Operation Strategies of Air Conditioning System in Public Buildings during Pandemic Time

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Background

- Droplet and aerosol transmissions are very important ways for virus transmission.
- Any air-sharing system, such as Air Conditioning Systems, is a potential tube for cross infection.
- Operation strategies of air conditioning system in public buildings should be carefully plotted before operation during pandemic.

- Buonanno et al., 2020: Quantitative assessment of the risk of airborne transmission of SARS-CoV-2 infection: perspective and retrospective applications
- Li et al., 2020: Evidence for probable aerosol transmission of SARS-CoV-2 in a poorly ventilated restaurant
- Somsen et al., 2020: Small droplet aerosols in poorly ventilated spaces and SARS-CoV-2 transmission
1. Background

2. Infection Risk Analysis in Public Buildings

3. Guidelines for Operation A/C

4. Concluding Remarks
Numerical Simulation and Probability Calculation

Simulation settings

- Based on Wells-Riley Equation
- Using the non-uniform distribution modified model to calculate the probability
- Standard k-ε model
- Supply air volume: the total ‘clean’ air volume
- Number of infector: one
- Respiratory volume: 0.3m³/h
- Volume fraction of tracer gas in exhaled air: 4%
- Exhaled air temperature: 35 °C
- Target location: nose height, different distances along three directions (front, right, 45 °)
- From the actual cases of COVID-19, it is estimated q=10~40 quanta/h. In our study, q=14, 27, 40 quanta/h is used in the analysis
Infection Probability when one infector in the room

- Occupant density: 4 m² per person
- Fresh air volume per person: 30m³/h
- Least fresh air ratio: 30%
- Duration: 8 h
Influence of Distance from Infector

- Infection probability decreases rapidly with the increasing distance.

Large office (120 m²)
USUR (upper supply and upper return), 2160 m³/h, 14 quanta/h

- Medium risk
- Low risk
Influence of Clean Air Volume

- Only fresh air (minimum fresh air rate): high risk
- All fresh air (maximum fresh air rate): reduced greatly
- Purified air should be increased as much as possible, and full fresh air mode should be operated when necessary.

Infection probability

- Fresh air + Purified return air (648 m³/h)
- Only fresh air (270 m³/h)
- All fresh air (900 m³/h)
Influence of Mask

- By wearing mask, the risk can be largely reduced

- Infection probability
  - Without mask
  - With mask
Infection Probability when one infector in A/C system

- Person: 4 m² per person
- Fresh air volume per person: 30 m³/h
- Least fresh air ratio: 30%
- Duration: 8 h
Infection Probability *when one infector in A/C system*

- **No-Return-Air systems make sure no infection in non-infected rooms**
- Filter has a significant effect on reducing the risk: with return air: no filtration (0%), medium-high risk; 30%, medium risk; 65%, medium-low risk
- Mask is effective: ventilation + mask: almost no risk

### Infection Probability

- **High risk**
- **Medium risk**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Infection Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>30% Fresh Air</td>
<td>14 quanta/h</td>
</tr>
<tr>
<td>100% Fresh Air</td>
<td>27 quanta/h</td>
</tr>
<tr>
<td>30%FA+70%RA (0%)</td>
<td>40 quanta/h</td>
</tr>
<tr>
<td>30%FA+70%RA (30%)</td>
<td>14 quanta/h</td>
</tr>
<tr>
<td>30%FA+70%RA (65%)</td>
<td>27 quanta/h</td>
</tr>
<tr>
<td>30%FA+70%RA (65%)+Mask</td>
<td>40 quanta/h</td>
</tr>
</tbody>
</table>
Remarks

- For rooms with infector, many measures can be used to decrease the infection probability, including keeping space, using fresh air, opening window, using air purifier, etc. But the probability can't be deceased to zero.

- For rooms without infector but sharing A/C with other rooms, No-Return-Air systems make sure no infection.

- For FCU/VRV + fresh air systems, medium-to-high efficiency filter should be added onto the FCU/VRV.

- Mask is a very cheap and effective way for avoiding infection.
Outline

1. Background

2. Infection Risk Analysis in Public Buildings

3. Guidelines for Operation A/C

4. Concluding Remarks
Guidelines for Operation A/C during Pandemic

  (http://www.gov.cn/xinwen/2020-02/13/content_5478015.htm)

  (https://mp.weixin.qq.com/s/BszoYuJ9PDeUHEqPG7lV0Q)

- **CAR (Chinese Association of Refrigeration)**: Recommendations for safely using air conditioning (heating) systems in response to COVID-19 after the Spring Festival holiday, 2020.2
Guidelines for Evaluation of Operation, Disinfection and Maintenance on Refrigeration and Air Conditioning During Work Resumption under the COVID-19 Epidemic

Processes to Restart the A/C (heating) Systems

1. System Evaluation
2. Sterilization & Disinfection
3. Review of Emergency Plan
4. Precautions for operation and maintenance
① System Evaluation

(1) Evaluation of Functions of A/C Systems

- Whether the air-conditioning (heating) system can switch to the operation mode conforming to the epidemic control standard?
- Whether the fresh air change rate meets the requirement of the standard?
- Whether the system can operate in the all fresh air mode?
- Whether the polluted areas can be isolated and operated independently?
- Whether the negative pressure of the polluted areas can be maintained?
- Whether there is potential of cross infection? In particular, whether the distance, orientation, and height of the intake port of the fresh air and the exhaust port of the exhaust air can avoid cross infection?
- Whether the system has automatic disinfection functions?

(2) Hygiene Evaluation
During the epidemic, it is recommended that all HVAC systems should be sterilized and disinfected before restarted.

Strictly follow the sterilization and disinfection specifications for different types of HVAC and cold chain systems:

- Room air conditioners
- House-hold central air conditioning unit
- Multi-split air conditioner
- Central air-conditioning
- Clean air-conditioning
*The sterilization and disinfection of the centralized HVAC system shall be carried out by qualified companies in accordance with national regulations as follows: "Sanitary Code for Centralized Air Conditioning and Ventilation Systems in Public Places" (WS 394-2012) "Code for Hygiene Evaluation of Centralized Air Conditioning and Ventilation System in Public Places" (WS / T 395-2012) "Code for Cleaning and Disinfection of Centralized Air Conditioning and Ventilation System in Public Places" (WS / T 396-2012) Other projects should be sterilized and disinfected by professionals.
If virus contamination is found,

a) How to quickly report to decision-makers?

b) Whether shut down the system or switch to other operation mode?

c) Technicians must be proficient in the system isolation, fresh air adjustment and negative pressure control to avoid cross infection.

d) In the hospital, attention should be also paid to the exhausted air handling.
Precautions for Operation and Maintenance

- Personal protection of technicians must be done, including washing hands, wearing masks, wearing gloves and even goggles when in special places, such as hospitals or contaminated areas.
- The technicians should strictly follow the daily report requirement.
Concluding remarks

• **Building air-conditioning and ventilation systems play an important role in prevention and control of the epidemic.**

• **The centralized air-conditioning system has a low risk when it is properly operated.**

• **Operation Strategies and emergency plan should be carefully prepared according to the type of air conditioning system.**
Thanks for your attention!

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