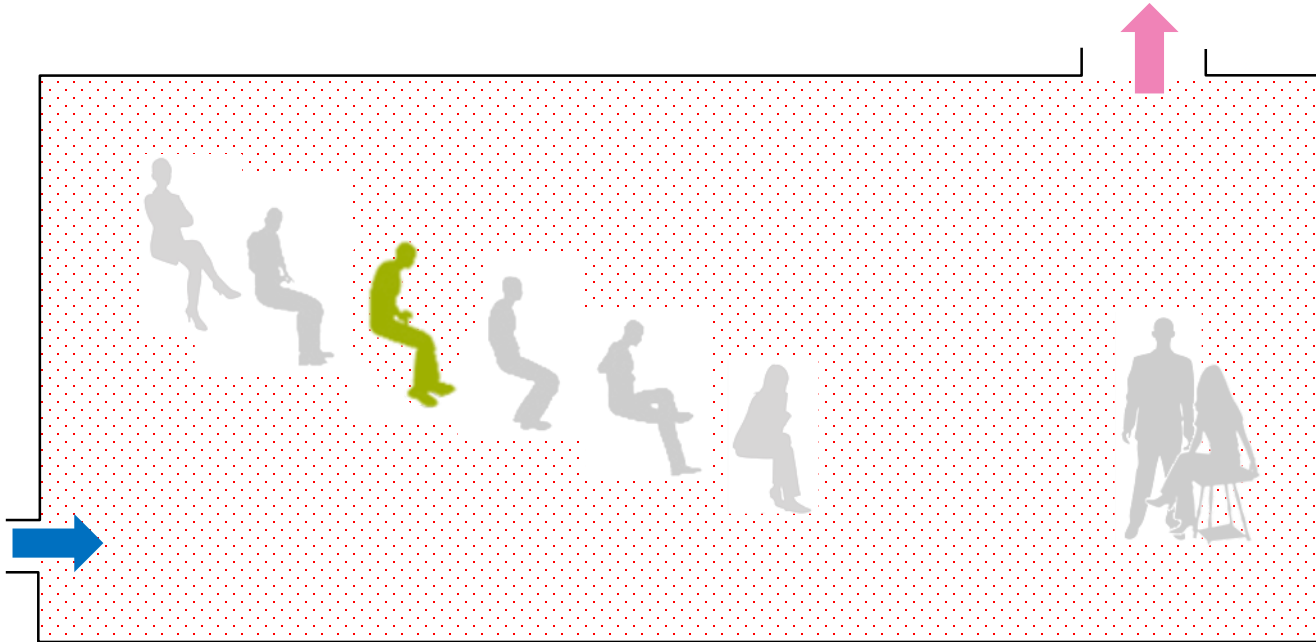
Control with ventilation

- Air change rate
- Air distribution effect

# IMPACTS OF VENTILATION SYSTEM

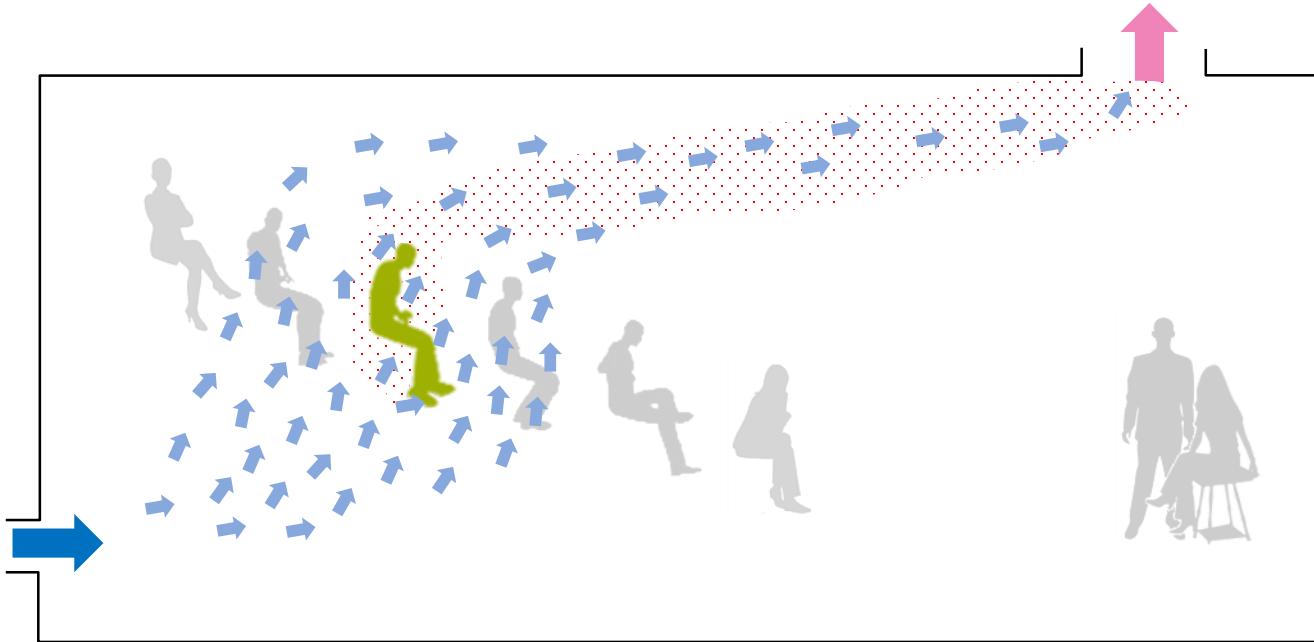
# Impacts of Ventilation System

The ventilation rate (in air-changes per hour) affects **concentration** of contaminants



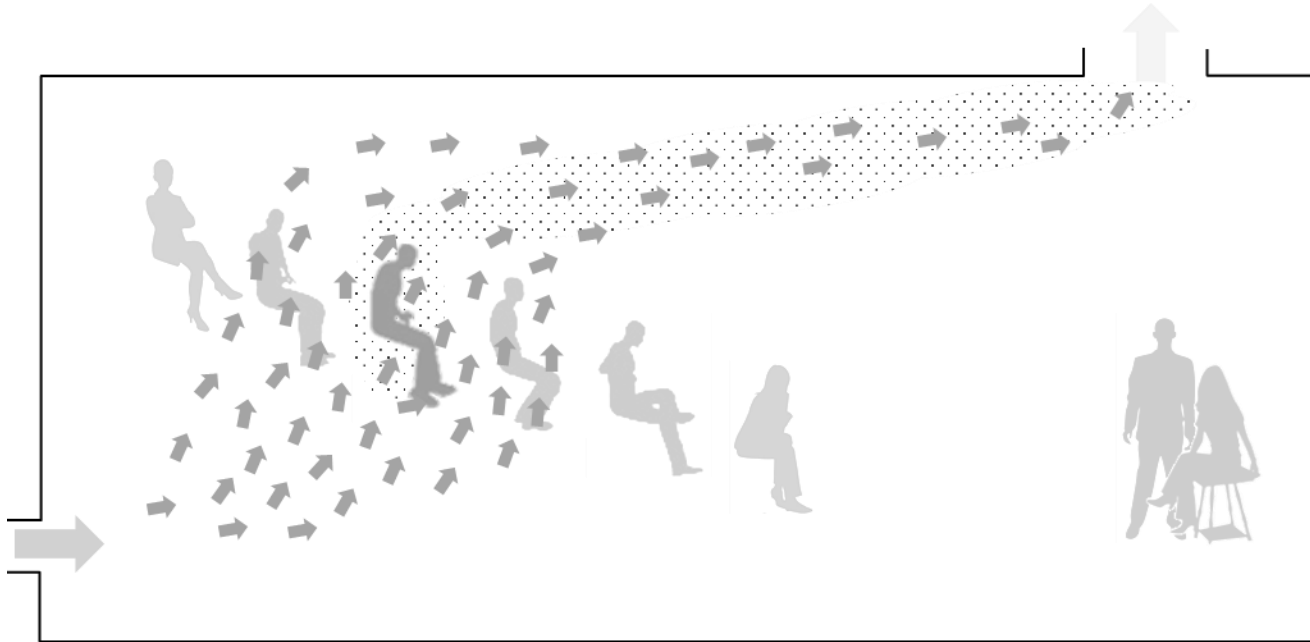
# Impacts of Ventilation System

The air flow pattern affects **distribution** of contaminants



# Impacts of Ventilation System

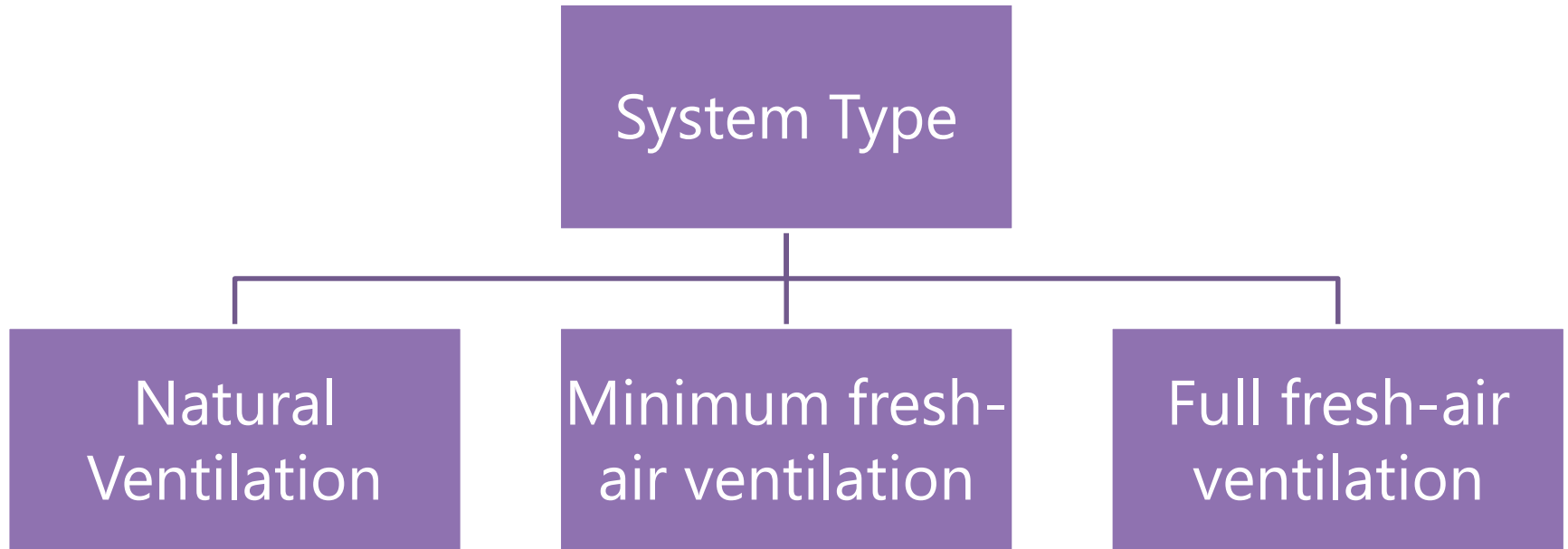
High volumes of fresh air moving contaminants away from others minimises risk of infection



# UNDERSTANDING EXISTING SYSTEMS



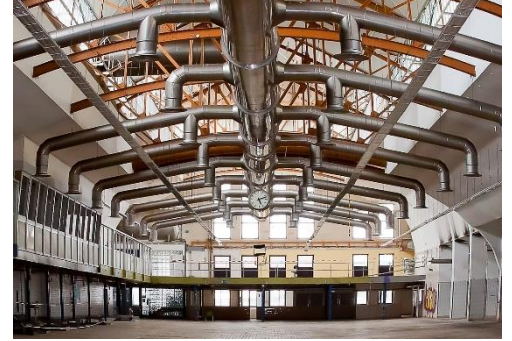
# System Identification



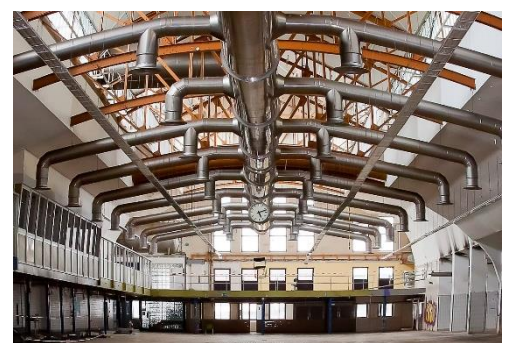
# Ventilation vs Cooling

| Natural Ventilation | Minimum Fresh Air                          | Full Fresh Air  |
|---------------------|--|---|
|                     | Mechanical Ventilation + Cooling Terminals | Mechanical Ventilation + Cooling in Air Handling Unit |

COOLING



VENTILATION



# Minimum Ventilation Rates

## BS EN 13779 (Reproduced in CIBSE Guide B)

**Table 2.4** Ventilation requirements (reproduced from BS EN 13779: 2007 (BSI, 2007a), by permission of the British Standards Institution)

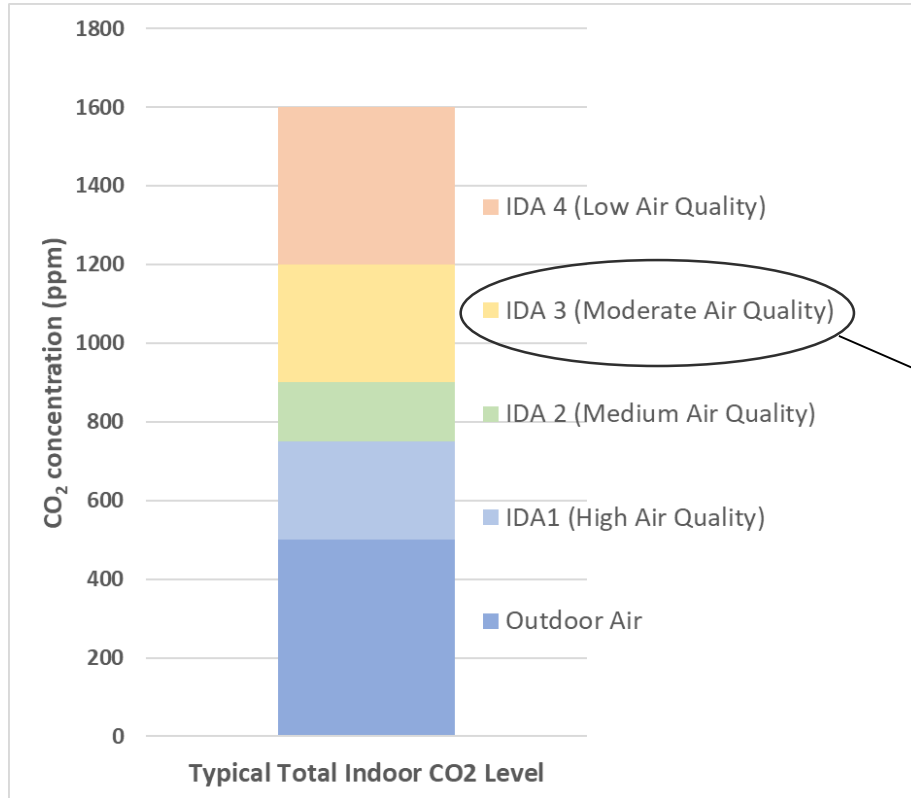
| Classification | Indoor air quality standard | Ventilation range ( $l \cdot s^{-1}$ per person) | Default value ( $l \cdot s^{-1}$ per person) |
|----------------|-----------------------------|--|--|
| IDA1           | High                        | >15  | 20   |
| IDA2           | Medium                      | 10–15  | 12.5   |
| IDA3           | Moderate                    | 6–10   | 8  |
| IDA4           | Low                         | <6   | 5  |

## Yellow Book, ABTT

**Table 18.** Recommended input <sup>(1)</sup> of fresh air to be provided to all habitable parts of the premises

| Level of activity/type of accommodation   | Typical metabolic rate (met) <sup>(2)</sup> | Fresh air input in litres per second per person (l/s/p)                  |
|---|---|--|
| Sedentary (for example sitting in an auditorium or standing still in an art gallery)  | 1   | 8  |
| Mixed activities such as offices  | 1.5   | 12   |
| Light activity or level of physical exertion (for example working in bars and serveries, playing most musical instruments and in technical workshops) | 2   | 16   |
| Moderate activity or level of physical exertion (for example ballroom dancing, setting up scenery, 'get-ins')   | 3   | 24   |
| High level of physical exertion (for example vigorous dancing as in clubs, boxing, wrestling)   | 4   | 32 <sup>(3)</sup>  |
| Lavatories  | --  | Not less than 6 l/s per WC in addition to 6 air changes per hour overall |
| Commercial kitchens   | --  | 60 air changes per hour or more <sup>(4)</sup>                           |
| Reheat kitchens   | --  | Not less than 20 air changes per hour <sup>(4)</sup>                     |

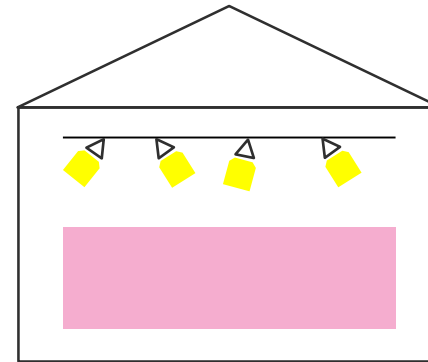
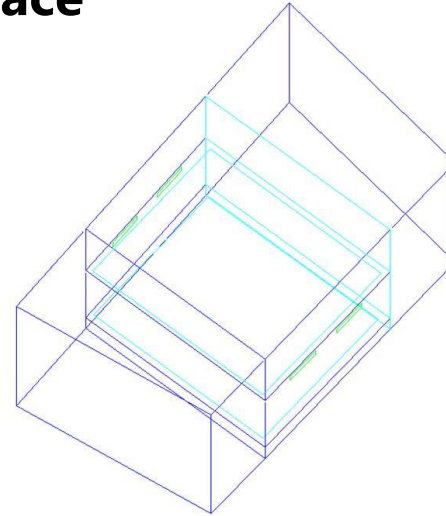
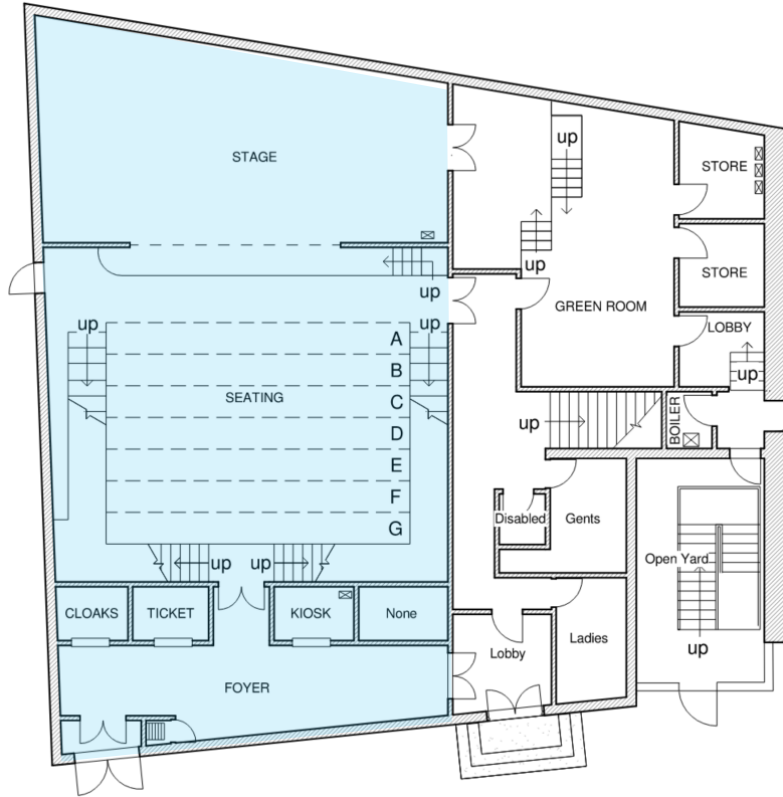
# Indoor Air Quality



Yellow Book Equivalent

# EXAMPLE

# Existing Natural Infiltration Ventilated Space



# Existing Natural Infiltration Ventilated Space

## Base Case – Infiltration Only

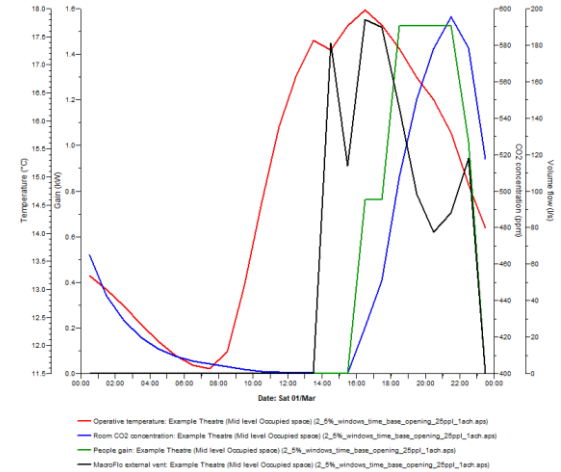
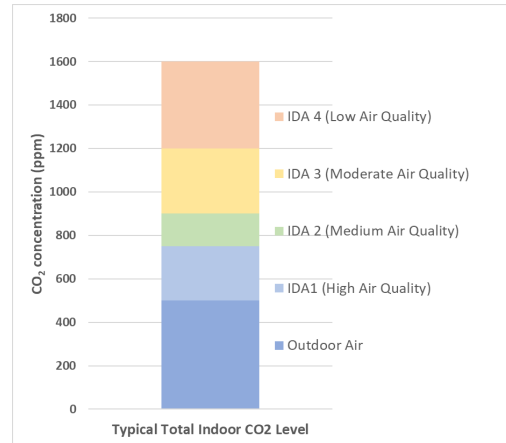
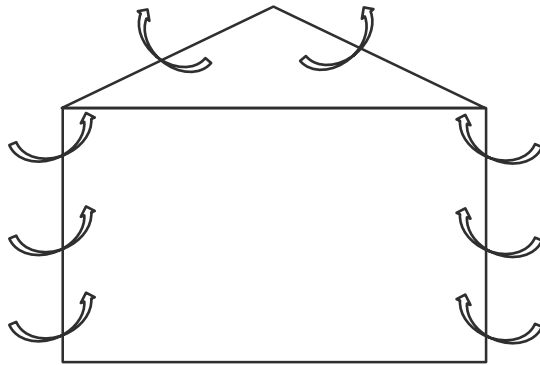
100 audience members

Performance starts at 18:30

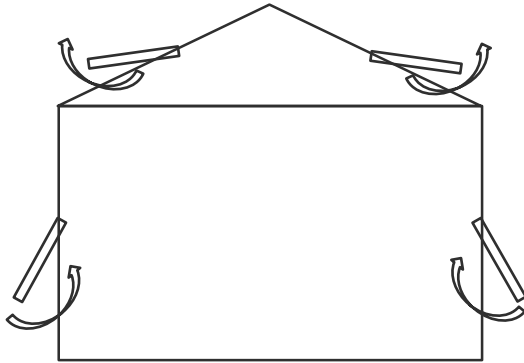
Winter performance

CO<sub>2</sub> concentration at 1400ppm by 21:00

Low Air Quality



# Controlled Natural Ventilation



## Base Case – Infiltration Only

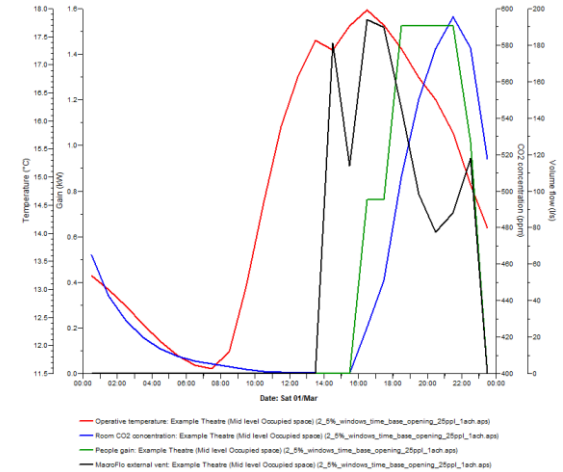
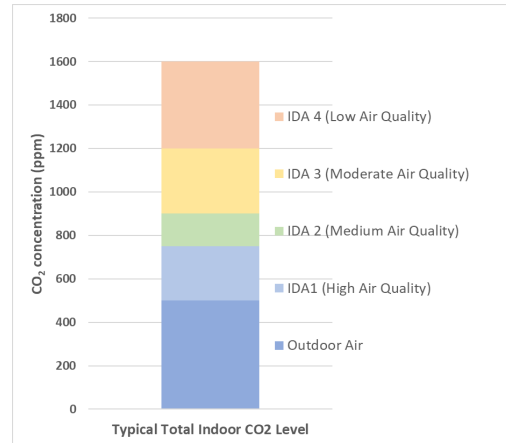
100 audience members

Openable windows (5% of floor area)

CO<sub>2</sub> concentration at 1000ppm by 21:00

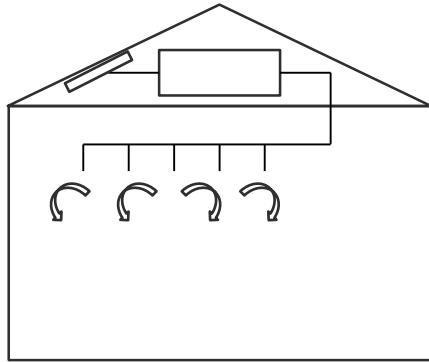
Moderate Air Quality

18°C Internal Temperature





# Mechanical Ventilation



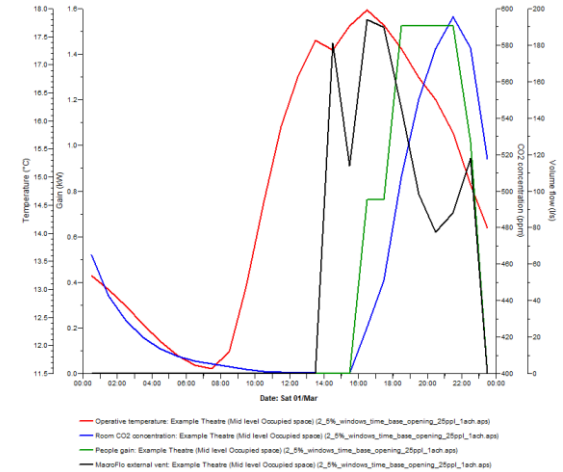
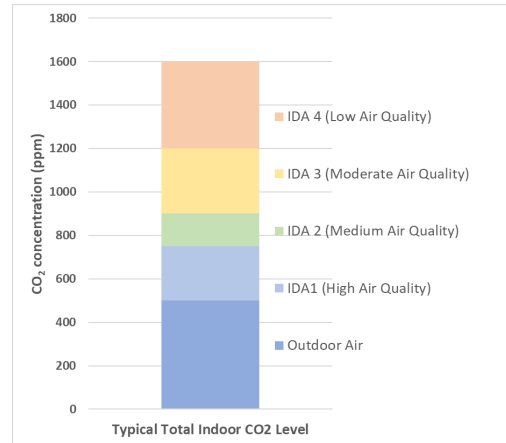
## Base Case – Infiltration Only

100 audience members

Mechanical air-handling unit (4 ACH)

CO<sub>2</sub> concentration at 800ppm by 21:00

Medium Air Quality



# PRACTICAL STEPS

# Natural Ventilation System

- Maximise air flow by opening windows and doors
- Remove constraints on flow of air, e.g. curtains or blinds
- Encourage cross ventilation by providing openings on multiple side of the building
- Encourage stack driven ventilation by opening windows on upper levels as well as lower levels
- Maximise extract volumes on any mechanical systems installed (e.g. WC extracts and kitchen extracts)
- Where safe, open internal doors to permit cross flow of air, (do not prop open fire doors for example)
- Consider ventilation patterns, flush/purge the space before/interval/after

# Natural Ventilation System

## Challenges

- Noise break-in from outside
- Noise break-out to neighbours
- Noise between connected rooms
- Noise from any ramped up fans
- Discomfort to building occupiers from draughts and cold air in winter
- Increased heating energy/bills to compensate for higher air change rate
- Do not open windows in WC facilities with mechanical extract as this could positively pressurise these spaces

# Mechanical ventilation systems

- Maximise air-volume on the system
- Ensure any recirculation systems are bypassed
- Ensure system is correctly maintained/commissioned and any thermal wheel does not have high-leakage
- Run on systems for 2-3 hours after performance to purge the space

# Mechanical ventilation systems

## Challenges

- Noise break-out from AHU system to neighbours in acoustically sensitive areas
- Noise from any ramped up fans
- Underperformance of heating and cooling system with increased air volumes
- Increased heating energy/bills to compensate for higher air change rate
  
- For displacement systems, ensure increased volumes do not lead to mixing

# NEW INSTALLATIONS

# Filter technology

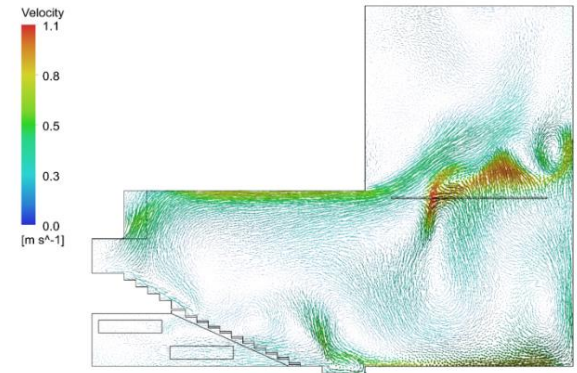
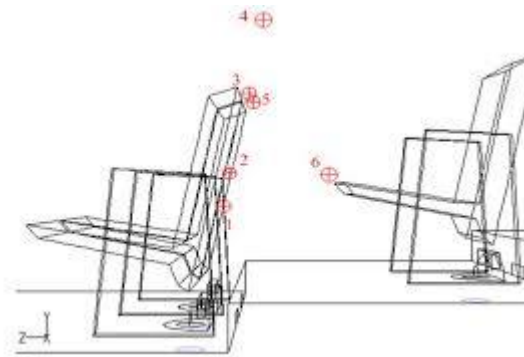
- Only beneficial where air is recirculated and fresh air is not available
- Hepa filtration, UV filtration or Electro-static filtration required to remove viral aerosols from the air stream.
- Filtration systems are expensive and require maintenance to be effective
- Recirculating systems within the space serve will potentially disrupt a displacement airflow pattern
- Fresh air is better than filtration





# New ventilation systems

- Displacement approach removes contaminants from the occupied zone
- Allow for enhanced fresh air rate
- Consider heat-recovery system to reduce risk of leakage from return to supply flow
  
- Where entire new systems are not feasible consider providing extraction only system to enhance air-change rate



# Things to consider for new systems

- Enhanced heating demands
- Cooling demands
  
- Acoustic impacts
- Planning & Building Control approvals
- Listed building consent
- Fire and smoke systems

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# The End

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