Ventilation guidance for COVID-19

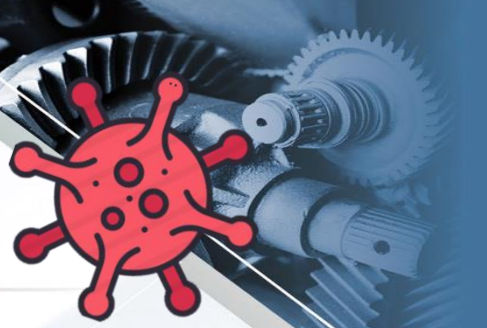
CSIR

Touching lives through innovation

Routes of Transmission

CONTACT	DROPLET	AIRBORNE	FOMITE	FAECAL AEROSOL
				
Direct or Indirect Contact An example of indirect contact is shared toys as vehicle for transmitting pathogenic bacteria among paediatric patients.	Droplets travel directly from the respiratory tract of the infectious individual *through the air* to susceptible individual's mucous membrane, over short distances	Aerosols are transmitted *by the air* from the source to the susceptible person. **Opportunistic** airborne transmission of SARS cannot be excluded. AGP are associated with transmission of infection - risk factor in a multi-bedroom or shared airspace (over long periods)	For example, risk of invasive burn wound infection usually associated with the use of invasive devices.	faecal–aerosol transmission **might** have caused outbreak of COVID-19 in the Amoy Gardens high rise complex in South Korea
Pseudomonas aeruginosa SARS-CoV-2	Neisseria meningitidis SARS-CoV-2	Tuberculosis – **Obligatory**. SARS-CoV-2 (Long range?)	Staphylococcus aureus Clostridium difficile	SARS-CoV-2 cases have also been recorded

Potential for Transmission (Airborne)



Modes of Transmission	Definitions – applied aerosol transmission
Obligate	*obligate:* under natural conditions diseases occur following transmission of the agent **only** through inhalation of microscopic particle aerosols (e.g., tuberculosis)
Preferential	*preferential*: the natural infection results from transmission through **multiple** routes, but small particle aerosols are the **predominant** route (e.g., measles)
Opportunistic	*opportunistic:* agents that cause disease, **under special circumstances** may be transmitted via fine particle aerosols.

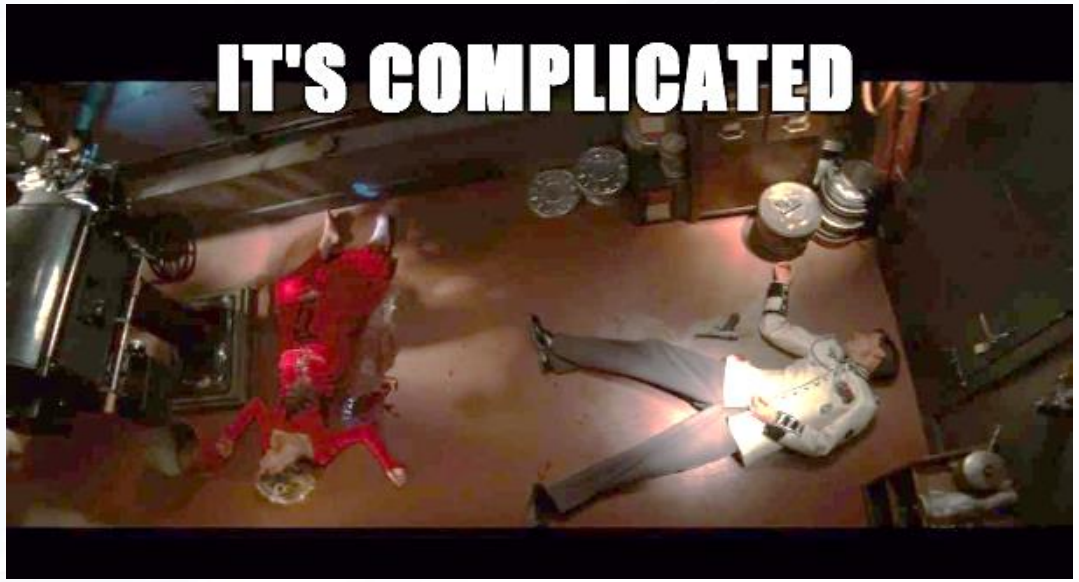
- This conceptual framework can explain rare occurrences of airborne transmission of agents that are transmitted most frequently by other routes (e.g., smallpox, influenza). https://www.cdc.gov/infectioncontrol/guidelines
- In these cases, the exceptions do not prove the rule.

Airborne Transmission Mechanics

“Airborne” naturally means “carried by air”

Factors which affect this are:

- Indoor Environmental Conditions
  - Temperature
  - Humidity
  - Air Velocity vectors
- Nature of droplets (size and content)
- Type of organism
  - Resilience
  - Inoculation dose (particles/ CFU)
- Source strength
  - Aerosol generating procedures
  - Singing
  - Gyms – high respiration rates
  - Contaminant removal rates – ventilation, air cleaners



Is COVID-19 “Airborne”

- COVID-19 is probably no more airborne than SARS[1]
- SARS (CoV-1) is not thought to be predominantly “airborne”
- Transmission *by* the air is not the same as transmission *though* the air
- Droplet transmission can be ballistic
- Ballistic transmission range can be extended by air jets or in toroidal vortices (like smoke rings)
- Long-range airborne transmission requires the disease to propagate with low infectious quanta or high viral shedding (TB vs SARS-CoV-2)
- Strong negative signal from Diamond Princess outbreak (2020) which demonstrated no transmission though recirculating ventilation systems [2]
- COVID-19 “Airborne” transmission similar to opportunistic long-range droplet transmission

[1] van Dorenmalen 2020

[2] ASHRAE 2021

HVAC: To Ventilate or Not?

- APPARENTLY CONFLICTING ADVICE:
  - Use/modify HVAC during COVID (ASHRAE, WHO, CDC)
  - Don’t use AC during COVID (various)

- ADVICE STEMS FROM
  - Confusing definition of “HVAC”
  - Weak/conflicting evidence for airborne transmission

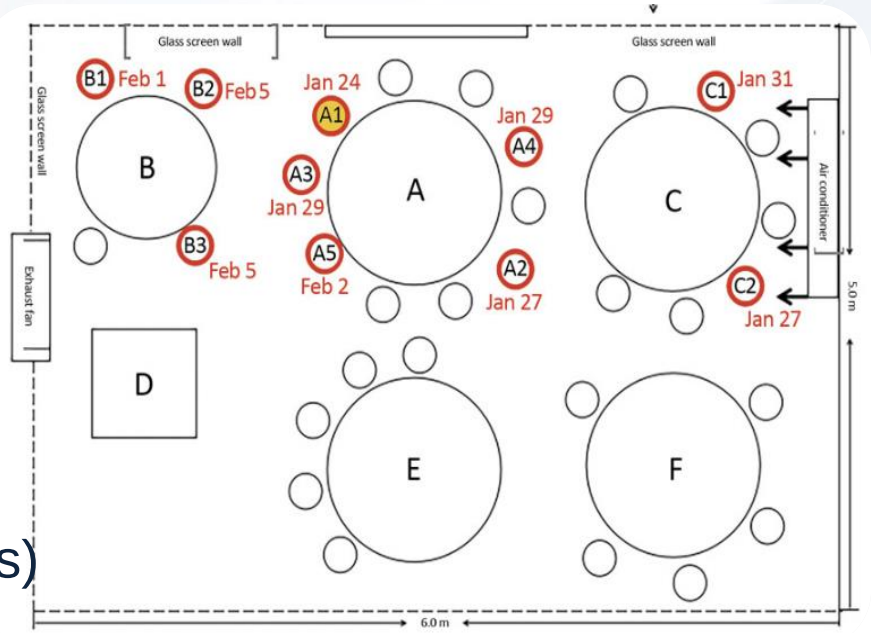
- CONTINGENCY OPERATION
  - Testing
  - Maintenance and Cleaning
  - Supplementary Systems

TERMINOLOGY MATTERS

- **HVAC:-** Heating, Ventilation and Airconditioning
- **Ventilation:-** the process where “fresh” air is introduced or removed from a space to reduce indoor contaminant levels
- **Airconditioning:-** the mechanical process of cooling (or heating) the air to improve comfort levels in a space
- **Droplet transmission:-** short range person to person/fomite through droplets too heavy to remain suspended in air indefinitely
- **Airborne transmission:-** long range person to person respiratory transmission though the air (responds to ventilation interventions)
- **ASHRAE:-** American Society of Refrigeration and Air-conditioning Engineers
- **REHVA:-** Federation of European HVAC Associations

Does HVAC spread COVID-19

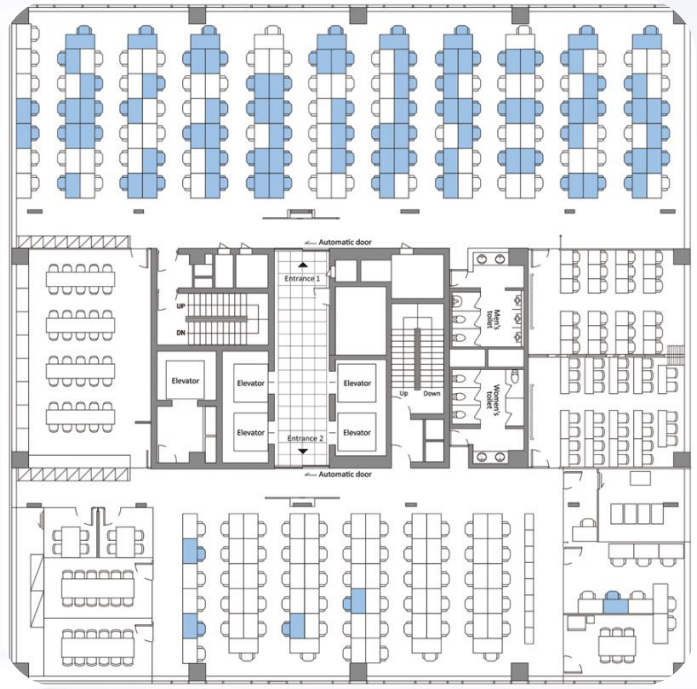
- **Guangzhou restaurant outbreak 2020[1]**
  - Restaurant was poorly ventilated but had a high wall split unit.
  - Samples from the air conditioner were all nucleotide negative
  - Transmission was likely long-range droplet (1m between tables)
  - Asymptomatic transmission from source family a possibility
  - Exposure time correlated with transmission



[1] https://wwwnc.cdc.gov/eid/article/26/7/20-0764_article

Does HVAC spread COVID-19

- **South Korea Call Centre Outbreak 2020[2]**
  - 11th floor office was poorly ventilated (limited data)
  - COVID-19 "*is exceptionally contagious in crowded office settings*"
  - Outbreak follows physical compartmentalisation more than HVAC zones
  - Lobbies and lifts resulted in limited spread 😳
  - Exposure time correlated with transmission



[2] https://wwwnc.cdc.gov/eid/article/26/8/20-1274_article

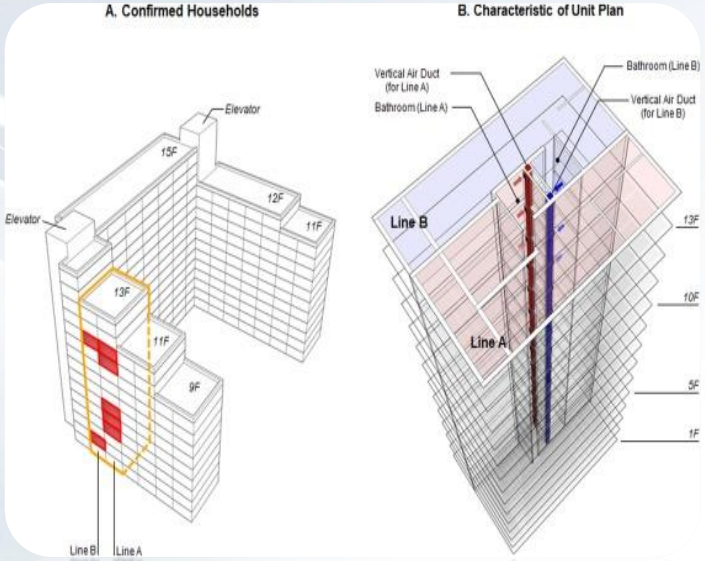
Does HVAC spread COVID-19

- **Aerosol and Surface Stability of SARS-CoV-2** [6]
  - van Doremalen report on airborne stability of SARS-CoV-2 states 3h stability in air[6]
  - van Doremalen uses Goldberg Drum to determine stability in air
    - Separate Ebola study used similar drum stability to argue that a new Ebola strain was not airborne[7]
  - van Doremalen report should be understood only as comparison between SARS-CoV-1 & 2

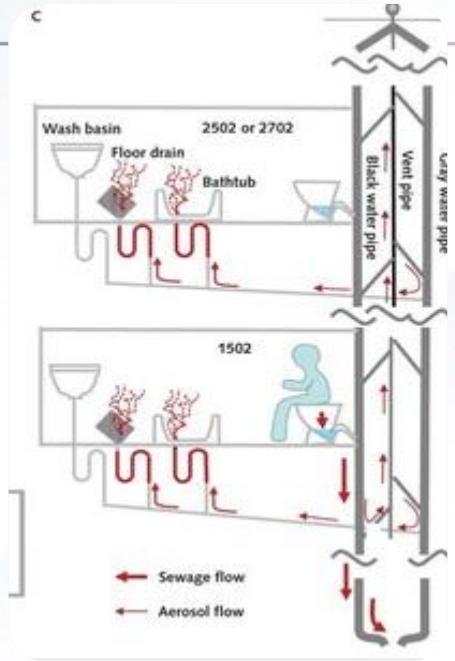
[6] Van Dormelen (2020) https://www.nejm.org/doi/pdf/10.1056/NEJMc2004973?articleTools=true

[7] Robert (2016) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5050463

Does HVAC spread COVID-19



[8] Hwang et al 2020, https://doi.org/10.1016/j.ijid.2020.12.035

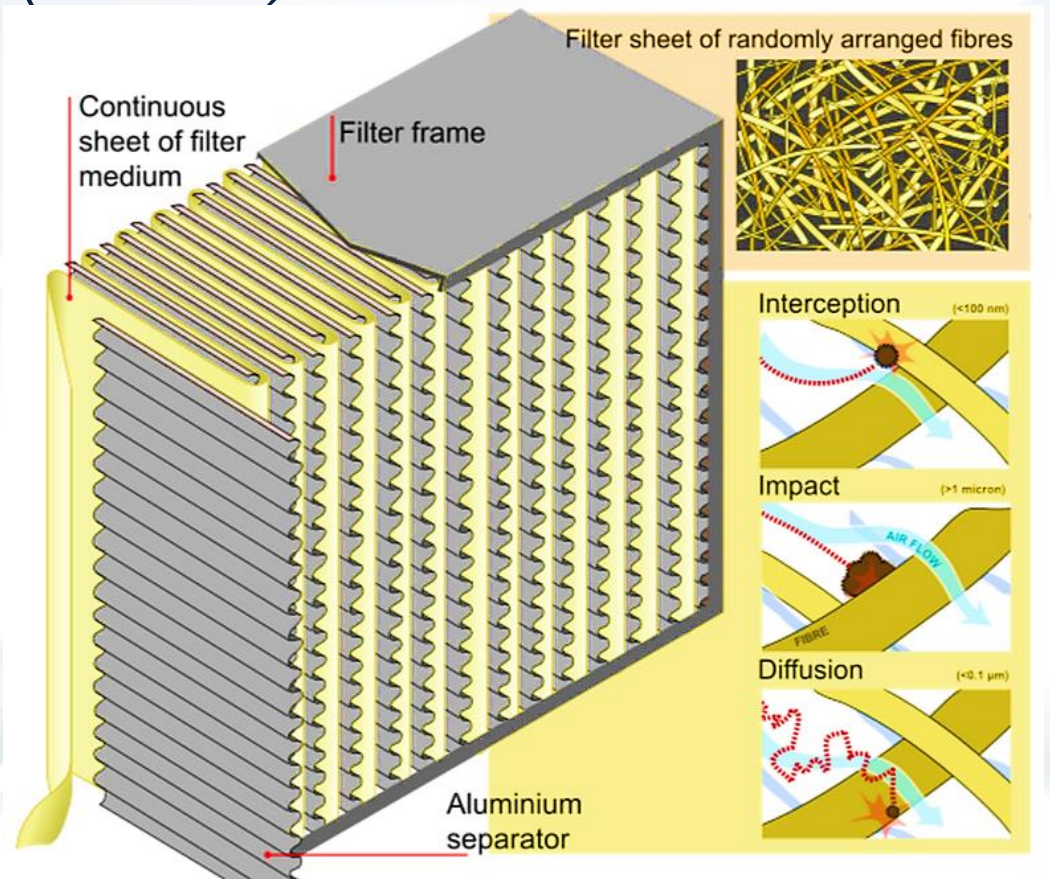


[9] Kang et al 2020, https://doi.org/10.1016/j.ijid.2020.12.035

- Reported airborne transmission are fecal aerosol transmission events (& system failures)
- Transmission events though ventilation ducting are not reported

COVID-19: Filtration

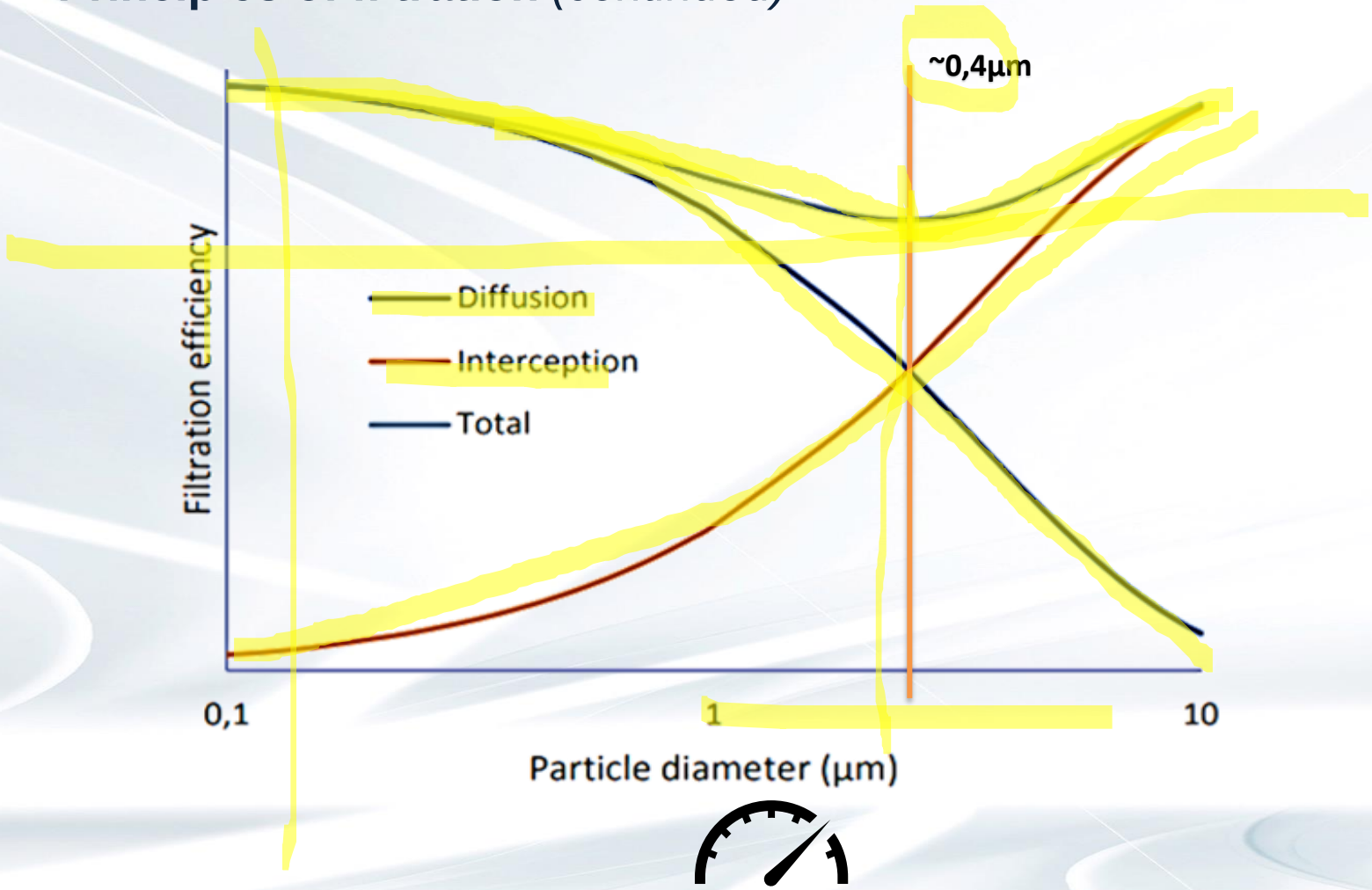
Principles of filtration *(continued)*



(Camfil Farr)

COVID-19: Filtration

Principles of filtration *(continued)*



COVID-19: Filtration

- HEPA (high efficiency) filtration not generally necessary
  - High filter pressure drops may stall ventilation or drastically reduce airflow
- ASHRAE recommends no more than SANS1464 M6 (ePM2.5-50%) filters for recirculation
  - WHO recommends F8 (ePM2.5-80%)
- Exhaust air can be safely discharged without HEPA filtration or UVGI decontamination

Should I still use my HVAC system?

- If it improves ventilation rates – **YES!**
  - Increase ventilation to more than double the regulatory [5] minimum per-person ventilation rates if possible
    - (or reduce people)
- More **outdoor air** is better
  - Open windows wherever possible and safe
- **Circulating Fans** improve ventilation effectiveness
  - Prevent stagnant air
  - Don't let AC units/fans blow directly down across groups of people (limit horizontal airflow)

[5] SANS 10400-O (2011)

Should I still use my HVAC system?

- Consider CO_2 monitoring (Fresh Air Demand Control)
  - REHVA COVID-19 Guide recommends CO_2 set-point **550 PPM** [8]
    - This equates to 40 L/s per person
  - CSIR recommends < 200 PPM above outdoor for TB
    - This equates to 32 L/s per person
  - COVID control by RH and temperature is not feasible (56°C @ >60%RH) [8]
  - Flush buildings for 2h before and after daily occupation (exhausts should run 24/7)
  - Reduce recirculation to ALARA for low risk buildings
  - No recirculation for high risk healthcare spaces (as usual)

[8] https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_V4.1_15042021.pdf

COVID-19: Engineers vs Doctors

WHO Position	US-CDC	ASHRAE and REHVA
• Primarily Small Droplet spread • Close contact < 1m • Droplet precautions • Limited airborne risk	• Mainly Respiratory Droplet spread • Close contact <6ft • Droplet precautions • Limited airborne risk	• "Sufficiently" likely airborne • Engineering controls to reduce exposure • Dilution ventilation

- WHO and CDC prioritize standard precautions and distancing over increased ventilation and filtration levels
- ASHRAE & REHVA strongly recommend additional dilution ventilation and filtration with minimum recirculation
- Emerging ASHRAE guidance may be less conservative and more in line with WHO (https://www.youtube.com/watch?v=202AZHa_bD0)

Maintenance and Cleaning

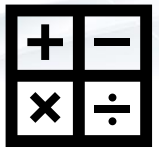
- Cleaning and maintenance is still very important
  - Catch up on any maintenance/cleaning **backlogs**
  - Fill drainage traps and test water supply
  - Cross-train technical **stand-in staff** for emergency shortages
- Safety:
  - Air distribution equipment can be contaminated (normally nucleotide negative RNA)
  - Transmission risk is low but standard PPR precautions should be taken when cleaning or handling HVAC equipment

Maintenance and Cleaning

- Cleaning with soap and water is acceptable if disinfectants are not feasible (as usual)
- Regular cleaning of blower-coil / indoor units (as usual)
- Biocide in drip trays (as usual)
- Check Material Safety Data Sheet of disinfectants
  - Avoid generating chlorine / chloramine / hypochlorous acid fumes in ventilation systems
- Store old recirculation filters for a week before disposing them. (Keep spares in stock)

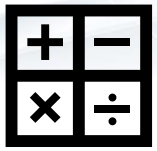
Supplementary Systems

- Portable Air Cleaners?
  - HEPA air cleaners
  - Sorbent bed air cleaners
  - Canned UVGI
  - PCO/Ozone/electrostatic etc
- Ensure sufficiently effective to be feasible



Supplementary Measures

- UVGI
  - Upper room UVGI – Not recommended for COVID-19?😳
  - Biofouling UV – Not recommended for COVID-19
  - Return airstream UVGI – redundant
- Transparent Shields between workers
  - Possibly reduce shared air by deflecting breathing plumes
- Orientation
  - Avoid face to face indoor seating



In summary

These 4 points are as valid now as ever

1. Decongest indoor spaces
2. Ventilate as well as possible (to building regulations' criteria)
3. Restore ventilation systems to full operation and maintain well
4. Resist investing in "miracle" technologies (PACs, PCO etc)

References

- Interim Guidance for Businesses and Employers Responding to Coronavirus Disease 2019 (COVID-19), May 2020
  - https://www.cdc.gov/coronavirus/2019-ncov/community/guidance-business-response.html
- ASHRAE vs WHO vs CDC Guidance
  - https://www.ashrae.org/covid-19/technical resources/does-ashrae-s-guidance-agree-with-guidance-from-who-and-cdc.pdf
- ASHRAE COVID-19 Resources
  - https://www.ashrae.org/technical-resources/resources
- NICD Environmental Health Guideline
  - https://www.nicd.ac.za/diseases-a-z-index/covid-19/covid-19-guidelines/environmental-health/
- REHVA COVID-19 guidance document
  - https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_ver2_20200403_1.pdf

Thank you

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https://youtu.be/a-XrJJ61L2k

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Touching lives through innovation