AirFixture®

Position Document 2020

UFAD vs OHAD

Minimize transfer of airborne infectious pathogens

Objective

In response to the COVID-19 Pandemic many engineers, architects and building owners are seeking the best design practices and methodologies to mitigate harmful particle transmission in office or school environments. This document explains the position of AirFixture on the mitigation of transmission of airborne infectious pathogens by using Under Floor Air Distribution (UFAD) instead of conventional Over Head Air Distribution (OHAD). OHAD can be a ducted VAV system, an overhead fan coil system, a VRF system or an active chilled beam system.

Introduction

ASHRAE recently published a document that outlines their position on infectious aerosols[1]. We are including links below so that the reader can review the full text of these reports.

The ASHRAE position document states that "disrupting the transmission pathways of infectious aerosols" is the most relevant tactic for HVAC design and control.

Air distribution patterns and dilution ventilation are two of the HVAC strategies that have the potential to reduce the risks of infectious aerosol dissemination, (among other things such as differential room pressurization, in-room air cleaning systems, controlling temperature and humidity, etc.).

A primary infectious disease control strategy is thorough ventilation with effective airflow patterns. This will dilute the room air around the source and aids in removal of infectious agents[1]. Thus, ASHRAE suggests application of these strategies to mitigate infectious aerosol transmission, which should be considered in the design of all facilities. Properly designed UFAD systems have a ventilation effectiveness of 1.2-1.5 (vs. 1.0 for OHAD). That means at least 20% better ventilation for the breathing zone for the same CFM of fresh air[2].

Another recent study published after the COVID-19 pandemic (in March/April 2020) in American Society for Microbiology, discusses Indoor Air Quality considerations to reduce transmission[3] of airborne pathogens.

Previous studies with SARS virus have confirmed that SARS virus is most often transmitted through droplets[3]. The secondary transmission method is through aerosolization. The size of most viruses, including Coronaviruses (CoVs) is between 0.004μm to 1.0μm. However, viruses are expelled from the body as droplets and aerosols. SARS-CoV-2 (COVID-19 virus) has been observed in aerosolized particles of size between 0.25μm to 0.5μm. IAQ in Built Environments relies mostly on inline filtration media to mitigate the transmission of virus through air delivery systems.

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AirFixture Position on UFAD vs. Conventional OHAD

ASHRAE position document[1] lists some HVAC strategies that have the potential to reduce the risks of infectious aerosol dissemination. Among them, the main difference between UFAD and OHAD is in the air distribution patterns and dilution ventilation.

A conventional OHAD (mixed-air distribution system) supplies turbulent jet air from ceiling or overhead diffusers at lower temperatures and higher velocities. It is designed to quickly mix with room air in the occupied zone, resulting in the uniform spread of contaminates throughout the space. This creates a condition in the breathing zone that is roughly equal to that of the return air leaving the room at the ceiling level[4]. The contaminants that are mixed include exhaled particles and aerosols. Therefore, there is a significantly higher chance of occupants inhaling droplets and aerosols that are emitted from another person or from surfaces (through aerosolization) with OHAD systems. This air movement pattern promotes more in-room mixing directly increasing the particle transmission among occupants in the space as demonstrated in Figure 1.

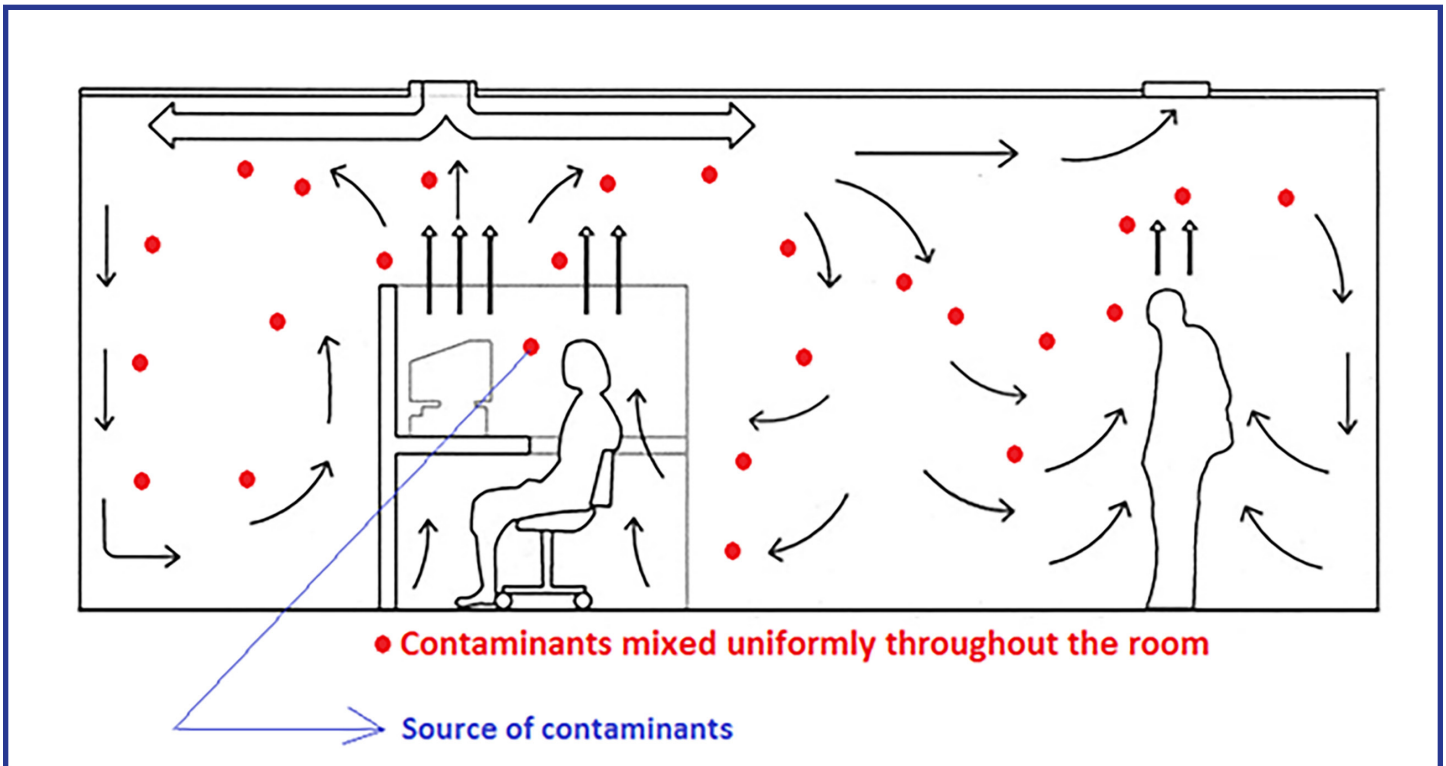

Figure 1: OHAD system mixing contaminants uniformly throughout the room.

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With UFAD, the supply air is introduced in the occupied zone at the floor level, at a relatively higher temperature and lower velocities than that of OHAD systems. A combination of low velocity floor diffusers and natural convection (where the supply air absorbs the cooling load) causes the air to rise above the occupied zone and into the ceiling return system. This air rising out of the breathing zone carries the contaminants and exhaled particles including aerosols, out of the occupied zone. This helps mitigate infectious aerosol transmission, as is recommended by ASHRAE position document. One of the best visually obvious applications of this air pattern is UFAD applied in smoking casinos. The clean supply air (usually 100% OA) is distributed at floor level into a stratified layer in the breathing zone. The cooling load (heat), smoke and other contaminants rise out of the breathing zone into the ceiling return or exhaust system.

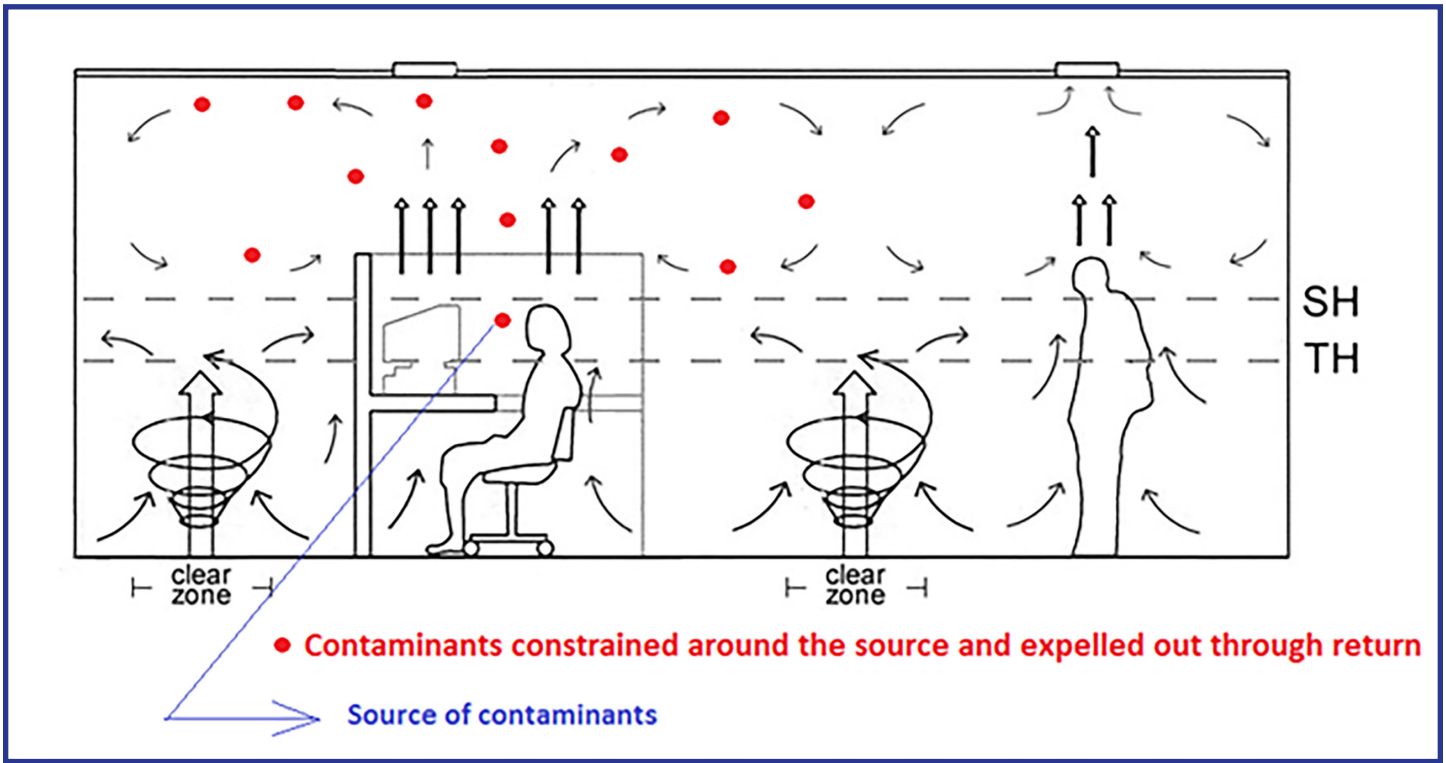
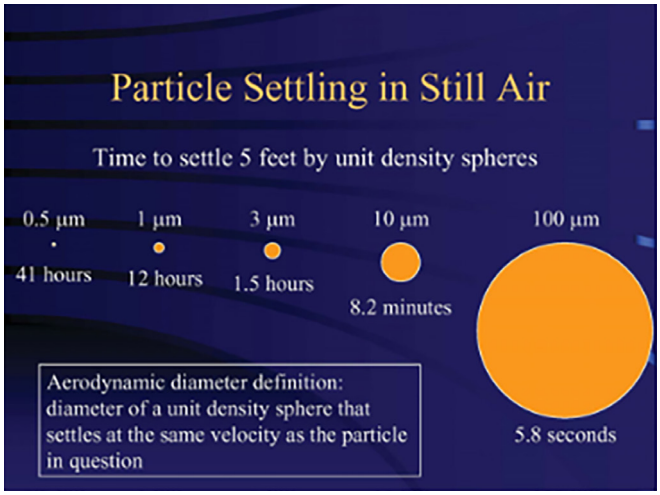
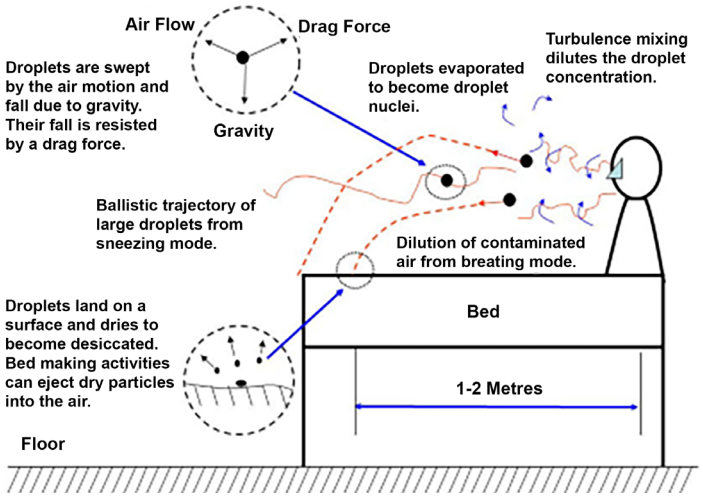


Figure 2: UFAD system does not mix the contaminants between airstreams from adjacent diffusers.

From the work of Dr. Stephanie Taylor, large droplets 10-100 microns fall to the floor in seconds. The key issue is that the particle size is transitioning smaller in a few seconds (unless 40-60% Relative Humidity is provided, which is unlikely). Large droplet particles transition to below 1 micron in a few seconds.



(a)



(b)

Figure 3: (a) Comparative settling times by particle diameter for particles settling in still air (Baron n.d.) and (b) theoretical aerobiology of transmission of droplets and small airborne particles produced by an infected patient with an acute infection (Yuguo Li)[1].

So, the way we see it is big particles fall quickly and dry to become desiccated. All other particles are quickly shrinking in size from desiccation and will float on prevailing warm air currents heading to the ceiling return air.

Particles deposited on the floor and surfaces are removed with housekeeping, sanitation and disinfection efforts. UFAD diffusers do not lift particles deposited on floor or other surfaces because of their low discharge velocity.

Thus, a low turbulence floor-to-ceiling airflow pattern from a well-designed UFAD system is the best practical method to ventilate and condition spaces, particularly when airborne pathogens are present. UFAD is obviously (in our view) better than OH mixing systems.

"Sufficient ventilation in the places people visit and work is very important, said Yuguo Li, ...an engineering professor at the University of Hong Kong. Proper ventilation – such as forcing air toward the ceiling and pumping it outside, or bringing fresh air into a room – dilutes the amount of virus in a space, lowering the risk of infection."

– Article *"How Exactly Do You Catch Covid-19? There Is A Growing Consensus."*
The Wall Street Journal, June 16th, 2020

Casinos: The ventilation supplied by UFAD systems in casinos provides obvious sensory and visual proof of the ventilation effectiveness. Harmful and irritating particles are diluted and removed from the breathing zone continuously. UFAD systems provide 20-50% better ventilation effectiveness than OHAD systems[5] for better dilution of infectious particles and a floor to ceiling flow pattern that removes harmful particles from the breathing zone with much less horizontal room mixing. Therefore, by changing the air delivery method alone designers can provide clients with systems that significantly mitigate transmission pathways of infections aerosols.

- Particles of interest:
  - Visible particles – 25 microns (uM)
  - Heavy atmospheric dust – 10 uM
  - Mold, pollen – 4.0 to 10.0 uM
  - Bacteria, Viruses – 0.3 to 5.0 uM
  - Smoke, some viruses – 0.3 to 0.14 uM

Particle Size (uM)	Settling time from a height of 4 feet
100.0	4.0 seconds
10.0	**6.8 minutes**
5.0	**19.2 minutes**
1.0	**9.4 hours**
0.5	**34.3 hours**
0.3	**17.8 days**
0.1	**42.5 days**
<0.1	**Indefinitely**

Figure 4: Sizes of select particles commonly found in the air in casinos.

Additionally, there is a clearly beneficial industry effort to provide active humidity control in the Built Environment. 40-60%RH control is highly effective in mitigating infectious particle transmission[7]. AirFixture supports this strategy by offering humidification in our AHUs and offering other wall mounted in-room humidifiers.

HEPA and other filtration methods are effective in removal of harmful particles in the return path of conventional UFAD and OHAD systems[3, 6]. These are making their way into many new projects.

Carefully applied, high intensity UV lighting systems are a very effective and benign method of killing harmful particles in AHU systems, ducts, and other fan powered products. UV light will also keep coils clean providing an operation and maintenance benefit at the same time. These are available in many of AirFixture's products.

AirFixture Position Summary

In summary, designers must evaluate air distribution as a primary means of transferring airborne infectious pathogens in indoor spaces. UFAD systems promote air stratification, a floor-to-ceiling airflow pattern, and minimize the amount of air mixing in the occupied space. This results in a lower potential of airborne transmission of harmful particles. UFAD also supports other technologies that have been proven to improve occupant health.

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