ENHANCED HVAC INFECTION CONTROL: COVERED MALLS

Introduction

As we wrap up our white paper series on Enhanced HVAC Infection Control, we will be addressing specific building types and occupancy classifications in an effort to identify the most useful strategies that can be applied to each type of building or occupancy in order to improve the air quality and safety of the indoor environment.

Our primary objective will be to answer the question:

> *What should I do to my building to improve the safety and comfort of the occupants?*

In this white paper we will discuss the unique characteristics of the HVAC systems in covered mall buildings to see how well they can be adapted to the best recommendations and guidelines regarding indoor air quality and infection control.

Design Criteria

According to the International Code Council (ICC), a Covered Mall Building is defined as:

> *A single building enclosing a number of tenants and occupants, such as retail stores, drinking and dining establishments, entertainment and amusement facilities, passenger transportation terminals, offices and other similar uses wherein two or more tenants have a main entrance into one or more malls.*

The ICC definition goes on to include Open Mall Buildings defined as:

> *Several structures housing a number of tenants, such as retail stores, drinking and dining establishments, entertainment and amusement facilities, offices, and other similar uses, wherein two or more tenants have a main entrance into one or more open malls. Anchor buildings are not considered as a part of the open mall building.*

In this article, we are focused on the enclosed, covered mall building, which is provided with mechanical heating, ventilation and air conditioning systems. A covered mall building is typically divided into the "common mall area" and the individual tenant bays, consisting of the retailers, restauranteurs and other occupants of the overall building. A future white paper will address the individual needs of the individual tenants based on their specific occupancy categories and the unique aspects of their HVAC systems design.

The design and construction of any covered mall building is a very long and involved process, engaging a myriad of consultants and contractors to achieve the final objective of a safe, comfortable and attractive environment for the life of the building. The design team must anticipate and take into account the different types of tenants, the various activities that might take place at the mall, and any seasonal variations the facility might experience. In addition, the code and regulatory requirements for covered malls are some of the most extensive and stringent of any building type.

These projects are designed and constructed by only the largest and most experienced firms, with great attention to detail to make sure that all requirements are met. Jurisdictional oversight of covered malls is very strict, due to their size and potential impact on the local community. Because of these stringent conditions, the HVAC systems in covered malls are some of the largest and most robust systems, which can operate under a wide variety of indoor and outdoor conditions and still maintain the desired comfort levels. The quality of the design and construction, coupled with the stringent regulatory requirements make covered mall buildings potentially some of the safest indoor environments available.

Ventilation Systems

The HVAC systems for covered mall common areas are designed to provide ventilation for peak occupancy loads and still maintain the desired comfort level at all design conditions. The outdoor air ventilation requirements are prescribed by the applicable codes and standards, which typically include both a high occupancy rate (25 SF/person) and a high ventilation rate (7.5 CFM/person + 0.06 CFM/square foot). Based on these requirements, a typical covered mall concourse area of 50,000 square feet, for example, would be required to provide up to 18,000 CFM of outdoor air ventilation depending on the occupancy load.

This ventilation rate would support a peak occupancy of over 2,000 people in the 50,000 square foot space at one time, while maintaining air quality levels within acceptable standards.

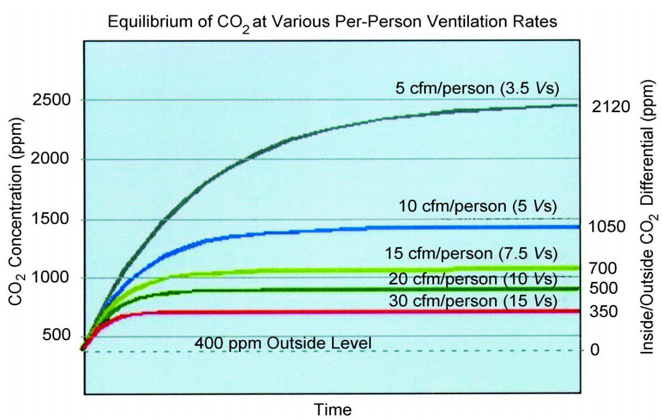
This high peak ventilation rate in the covered mall provides the opportunity for much higher than normal ventilation rates at any time the covered mall building is not operating at peak occupancy.

Peak occupancy levels in covered malls rarely occur, and usually only during the holiday shopping season. As a result, during the vast majority of the year, the ventilation systems are operated at a reduced rate by means of CO_2 sensor controlled dampers. The CO_2 sensor controlled dampers regulate the amount of outdoor air introduced in order to control energy costs during non-peak periods.

Since covered mall HVAC units are usually large, high capacity units, they are equipped with outdoor air economizer dampers and powered exhaust systems, as required by nearly all energy codes. This means the units are capable of bringing in up to 100% of the total circulated air from the outdoors.

By simply adjusting the CO_2 ventilation control set point, it is possible to dramatically increase the amount of fresh air ventilation provided to the space. Per our previous white paper on *Dilution Ventilation*, a doubling of the ventilation rate will roughly cut the concentration of contaminates in the air by approximately one-half, including airborne or aerosol viruses. By simply reducing the CO_2 ventilation control set point from 1,200 ppm to 600 ppm, the ventilation rate will be doubled and the concentration of contaminates will be halved, without any adverse impacts on the HVAC systems, which are designed for these high ventilation rates.

Most modern CO_2 ventilation controls are set up to maintain a fixed differential (700 ppm) above outdoor ambient CO_2 levels, which are typically 300 to 500 ppm ambient depending on the geographic location. Cut the set point differential value by one-half and the ventilation rate will approximately double. The following graph illustrates the correlation between indoor equilibrium CO_2 concentration and ventilation rates.



The only caveat to this strategy is an increase in energy consumption at any time the outdoor conditions are unfavorable relative to the desired indoor temperature and humidity conditions. Therefore, dilution ventilation is an easily accomplished strategy for covered mall buildings, as long as the cost of the energy consumed is recognized as the tradeoff. In some cases, even this caveat can be partially mitigated by installing energy recovery units on the units, where such systems can be reasonably applied. This will reduce energy costs, especially during periods of increased ventilation rates.

The recommendation for increased outdoor air ventilation should be readily achievable by covered mall HVAC systems, without any need for expensive or time consuming system modifications.

Filtration Upgrades

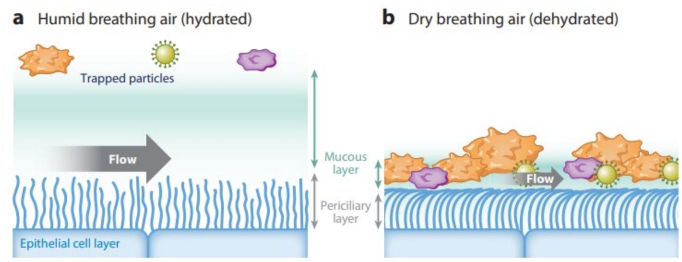
Due to the size of covered mall buildings and their high occupancy requirements, the HVAC units serving them consist of large, high capacity commercial equipment. These units are specified to have large fans capable of overcoming high static pressures (resistance to airflow). In our previous white paper on *Filtration*, we found that MERV Ratings of 13 and up provide a very effective means of stopping the spread of infectious particles, such as the SARS-CoV-2 virus.

The additional static pressure that comes with replacing existing filters with a higher MERV rating (typically 1.0" for MERV 13 to 1.5" for MERV 16) should be relatively easy to accomplish in a covered mall setting. If the HVAC units are belt-driven, the sheaves (pulleys) may need to be adjusted or even replaced. If the units are equipped with the direct-drive type motors, these are also relatively easy to adjust to account for the increased static pressure of higher efficiency filters. None of these modifications would be difficult or expensive to achieve in practice.

Again, the recommendation for increased filter efficiency to MERV 11 to 13 should be readily achievable by covered mall HVAC systems, without any need for expensive or time consuming system modifications. Anything above MERV 13 becomes more challenging due to the 6"-12" filter depth and increased static pressure drops at these higher efficiencies.

Humidity Control

Numerous medical studies over many years have shown that the cilia in the body's airways do not function as efficiently in low humidity conditions as they do in higher humidity conditions. Cilia are the hair-like organelles lining the body's airways that expel viral and other particles. If the air gets too dry, they simply are not able to move foreign particles away from the respiratory system as effectively as they can under normal humidity conditions.



According to ASHRAE Standard 62.1 *Ventilation for Acceptable Indoor Air Quality*, indoor relative humidity (RH) levels should be maintained at or below 65% to prevent microbial growth. ASHRAE Standard 62.1 does not provide a minimum recommended humidity level, however other ASHRAE guidelines recommend that humidity levels be maintained between 30% and 60% RH. The United States Environmental Protection Agency also recommends maintaining indoor relative humidity between 30 and 60% RH [EPA 2012]. Relative humidity levels lower than 30% have also been found to cause eye irritation, nasal congestion and, for some individuals, aggravated allergies. The ideal indoor relative humidity for human respiratory function and good health is generally accepted to be between 30% and 60% RH.

Low relative humidity can also lead to increased survival of airborne viruses, thereby increasing the spread of viral infections. A recent technical review (*Seasonality of Respiratory Viral Infections, Annual Review of Virology, March 2020*) completed by a group of doctors and researchers from Yale University and the University of Zurich, Miyu Moriyama, Walter J. Hugentobler and Akiko Iwasaki, confirmed that the airborne stability and viability of a virus in heavily influenced by the relative humidity, particularly inside of buildings, where the air is shared by multiple occupants. This very thorough compilation and review of the available research on the link between environmental parameters and disease spread found that viruses are able to remain viable and airborne for much longer periods of time at humidity levels below 30%. The virus's increased viability at low humidity, coupled with a reduced effectiveness of the cilia at low humidity results in a significant increase in the infection transmission rate inside buildings.

Enclosed malls, with their rigorous design requirements and increased capacity to handle high occupancy periods, allow for better dehumidification control in the summer months. The large covered mall HVAC units are capable of running efficiently under part-load conditions and thus are able to maintain constant humidity levels within the ideal range of 30-60% RH, without cycling of the air conditioning systems that is required with smaller commercial and residential equipment.

Covered malls typically do not include winter humidification capabilities, instead relying on respiration and food service to provide baseline levels of humidity. Some mall HVAC systems have the ability to add humidity centrally, with the addition of steam humidification units at key locations throughout the mall, in those geographic locations with low outdoor humidity levels during the winter months. Milder climates are not as susceptible to low humidity levels and should be able to maintain humidity levels without supplementation.

Building Management Systems

Covered mall buildings are typically controlled by a Building Management System (BMS). The BMS allows for the mall conditions, including temperature, humidity, equipment status and outdoor conditions to be closely monitored and controlled automatically as conditions change. Any deviation from the set point conditions can be set to trigger alarms, warning the facility personnel and off-site maintenance organizations so that the appropriate intervention can take place in a timely manner.

Summary

Covered mall buildings, by the nature of their large, well designed HVAC systems and controls, are well positioned to be easily adapted to the latest recommendations and guidelines with regard to indoor air quality and infection control. The advanced ventilation, filtration and humidity control strategies discussed in our previous white papers can be easily implemented in a covered mall environment to provide one of the safest, healthiest, anti-viral indoor environments.

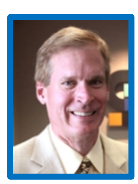
Our specific recommendations for covered mall buildings include the following:

- ✓ Increase Ventilation Rates: Lower demand controlled ventilation (DCV) CO_2 sensor settings to 700 ppm *total* or 350 ppm *differential* to drive up outdoor air ventilation rates. If there are no demand controlled ventilation systems present (older malls), install DCV immediately to reap the energy benefits and gain control of the indoor pollutant concentration levels.
- ✓ Increase Filtration System Rating: Install minimum MERV 11 and preferably MERV 13 (or higher) filters to improve the system's efficiency at removing airborne particles containing infectious materials. MERV ratings lower than 11 have almost zero impact on particulates smaller than 1.0 micron and will not stop most infectious particles, including viruses.
- ✓ Relative Humidity Range: Monitor and maintain humidity levels between 30% and 60% RH. Summer dehumidification will usually be controlled within this range using the existing multi-stage equipment. Winter humidification may require the addition of steam generating humidifiers in key areas of the concourse to raise the humidity level above 30% in colder winter climate locations.

RESOURCES	
ASHRAE	https://www.ashrae.org/
U.S. Environmental Protection Agency	https://www.epa.gov/
Centers for Disease Control and Prevention	https://www.cdc.gov/
Annual of Virology, Seasonality of Respiratory Viral Infections, March 2020	https://www.annualreviews.org/doi/pdf/10.1146/annurev-virology-012420-022445
ASHRAE Journal	https://www.ashraejournal.org/

About Pedro Ferrer:

Pedro Ferrer, P.E., has been involved in the design of mechanical systems for malls, mixed-use developments, corporate offices, national retail roll-outs, commercial and institutional buildings for over 26 years with Schnackel Engineers.



About Gregory Schnackel:

Gregory Schnackel, P.E., LEED AP has been involved in the design of mechanical, electrical, plumbing, fire protections and information technology systems for malls, mixed-use developments, corporate offices, national retail roll-outs, schools, hospitals, medical facilities, commercial and institutional buildings for over 40 years with Schnackel Engineers.