Assessment to Improve Air Quality at Various Illinois Veterans' Homes

Illinois Department of Veterans' Affairs

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Responsibilities for the content of the HVAC Systems Assessment are as follows:

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Section 1: Illinois Department of Veteran's Affairs Preamble

OBJECTIVE

The Illinois Department of Veterans Affairs engaged BRiC Partnership, LLC to provide engineering and consulting services for determining the most effective immediate measures to improve air quality at IDVA homes (Quincy, LaSalle, Anna, Chicago and Manteno). Specifically, but not limited to evaluating current HVAC filtration efficiency, retrofit capability of existing HVAC for more efficient filtration, and stand-alone filtration appliances for use in resident rooms, common areas and other areas frequented by staff and residents.

Quincy Veterans' Home, Quincy, IL (1707 N. 12th Street)

Building investigation occurred during the period from Monday, December 14, through Wednesday, December 16, 2020. HVAC system investigation was conducted in Hammond Hall, Anderson Barracks, Sommerville Barracks, Schapers Hospital, Markword Infirmary and Fifer Skilled Care Nursing Facility.

The Adjutant Illinois Veterans' Home, Anna, IL (792 N. Main Street)

Building investigation occurred on December 18, 2020. HVAC system investigation was conducted in skilled care nursing facility and adjoining six apartment-style domiciliary units.

Manteno Veterans' Home, Manteno, IL (1 Veterans Drive)

Building investigation occurred on December 18, 2020. HVAC system investigation was conducted in five major nursing care units, known as R1, R2, R3, and R4.

LaSalle Veterans' Home, LaSalle, IL (1015 O'Conor Avenue)

Building investigation occurred on December 18, 2020. HVAC system investigation was conducted in Resident Wings A, C, D, and F and adjacent Office Wing E.

Chicago Veterans Home, Chicago, IL (4520 N Oak Park Avenue)

Building investigation occurred on February 2, 2021. HVAC system investigation was conducted in Resident Wings North, South, East and West.

PREVIOUS WORK

While conducting work previous to this project, I reviewed the following industry documents:

1. ASHRAE Pandemic COVID-19 and Airborne Transmission: 4/17/2020
2. ASHRAE Position Document on Infectious Aerosols: 4/14/2020, expiring April 14, 2023

3. ASHRAE COVID-19 (Coronavirus) Preparedness Resources
4. CDC Position on Bipolar Ionization
5. ANSI/ASHRAE/ASHE Standard 170-2017 Ventilation of Health Care Facilities
6. Centers for Disease Control and Prevention, Appendix B. Air: Guidelines for Environmental Infection Control in Health-Care Facilities (2003)
7. World Health Organization: Modes of Transmission of Virus Causing COVID-19: Implications for IPC (Infection Prevention and Control) Precaution Recommendations (first published March 29, 2020, updated on July 9, 2020)
8. U.S. National Ambient Air Quality Standards
9. Engineered Systems Magazine: HVAC Design in Commercial Buildings to Mitigate COVID-19: Improve Filtration, Don't Increase Ventilation (July 29, 2020)
10. Manufacturer Members: National Air Filtration Association
11. Global Plasma Solutions Independent Laboratory Test Results, Pathogens (2011 through 2020): Effectiveness of Needlepoint Bipolar Ionization

PREMISE for IDVA WORK:

Given that most publications regarding HVAC system response in the context of COVID-19 transmission indicate the evolving nature of discovery and therefore application of mitigation techniques, I felt it best to consult more recent industry information.

In developing this report, I extract from the most recent information I have reviewed and 1) check to see if current analysis and recommended approaches are consistent with previous research; 2) check for new information, revisions to previous analysis and new approaches; and 3) weave both previous analysis and approaches which remain consistent and are appropriate and new analysis and approaches as appropriate into analyzing each of HVAC systems present at each of the five IDVA sites.

HVAC engineers utilize information published by ASHRAE (American Society of Heating, Refrigeration, Air Conditioning Engineers) when designing new systems, evaluating existing systems and buildings, and continuing their professional development.

ASHRAE publishes a monthly industry journal entitled, ASHRAE Journal, The Magazine of HVAC & R Technology and Applications; the Journal is a peer-reviewed publication.

In its September 2020 Journal, under its feature section "Filling the Knowledge Gaps" ASHRAE published an article entitled "HVAC and COVID 19", authored by Ed Light, James Bailey P.E., Reid Lucas, and Laurence Lee. The article begins with the following:

> *"ASHRAE has issued general guidance for HVAC operation during the COVID-19 pandemic based on the very limited information available at this time, but there is considerable uncertainty over where these measures are effective. This paper summarizes what is known about the virus responsible for COVID-19 (SARS CoV-2) and similar viruses regarding the role*

of HVAC in both the spread and control of infection. It also identifies critical information gaps and recommends research priorities.

Scientific publications were reviewed (including 2020 preprints of COVID-19 research) and papers previously published on related viruses such as SARS (2003 pandemic). The authors considered this information based on their experience as mechanical engineers specializing in HVAC design and operation and industrial hygienists specializing in indoor air quality. It should be noted that this subject is rapidly evolving as efforts to control the pandemic continue.

Transmission of respiratory infections through the air is classified as direct contact (within a few meters) or airborne (i.e., beyond a few meters). SARS-CoV-2 is infectious until it degrades (inactivated), but it has not been established how long the virus remains infectious in air. Because viruses generally have a minimum dose at which they cause infection and show a dose-response relationship, health risk is related to concentration in air and duration of exposure. These factors are not known for SARS-CoV-2.

CDC and WHO guidelines for COVID-19 response assume that the important routes of COVID-19 transmission are direct contact with the patient, short-range droplet exposure and transfer from surfaces where aerosols have settled (fomites). Based on this assumption, recommended response measures by public health agencies are generally limited to social distancing, face coverings, handwashing and surface sanitizing. However, increasing evidence suggest that smaller aerosols remain suspended in the air, where they expose occupants (airborne transmission).

A group of Australian and Chinese researchers concluded that there is now sufficient evidence of airborne transmission of COVID-19 to justify improving ventilation and filtration where this would reduce SARS-CoV-2 exposure, and ASHRAE has adopted this position."

The article proceeds with epidemiological case studies which suggest airborne transmission of COVID-19. However, in all cases presented within the study, airborne transmission was determined to be causal <u>in combination</u> with close contact (i.e., droplet exposure within 2 meters, or 7 feet); airborne transmission is defined as aerosol exposure beyond 2 meters, or 7 feet. In all cases, transmission was epidemiologically linked to an infected person; it did not begin with airborne travel into the group. Once a person becomes infected, behavioral protocols to mitigate transmission are essential, i.e., masking, social distancing, and sanitizing measures.

Let's pause to discuss what exactly is travelling through air currents; the travelling particle is known as an infectious aerosol; ASHRAE defines an aerosol as a system of liquid or solid particles uniformly distributed in a finely divided state through a gas; usually the gas is air. They are small and buoyant enough to behave much like a gas. In an aerosol, the infecting microorganism, or virus, can be attached to water, it can be attached to biological material expelled from the person (such as mucus proteins, or other biological matter), or it can be attached to both; the combination of a virus with an attachment is called a particle. In either case, its mass is sufficiently small that it becomes air-borne; ASHRAE's concern is that small aerosols may persist in the breathing zone, available for inhalation into the upper and lower respiratory tracts or they may settle onto surfaces, where they can be indirectly transmitted by resuspension or fomite contact. Fomite contact is defined as contact, primarily through the hands, with an object contaminated with an infectious organism, such as a doorknob or desk surface.

Let's review what happens when a person coughs, sneezes, shouts, breaths, sings, or speaks. All of these actions expel particles from the mouth and/or the nose; these particles can combine proteins, water, microorganisms and other biological material, in the form of droplets and aerosols. The microorganism of concern is COVID-19. ASHRAE defines droplets as particles large enough, in other words of enough mass, such that gravity will compel the droplet to fall to a surface in 3-7 feet and thus not become air-borne. The WHO further defines respiratory droplets as those droplet particles of greater than 5 to 10 microns in diameter. Repeating, aerosols are defined by ASHRAE as a system of liquid or solid particles uniformly distributed in a finely divided state through a gas, usually the gas is air; the volume of proteins, water and other biological material connected to the microorganism is sufficiently less than that of a droplet such that the mass of the material plus the microorganism is capable of buoyancy. Also to be considered are droplet nuclei, which are formed from droplets that become less massive by evaporation of water that accompanied the microorganism and thus may become aerosols, capable of buoyancy. Droplet nuclei may lose enough water by evaporation while traversing in air that they become airborne or they may begin as droplets that have landed on a surface, water has sufficiently evaporated, such that they now can become airborne through local air disturbance. The WHO defines droplet nuclei as those droplet particles less than 5 microns in diameter which can remain in air for long periods of time and be transmitted to others over distances greater than one meter. Once a microorganism has desiccated (i.e., lost its water) it becomes dormant, and it may remain airborne or become airborne through resuspension from a surface; once it reaches the upper or lower respiratory system of a secondary host (say a person) it will rehydrate and may become infectious.

Conclusions reached through the case studies:

1. Transmission occurred in occupancies served by HVAC systems with substandard ventilation rates or completely recirculating systems which did not introduce any outdoor air into the HVAC system. In the article, the standard for comparison is AHSRAE Standard 62.1 – 2019 Ventilation for Acceptable Indoor Air Quality which consists of prescribed rates pertaining to outdoor air <u>and</u> rates for the exchange of air within an occupied space. In the 62.1 Standard, *Ventilation* is defined as "the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space." Substandard is therefore defined as HVAC systems producing insufficient total air exchange rates along with insufficient or zero outdoor air introduction rates. The purpose of ASHRAE Standard 62.1 is to specify minimum

ventilation rates and other measures intended to provide indoor air quality that is acceptable to human occupants and that minimizes adverse health effects. The Standard defines "*acceptable indoor air quality"* as "air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction."

Application to IDVA: attain and maintain code required minimum ventilation rates, more specifically, introduce code complaint outdoor air at the prescribed rate and provide prescribed total air exchange rates. In all buildings, at all IDVA sites, ventilation is being provided; whether or not the current ventilation rates meet the code required rates established at the time of design is not known. This is not to say that in all buildings, at all IDVA sites, outdoor air is always being introduced at all times of building occupancy; the mechanical HVAC systems serving Anderson and Sommerville Barracks at the Quincy site do not bring in outdoor air during the winter, only during summer. This condition needs to be further assessed; the International Mechanical Code does allow natural ventilation if sufficient means are available in the building exterior. The author does not know if Anderson and Sommerville would qualify for natural ventilation. Further, air exchange rates at Anderson and Sommerville need to be analyzed also for code compliance. Although not difficult to reverse-engineer, it is difficult to ascertain adequacy at any given moment. Most engineers will assume that code required ventilation rates are not being achieved in older buildings due to systems becoming unbalanced for a variety of reasons, such as: wear of mechanical equipment, i.e., fans and belts; inoperability of devices responsible for maintaining outdoor air quantities (e.g., damper actuators); and/or changes to the building occupancy, floor plan and or HVAC systems.

Relative to buildings, the introduction of outdoor air into an HVAC system is required to reduce the level of contaminants that would otherwise accumulate within the built environment, compromising human health; reducing the level of contaminants is known as dilution. This is not to say that pollutants, microorganisms, and other contaminants are not present in outdoor air, they are but they are of much less concentration than when allowed to accumulate indoors, if not for the introduction of outdoor air. The acceptable level of concentration of contaminants in outdoor air is established by EPA standards. The national EPA standards do not establish levels for microorganisms per se; they address microorganism control by way of establishing concentration levels for particulate matter, establishing concentrations for particles of 2.5 microns and less per cubic meter of air and greater than 2.5 microns but less than 10 microns per cubic meter of air. Filtration of incoming outdoor air is the preventative measure to mitigate the concentration of particles exceeding the stipulated limits from making their way into the occupied environment.

I am not aware of any data set which tabulates existence of the concentration of particles of COVID-19 virus connected to other matter (such as mucus, proteins, water or a combination of one or more of the three) in ambient air or in building/room air. On the one hand, the WHO informs that there are reports from settings where symptomatic COVID-19 patients have been admitted and in which no COVID-19 RNA (ribonucleic acid – RNA viruses have higher mutation rates) was detected in air samples taken within the space. On the other hand, WHO is also aware of other studies which have evaluated the presence of COVID-19 RNA in air samples but which are not yet published in peer-reviewed journals. Without the ambient air data set, it is not possible to measure the risk of bringing in more outdoor air and without a means of measuring concentrations in building/room air, it is not possible to determine the effectiveness of bringing in more outdoor air; what can be said is that the concentration of COVID-19 connected to other matter in the ambient environment must be less than the concentration of the same particle in the building/room environment due to the vast difference in volume of air. Nonetheless, all it takes is one virus to infect a person. If the goal is to do all that can be done, then increasing outdoor air rates should be done, without any consideration for cost/benefit. If the goal is to do reasonably responsible things, then increasing outdoor rates should likely be avoided due to the inability to determine benefit but with the certainty of increased operating costs. Instilling a purge by increasing the outdoor air introduction rate to 100% would seem to be an effective emergency measure, should it be documented that rates of infection have risen in a particular portion of the building, possibly indicating an elevated level of infective microorganism in the space. However, one is not sure if the rate of incidence is due to the space or due to a person being exposed elsewhere; likewise, without measurable data, it is impossible to say how long to employ such a strategy and what threshold of microorganism should exist before it is dis-engaged.

Of interest: the article includes a case entitled "Well Ventilated Cruise Ship" pertaining to an epidemiological investigation of 696 COVID-19 cases aboard the Diamond Princess cruise ship which has a recirculating HVAC system that was reported to be operating with ventilation rates consistent with ASHRAE standards. None of those passengers who were quarantined in their cabins with no COVID-19 positive individuals present, yet still exposed to air recirculating from other cabins with positive COVID-19 positive passengers, developed a COVID-19 infection. The lack of infection suggests that circulation and dilution of air through the HVAC system did not cause an infection. The article also stated that infections did occur in previously uninfected persons who were quarantined with an infected individual. This could have been because of an inability to distance; relating to IDVA, the inability to distance in resident rooms may be more transmissive than recirculating air. Filter efficiency was not discussed in the article.

2. Modeling of airflow patterns established that "bubbles" were formed around small terminal devices, such as fan-coil units. If multiple fan-coil units were present in a room, multiple bubbles were created, bounded by the extent of influence of each individual fan. Modeling also suggested that air from small terminal units was directed into the breathing zone of occupants of the room. Droplets and droplet-nuclei, although strong contributors

to transmission, are not the concern relative to air patterns (unless droplet nuclei become buoyant), aerosolized COVID-19 is the concern as it is buoyant. Aerosolized COVID-19 is defined as having mass less than 5 microns, capable of buoyancy; it's important to recall that COVID-19 is .125 microns in diameter and that it never travels alone, it is attached to something (mucous is common). The attachment is thought to bring it to a size sufficient to be captured in high-efficiency filters. It stands to reason that bubbles would increase the duration of exposure and permit higher concentrations of infectious particles increasing the health risk aligned with a dose-response relationship.

Application to IDVA: The study stated that conclusions cannot be drawn correlating the prevalence of airborne transmission to the fan-coil system, however, the study also stated that air from a contaminated zone did not mix significantly with air from an adjacent zone or the rest of the rooms and that infected persons were limited to a contaminated zone; infection did not spread to adjacent uncontaminated zones. More simply, if a bubble contained an infected occupant and the air within the bubble is recirculated, transmission amongst the occupants of the bubble is likely; transmission amongst bubbles is not likely due to air not mixing significantly between adjacent bubbles.

There is a propensity for small terminal HVAC units to form bubbles. In the IDVA facilities, due to the nature of the resident rooms, that is, walled rooms which contain 1 to 4 residents, HVAC units which promote air circulation within the room (creating the bubble) and discharge air such that resulting air patterns engage the breathing zone of the occupants, can exacerbate transmission if one of the occupants becomes infected. Given that COVID-19 can be transmitted simply through breathing, the movement of recirculated air into and through breathing zones presents a concern. If an occupant of a resident room is infected, the chances of an aerosol infecting another occupant(s) is becoming increasingly evident, especially if there are no means of filtering the aerosol in the terminal HVAC unit. Given that small terminal HVAC units which serve resident rooms exist at four of the five sites, most without the ability to withstand enhanced filtration, all of which recirculate air, two of which introduce no outdoor air to dilute contaminants in the recirculated air, and one of which does introduce outdoor air but its introduction is not continuous, other measures should be considered. These measures should include masking, distancing , sanitizing hands and surfaces, uninfected residents staying within the room, infected residents moving into isolation, minimizing time of close contact of staff with residents, proper PPE for staff, and installation of portable HEPA filters with UV-C capable of producing an air exchange rate between six and twelve air changes per hour within the resident room, located near breathing zones and such that their air patterns interrupt the pattern of air distribution from the small terminal HVAC unit serving the room. In all IDVA facilities utilizing small terminal HVAC units, it will not be possible to replace the resident room heating and cooling service provided by the terminal HVAC unit without large capital investment and significant time. The portable HEPA filter with UV-C is an immediate mitigation strategy designed to move air quickly, capturing the organism within the HEPA filter and killing it with UV disinfection; these are effective measures against airborne transmission.

In limited application, fan-coil units in the IDVA facilities have 1" filters; it is possible to replace the 1" filter with a filter of the same thickness yet much higher efficiency. The concern is two-fold: fan-coil fan motors are generally fractional therefore not generally capable of taking on the air pressure drop which comes with high-efficiency filters, and housing construction of fan-coil units is such that they are generally porous, therefore it's uncertain how much of the recirculating air is actually being drawn through the filter; much less is expected when the filter resistance is increased.

It should be noted that almost all HVAC systems approach some degree of "bubble" like air distribution; some notable exceptions include hospital operating rooms and clean rooms found in computer chip manufacturing facilities. However, unlike the small terminal HVAC unit serving a resident room, these HVAC systems are much larger than terminal type equipment, handling much larger volumes of air and have the capability to accept much deeper filters offering higher rates of filtration.

Recirculating systems and the function they serve at each IDVA facility is identified in the attached DOCUMENTATION sheets.

We need to consider the impact of outdoor air discharged into the room via the Dedicated Outdoor Air System (DOAS) unit; this type of unit exists at Hammond Hall at Quincy, at the four resident wings and the main administration wing at Manteno, within resident wings at LaSalle and the four resident wings at Chicago. It does not exist anywhere else. The purpose of this unit is to bring code required outdoor air into the resident room; the purpose of the outdoor air is to provide fresh air for breathing purposes and to dilute contaminants in the indoor environment; most HVAC designers will also use this air to offset bathroom exhaust. All relevant codes require a minimum of two air exchange rates per hour of outdoor air and two total air exchange rates in nursing homes. Depending on placement of the diffuser providing this air to the space, most often the air that comes in via the DOAS unit is 1) not being uniformly distributed throughout the resident room; 2) its quantity may not be enough to adequately dilute the daily viral load added to the space by an infected or asymptomatic person but yet still contagious; and 3) it's generally going to be making its way to bathroom exhaust, averting a sweep of the room. Two of the three causes of viral load, droplet and droplet nuclei, are not airborne thus air movement is only so effective at removal or mitigating the overall impact of COVID-19. In the September 2020 Journal article, ASHRAE's most recent studies conclude "Increasing outdoor air dilutes the concentration of airborne SARS-Co-V-2. Minimum acceptable ventilation rates have not been established for operation of buildings where infected occupants may be present. It is not known whether increasing ventilation rates above ASHRAE minimums actually reduces disease transmission." This statement remains consistent with ASHRAE's earlier statement, manifested in its publication entitled "ASHRAE Position Document on Infectious Aerosols" dated April 14, 2020, when addressing reducing the concentration of airborne pathogens by dilution utilizing increased outdoor air rates, "However, it remains unclear by how much infectious particle loads must be reduced to achieve a measurable reduction in disease transmissions (infectious doses vary widely among different pathogens) and whether these reduction warrant the associated costs (Pantellic and Tham 2011: Pantellic and Tham 2012)." ASHRAE cites this measure as having an "Evidence Level B" which means "Recommended; at least fair evidence" as evaluated through a rubric developed by the "Agency for Healthcare Research and Quality (AHRQ)." I think it's important to note that ASHRAE has subjected its conclusion to a validation rubric; it's easy for someone to think that ASHRAE's minimum outdoor air rates may not be effective against severe airborne transmission of disease and that they should be coming forward with new minimum rates; the conclusion drawn by the validation rubric doesn't support that position.

Relative to contaminant level in an occupied space, ASHRAE's guidance for the number of outdoor air exchange rates is for the primary purpose of "controlling air contaminant levels" and to produce an "indoor air quality that is acceptable to human occupants and that minimizes adverse health effects." Repeating from above, "Minimum acceptable ventilation rates have not been established for operation of buildings where infected occupants may be present. It is not known whether increasing ventilation rates above ASHRAE minimums actually reduces disease transmission." Keep in mind that the reference point for ASHRAE's commentary is AHSRAE Standard 62.1 – 2019 Ventilation for Acceptable Indoor Air Quality.

In its publication, ANSI/ASHRAE/ASHE Standard 170-2017 Ventilation of Health Care Facilities, Article 9. SPACE VENTILATION – NURSING HOME SPACES, the Standard states "The ventilation requirements of this standard are minimums that provide control of environmental comfort, asepsis, and odor in nursing home health care facilities. However, because they are minimum requirements and because of the diversity of the population and variations in susceptibility and sensitivity, these requirements do not provide assured protection from discomfort, airborne transmission of contagions, and odors."

A few definitions are helpful:

Asepsis: a condition in which no living disease causing microorganism is present; absence of bacteria, viruses and other microorganisms.

Contagions: involves the communication of disease from one person to another by close contact.

Control: to positively influence but not remove, involving a reduction in the incidence, prevalence, morbidity or mortality of an infectious disease; it is not elimination or reducing to zero and it is not eradication or permanent reduction.

Concluding, asepsis is the target but protection against airborne transmission of contagions is not assured, therefore hazards to health remain, especially if comorbidities are present.

3. Pressurization is helpful and where pressurization is designed to inhibit movement of infectious particles, it should be maintained.

   Application to IDVA: Pressure differentials between a room or suite of rooms relative to adjacent rooms or spaces is accomplished by introducing more air into a space relative to an adjacent space, thereby creating a positive pressure in the space where the larger quantity of air is introduced, or by exhausting air from a space requiring makeup air from an adjacent space, thereby creating a negative pressure in the room being exhausted. This arrangement, positive and negative, is common in healthcare settings but is also required by code in other occupied areas such as restrooms.

4. Filtration. There is data to support a MERV-10 pre-filter will catch 70% of COVID-19 and that a MERV-15 final filter may not have removed additional virus.

   Application to IDVA: Manteno has installed MERV-14 filters in air handling units.

   A MERV-13 filter will remove 50% or better of particles in the 0.3 to 1.0 micron range; 85% or better of particles in the 1.0 to 3.0 micron range; and 90% or better of particles in the 3.0 to 10.0 range.

   MERV-14 filters are available in 2" thickness but beyond MERV-14, thicknesses increase; all air handling units observed have a 2" filter rack. MERV-14 will remove 75 to 84% of particles in the 0.3 to 1.0 micron range; 90% or better of particles in the 1.0 to 3.0 micron range; and 95% or better of particles in the 3.0 to 10.0 range.

   Aerosols are approximately 10 microns or less, however, as stated before, the COVID-19 virus itself is smaller; in a USA Today article authored by DeeDee Stiepan entitled COVID-19: Mayo Clinic Expert Answers Questions About Masks After CDC Updates its Recommendation, the Mayo Clinic expert, Dr. Gregory Poland, informs that COVID-19 by itself is approximately .12 microns in diameter. Other sources stipulate the range for the virus is .06 to .14 microns in diameter. The virus is always attached to something larger than itself; there is never a naked virus floating in the air or released by people. Viruses attach themselves to water, mucus proteins and other biological matter, all larger than 1 micron. What's interesting to note is that particles less than .3 microns in diameter move in an erratic, zig-zagging kind of motion, called Brownian Motion, enhancing their chance of getting snared by filter media. So even though the virus is very small, approximately

.12 microns in diameter, when a single virus attaches itself to something else, Brownian Motion may continue, enhancing the ability of the filter to capture, or the size of the particle may now be sufficient to ensure arrestance. Either way, filtration becomes effective. Some filters are manufactured with a positive electrically charged media making them electrically attractive to the negative electrically charged envelope of the lipid encircled virus; this means that as airborne aerosols pass through the filter media, the aerosols can become stuck to the filter media by electrical attraction depending on the effect of the net electrical charge on the particle due to the virus plus its carriers. The combination of Brownian Motion, positively charged filter media, and COVID-19's propensity to attach itself to matter larger than itself, makes MERV-13 to 14 filters effective. MERV-14 will come with a higher pressure drop than MERV-13 filters, something to consider when placed in an air handling unit with a small fan motor.

Air currents are required to move a droplet nuclei or an aerosol back to a source where it can be filtered. Admittedly, this is speculative business, meaning disturbances in air patterns in a room happens when people or objects move; this makes predicting that contaminants will make their way to a filter bank before they become inhaled by an occupant speculative business at best; this is reality but it doesn't mean that we can ignore filtration at air handling units. There is a mix of air distribution at the five sites visited; air patterns emerging from air systems only serving the resident rooms; air patterns emerging from air handling units serving areas adjacent to the resident rooms, such as corridors and nursing stations; and air patterns emerging from air handling units serving the resident rooms and also serving areas adjacent to the resident rooms, such as corridors and nursing stations. In all cases, it's entirely conceivable that air patterns will emerge which bring COVID-19 back to the air handling unit.

Recall that ASHRAE states in a publication entitled "ASHRAE Position Document on Infectious Aerosols", "However, it remains unclear by how much infectious particle loads must be reduced to achieve a measurable reduction in disease transmissions (infectious does vary widely among different pathogens" and whether these reductions warrant the associated costs (Pantellic and Tham 2011: Pantellic and Tham 2012)".

My feeling is that given the discourse addressing bubbles and the fact that air handling units serve areas adjacent to resident rooms, providing MERV-13 minimum filters at the air handling units in addition to portable HEPA filters with UV-C within the breathing zone of resident rooms is prudent. Various configurations of resident housing create a gradient of risk relative to airborne transmission, therefore, prioritizing placement of portable HEPA with UV-C units where the highest risk ensues is also prudent.

When filtration is combined with increasing air exchange rates, as the number of air changes per hour is increased, for a given filter efficiency, less time will be required to remove airborne contaminants. This is a positive outcome of increasing air exchange rates however filters will load quicker.

5. Mechanical hygiene. The virus can circulate through some HVAC systems and become attached to surfaces of various components of the system. The article did not discuss filter efficiency, however, even higher efficiency filters suitable for installation in many common HVAC systems such as MERV-13 filters, are effective but not 100%.

   Application to IDVA: consider surface cleansing of components exposed to air streams.

   In summary,

   - Evidence suggests it is necessary to achieve minimum outdoor air rates in order to dilute the concentration of indoor contaminants; disease transmission was evident in instances involving no outdoor air. There are zero installations in the five IDVA facilities visited where there is no mechanical capability to being in outdoor air. Actual operating sequences will dictate the occurrence and rate of introduction.
   - Evidence does not yet suggest by how much infectious particle load must be reduced through increasing the rate of outdoor air beyond minimum rates prescribed in ASHRAE Standards to achieve a measurable reduction in disease transmission. Where DOAS systems are installed, operate them; where they are not, there is not sufficient evidence to compel their installation.
   - Adherence to ASHRAE 62.1 or 170 does not assure protection from airborne transmission; asepsis is the target but protection against airborne transmission of contagions is not assured, therefore hazards to health remain, especially if comorbidities are present. Where DOAS systems are installed, operate them; where they are not, there is not sufficient evidence to compel their installation.
   - It would be best if we could create a pattern of air distribution that is directional, creating uniform, "sweeping-like", clean-to-dirty flow patterns, and moving infectious aerosols from breathing zones towards capture devices such as exhaust grilles or return air grilles that lead to a pressure relief/exhaust fan and duct system serving an air handling unit. However, whether it's a DOAS unit, or a recirculating air handling unit serving the resident rooms, the amount of air moving through the space is not sufficient to cause extraction of non-aerosolized COVID-19 particles; recall that of the three main forms of COVID-19 transmission, droplets are not buoyant and droplet nuclei are at least not initially buoyant. Creation of a clean-to-dirty air flow pattern through the breathing zone would be costly and time consuming to construct, especially within existing facilities. It should be considered for new facilities or facilities undergoing extensive renovation but it makes more sense to try and disrupt the air pattern within the breathing zone of existing resident rooms with portable HEPA filters with UV-C disinfectant capability.
   - Maintain pressure relationships where they exist; neutral in resident rooms, positive

in corridors relative to resident rooms, negative in resident rooms relative to adjacent areas in isolation areas.
- Increase outdoor air rates where the coils can handle the additional load in corridors to increase positive pressure relative to rooms and increase dilution.
- Provide minimum MERV-13 filters at central station air handling units and also local HEPA filters within portable HEPA filters with UV-C.
- Constantly operate air handling systems.
- Dis-engage CO2 sensing systems during the pandemic.
- In limited instances, the study identified COVID-19 virus present inside of air handling units; consider surface cleansing of components exposed to air streams.

There are studies which promote increasing relative humidity within spaces affected by COVID-19, supported by the premise that drier lung tissue is more susceptible to disease. We are not recommending this approach due to the fact that introduction of moisture into existing buildings not designed for higher space relative humidity can cause other harmful effects, some of which may be latent for quite some time before they are evident. Common problems are condensation on windows and doors, and development of condensation in walls due to the higher vapor pressure of the indoors relative to the lesser vapor pressure associated with common winter conditions – it is this difference in vapor pressure which drives moisture into spaces separating the two air conditions. The author contracted COVID-19 during preparation of this report; anecdotally, the author notes he felt much better when able to take a walk in the outdoors where air is colder and nearly saturated with moisture (December 2020/January 2021) and/or was able to crack a window or two in his isolation room.

Section 2: Background, Definitions, Acronyms and Useful Dialogue Accompanying Documentation Sheets

For each building, there is a documentation sheet which briefly describes the nature of the mechanical system serving the building; it further documents individual systems serving zones within the building; supply fan motor horsepower; the nature of the cooling medium (generally we are differentiating between stand-alone direct expansion units (DX) and units utilizing chilled water); the nature of the heating system; and the thickness of filters and the corresponding level of filtration efficiency installed at the time of our visit. Following the documentation sheet, we also include a second sheet detailing Strategies and Chalkboard. The Strategies section lists recommendations we make; the Chalkboard section illuminates conditions we observed which merit further discussion. We also note where maintenance is required if we clearly ascertained the need in the time allotted per building.

Our approach to increasing effectiveness against spread of COVID-19 is to begin with the ability of the air handling system to accept the increased air pressure drop associated with MERV-13 filters. Prior to our visit, we found several manufacturers which produce a 1" and a 2" MERV-13 filter. Admittedly, one particular manufacturer, Glassfloss, indicated that all of the filter media they purchase these days, is being manufactured into Personal Protective Equipment for the medical industry thus lead times are elongated. Knowing that additional air pressure drop associated with MERV-13 filters (about .25" w.c., clean) will tax motors and therefore reduce the supply air volume rate delivered from the fan, we chose 7.5 HP as the threshold - motors 7.5 HP or greater were generally thought to be able to take on the additional air pressure drop without adverse effects to the system; conversely, those systems with supply fan motors smaller than 7.5 HP are generally not recommended for change-out of filters. In a similar light, small, stand-alone DX systems were generally not chosen for filter change-out either; these systems will have less tolerance to take on variations in airflow expected with a larger pressure drop air filter. In these cases, as appropriate, we are recommending portable HEPA with UV-C filters.

Word definitions, acronyms and their meaning, and useful dialogue utilized in the Documentation sheets and in the Strategies and Chalkboard sheets follows:

1. 4P -AHU: an air handling system consisting of two fluids, chilled water supply and return connected to a chiller, and heating water supply and return; heating water may be produced from a building heat exchanger utilizing steam produced and distributed from a central system or heating water is produced by a boiler within the facility. AHU stands for a manufactured modular air handling unit or a customized and field erected air handling unit. The air handling unit will generally have a supply fan section, a chilled water coil section, a heating water coil section (the heating coil will either be in the preheat position, denoted as PH in which case it is located in a position to heat incoming outdoor air, or in a re-heat position, denoted as RH in which case it is located in a position after the cooling coil -in this position, its purpose is to allow a dehumidification cycle to be enacted whereby the cooling

coil will draw moisture out of the airstream and the reheat coil will heat the air so delivered air will not overcool the space), a filter section - generally an air handling unit will have a manufactured rack designed to hold 2" thick filters, and a mixing box - the mixing box mixes return air with outdoor air and is the beginning of the airstream relative to functions performed by the air handling unit. Air handling units are generally located in a mechanical room within the building, in a crawl space, or on the roof.

2. 2P -FCU: an air conveying system called a fan coil unit, generally consisting of a single coil, a supply fan, and a filter. Fan coil units are generally located in one of several ways; above ceilings, as a floor-mounted unit exposed within a room, or as an exposed ceiling hung unit. In IDVA facilities, these types of units are commonly utilized within resident rooms. The “2P” stands for two-pipe, meaning there are only two pipes connected to a single coil; when a decision has been made to provide cooling in the building, the supply pipe will deliver approximately 42 degree F. cold water produced via the chiller and distributed through the building to the coil and the return pipe will deliver low to mid-50's degree F. water to the chiller. Conversely, when a decision has been made to provide heating in the building, the coil now receives heating water produced via the building heat exchanger hereinbefore mentioned. 2P systems have limitations; buildings seldom operate in full cooling or full heating mode, most often, due to solar orientation, there is a need for the ability to simultaneously heat and cool within a building.
3. SAF HP: supply air fan horsepower. SF: motor safety factor, a percentage of stamped /plated horsepower which a motor may safely operate at, beyond the stamped/plated horsepower.
4. VFD: variable frequency drive, a device which speeds up or slows down the fan speed. Increasing fan speed will deliver more air to the space, increasing the air exchange rate within a space. This is of importance because the ability to increase the air exchange rate within a given space will increase the number of times a volume of air will move through filters, in a given timeframe (often air exchange rates are determined on an hourly basis). Increasing the number of passes through a filter, given proper efficiency of the filter, will reduce airborne contaminants, including infectious aerosols.
5. MERV- a filter efficiency rating, specifically, Minimum Efficiency Reporting Values, which reports a filter's ability to capture particles ranging in size from 0.3 microns to 10 microns. In this report, of importance is the COVID-19 infectious pathogen. Various epidemiologists report that the coronavirus is approximately .125 microns in diameter but never is found alone, accompanied by mucous proteins, water or a combination of the two and perhaps other biological matter. A MERV-13 filter will remove 50% or better of particles in the 0.3 to 1.0 micron range, 85% or better of particles in the 1.0 to 3.0 micron range and 90% or better of particles in the 3.0 to 10.0 micron range.
6. APD: air pressure drop, in inches of water column.
7. OA: outside air
8. EA: exhaust air
9. RA: return air
10. HEPA with UV-C: HEPA stands for High-Efficiency Particulate Air, and is a form of filtration which is a minimum of 99.97% efficient at removing particles whose diameter is equal to 0.3

microns, with the filter efficiency increasing for particle diameters both less than and greater than 0.3 microns. UV-C stands for ultraviolet light energy source which inactivates viral, bacterial and fungal organisms so they are unable to replicate and potentially cause disease. The entire UV spectrum is capable of inactivating microorganisms but UV-C energy is in the wavelength of 200 to 280 nanometers, with the most germicidal effective wavelength being 253.7 nanometers; at this wavelength, UV light will change the structure of DNA and RNA, the genetic code of all life forms, inhibiting organisms' ability to reproduce. We have been recommending a portable filter unit which first reduces volatile organic compounds from the airstream before passing through a HEPA filter. Directly upstream of the HEPA filer, a UV lamp bathes the incoming side of the HEPA filter, effectively killing microorganisms which accumulate on the incoming side of the HEPA filter. Other forms of UV protection are mounted in air handling units, on the upstream side of cooling coils, and in ductwork.

11. DCV: demand controlled ventilation. This is a control scheme which will measure the amount of carbon dioxide in the return airstream; CO2 is an indication of the number of people in the space; fewer people, less concentration of CO2 in the return airstream. It is an energy reduction strategy; with fewer people in the space, there is an opportunity to reduce the amount of code required outdoor air being introduced to the air handling unit. The treatment of outdoor air, specifically cooling and dehumidifying, heating, filtering and moving it through supply fan is very expensive, thus if there is an opportunity to reduce the amount of outdoor air coming into a space, considerable energy savings can be accumulated. In the case of reducing infectious pathogens, it's better to bring in more outdoor air in order to reduce the concentration of pathogens in the volume of air enclosed by a space. The concentration of pathogens expelled by individuals in a given space will be reduced if the outdoor air is increased because outdoor air coming into a space must also be relieved from the space, in order to not develop an excessively positive pressure in the space. Typically, this is accomplished via pressure relief systems associated with an air handling system. Recent ASHRAE literature points to the additional effectiveness of reducing concentration of infectious aerosols by increasing outdoor air rates as not being cost-effective when compared to increasing filter efficiency; minimal increases in effectively removing infectious aerosols is accomplished by increasing outdoor air rates; in comparison, much larger reductions are achievable through increasing filtration efficiency. If additional outdoor air is utilized to reduce concentrations of infectious bioaerosols, the demand controlled ventilation scheme should be disengaged since it will automatically reduce outdoor air rates if fewer people are in the space, effectively nullifying the approach. Outdoor air introduction can be an effective means of reducing concentration when utilized as a means of purge; engaging this method two hours before and after occupancy can be effective. Its use during occupied periods is a viable option but should be utilized with the understanding that operating costs will increase. In its publication "ASHRAE Position Document on Infectious Aerosols" ASHRAE states "However, it remains unclear by how much infectious particle loads must be reduced to achieve a measurable reduction in disease transmission (infectious doses vary widely among different pathogens) and whether these reductions warrant the associated costs (Pantellic and Tham 2011: Pantellic and Tham 2012)" ASHRAE cites dilution and extraction ventilation

as having an "Evidence Level B" which is "Recommended; at least fair evidence." as presented by a rubric developed by the "Agency for Healthcare Research and Quality (AHRQ)".

We have chosen to make a recommendation for increasing outdoor air rates in buildings which are served by a large chilled water system; larger chilled water systems are more able to accommodate a rise in chilled water return temperatures than a stand-alone DX system is able to accept higher suction temperature and pressure.

12. ERU: energy recovery unit. An energy recovery unit is a mechanical means of recovering energy from an airstream about to be exhausted from the building. In more modern times, the mechanical codes will require that when significant volumes of outdoor air are brought into a building to offset exhaust requirements from a building, the outdoor air must pass through a heat exchanger to exchange heat from the airstream about to be exhausted with the outdoor air coming into a building. To set up an example of how this works; in Hammond, outdoor air serving as make-up air for resident room bathroom exhaust is passed through an air-to-air heat exchanger wherein the warm exhaust air exchanges its heat to the cold incoming air in the winter time, raising its temperature thus reducing the amount of heat energy otherwise consumed from combusted natural gas, or steam, or hot water, to warm the incoming air. In an air-to-air heat exchanger however, a certain percentage of the exhaust air will bypass the heat exchange medium and transfer directly to the incoming air; typical percentages are between 3 and 10 percent. Of importance, is the possibility of a parcel of exhaust air containing an infectious aerosol which is not expelled from the building and now returns to the building via the incoming outdoor air.
13. DX: direct expansion, an expression utilized to refer to an air conditioning system utilizing refrigerant to cool air, as opposed to chilled water.
14. Purge: a mode of operation which utilizes 100% outdoor air or something between 50% and 100% outdoor air.
15. RH: relative humidity
16. MAU: make-up air unit; an air handling unit which cools, dehumidifies, heats and filters 100% outdoor air and supplies it to a building via a fan; the outdoor air satisfies code required rates as well as serves as makeup air for bathroom exhaust. Sometimes, these units are called DOAS units; DOAS is an acronym for Dedicated Outdoor Air System, an air handling unit which is solely dedicated to bringing in 100% outdoor air and exhausting an amount of air which approaches the incoming air quantity but is typically slightly less than the incoming air quantity in order to produce a positive pressure in the zone being served by the unit. Similarly, some rooms within a zone may be under neutral pressure within the room but the adjacent corridor may be under positive pressure relative to the room. Various pressure relationships may be created within a building in response to code requirements. The design of the make-up air system will create these pressure relationships.
17. Bioaerosols: a subcategory of particles released from terrestrial and marine ecosystems into the atmosphere. By definition, they are buoyant. They consist of both living and non-living components, such as fungi, pollen, bacteria and viruses. Common sources include soil, water,

and sewage. Bioaerosols can produce significant health effects by spreading infectious disease or triggering allergic responses or respiratory irritation.

18. Ionization: commonly referred to as Bipolar Ionization or Bipolar Needlepoint Ionization. These are air cleaners using reactive ions which react with airborne contaminants, including viruses. They work by increasing the mass of an airborne particle by agglomeration, that is, ions are driven into an airstream which has particles in it, traversing with the airstream. Ions will attach to a particle, thereby making its boundary more attractive to other particles by electrochemical reaction, either by positive to negative attraction or vice versa. Agglomeration results, increasing the diameter of an initial particle, either dropping it out of the airstream or rendering it large enough to be caught in filters. ASHRAE does not have a formal position on the use of ionizers, indicating that "Systems are reported to range from ineffective to very effective in reducing airborne particulates and acute health symptoms." and "Convincing scientifically-rigorous, peer-reviewed studies do not currently exist on this emerging technology; manufacturer data should be carefully considered."

    ASHRAE did reach out to the CDC to see if they had an opinion of the effectiveness of ionizers. ASHRAE stated:

    > "ASHRAE does not currently have a Society position on bipolar ionization. However, the ASHRAE ETF did reach out to CDC for their position on the technology. The following is the response form CDC in its entirety:
    >
    > Thank you for your question. Although this was pointed out in the earlier CDC responses, it is important for me to re-emphasize that CDC does not provide recommendations for, or against, any manufacturer or manufacturer's product. While bipolar ionization has been around for decades, the technology has matured and many of the earlier potential safety concerns are reportedly now resolved. If you are considering the acquisition of bipolar ionization equipment, you will want to be sure that the equipment meets UL 2998 standard certification (Environmental Claim Validation Procedure {ECVP) for Zero Ozone Emissions from Air Cleaners) which is intended to validate that no harmful levels of ozone are produced. Relative to many other air cleaning or disinfection technologies, needlepoint bipolar ionization has a less-documented track record in regards to cleaning/disinfecting large and fast volumes of moving air within heating, ventilation, and air conditioning {HVAC} systems. This is not to imply that the technology doesn't work as advertised, only that in the absence of an established body of evidence reflecting proven efficacy under as-used conditions, the technology is still considered by many to be an "emerging technology". As with all emerging technologies, consumers are encouraged to exercise caution and to do their homework. Consumers should research the technology, attempting to match any specific claims against the consumer's intended use. Consumers should request efficacy performance data that quantitatively demonstrates a clear protective benefit under conditions consistent with those for which the consumer is intending to apply the technology. Preferably, the documented performance data under

as-used conditions should be available from multiple sources, some of which should be independent, third party sources."

One particular manufacturer we have preliminarily investigated, seems to indicate its bipolar ionization systems range in application from about 2,400 CFM (6 tons of cooling) to 4,800 CFM {12 tons of cooling); both are rather small systems. We also think it appropriate to note that all IDVA facilities have mandated face masks and social distancing in all of its buildings; this mandate is clearly marked on every building entrance. The World Health Organization continues to state that the primary means of transmission of COVID-19 is in its droplet form, reinforcing the need for masks and social distancing. It is for these reasons we say, where we believe bipolar ionization could be an appropriate solution, we recommend continued investigation.

19. DAT: Discharge Air Temperature
20. SAT: Supply Air Temperature

DOCUMENTATION

Building Name: Hammond Hall, Quincy Veterans' Home

Basic HVAC System Description: Resident Rooms: 6 DOAS rooftop units with energy recovery (inclusive of DX refrigeration, hot gas reheat, and natural gas-fired heating) provide code required ventilation and bathroom make-up air; through-the-wall self-contained heating and cooling units provide space temperature control. Common areas are served by a DX air handling unit located in the basement with electric resistance heat. Kitchen make-up air is produced by a rooftop natural gas-fired heating and ventilating unit.

HVAC UNIT DESCRIPTION AND MARK	SAF HP	OA Available Y/N	Damper Position O/C	Damper Operable Y/N	Existing Filter Size	VFD	Existing MERV	Should MERV be increased Y/N	Proposed MERV and Thickness	Initial APD Proposed
DOAS RTU 1, 2, 3, 4 and 6	3	Y	O	Y	4"	Y	8	Y	13 - 4"	TBD
DOAS RTU 5	7.5	Y	O	Y	4"	Y	8	Y	13 - 4"	TBD
AHU-1	2.3 ECM	Y	O	Y	2"	Y	8	Y	13 - 2"	TBD
Packaged Terminal Heat Pumps	Fractional	N	NA	NA	¼" mesh	N	NA	N		

IS THERE REASON TO BELIEVE THAT UNFILTERED OA IS ENTERING THE BUILDING? (SPACE PRESSURIZATION REQUIRED)	Y	N	COMMENTS:	
CAN OA BE INCREASED	Y	N	COMMENTS:	Possibly to a slight degree at the DOAS units however it will require a corresponding increase in the exhaust systems to retain pressurization relationships; another concern, the exhaust fans are close to maximum current draw. Possibly also to a slight degree at AHU-1 but this AHU is already designed for 51% outside air (due to kitchen service).
10 FT SEPARATION AT OA AND EA	Y	N	COMMENTS:	Separation is not achieved at DOAS units; exhaust is filtered but with MERV-8. This is a manufactured item.
IS ADDITIONAL PURIFICATION BENEFICIAL TO THE BUILDING	Y	N	COMMENTS:	We recommend additional HEPA filtration at gathering locations; e.g., dining, conference rooms.
ERU PRESENT	Y	N	COMMENTS:	ERU's are protected up and downstream by MERV-8 filters.
CAN HVAC EQUIPMENT BE OPERATED 24/7	Y	N	COMMENTS:	It is controlled to operate 24/7. Purge is constant.
IS DCV LIKELY PRESENT	Y	N	COMMENTS:	The specification mentions demand controlled ventilation; this control mechanism should be disengaged during the pandemic.

NOTES:	

STRATEGIES AND CHALKBOARD

STRATEGIES

1. Change DOAS filters to 4" thick MERV-13; refer to CHALKBOARD discussion which follows.
2. Change AHU-1 filters to 2" thick MERV-13; refer to CHALKBOARD discussion which follows.
3. Given the discourse addressing bubbles and the fact that air handling units serve areas adjacent to resident rooms, providing MERV-13 minimum filters at the air handling units in addition to portable HEPA filters with UV-C within the breathing zone of resident rooms and in gathering areas is prudent.
4. Change the upstream filter on the DOAS exhaust system to 2", MERV-13 efficiency. This will protect the heat recovery wheel from capturing bioaerosols which can then be released into the incoming outdoor air stream. Confirm approach with Aaon sales/technical representative beforehand.
5. Monitor changes to HVAC systems recommended in BRiC December 18, 2020 letter.

CHALKBOARD

1. The original design drawings indicate the filter thickness for the six DOAS units is 2" with a MERV rating of 13; the specification states that the maximum clean pressure drop of the MERV-13 filters is .2" w.c.; the maximum dirty filter pressure drop is 1.0" w.c. Given this pressure drop is added to the pressure drop of all other internal devices, the selected supply fan is rated for 3.0 HP with the exception of DOAS – 5 which has a 7.5 HP supply fan. The test and balance report indicated that all DOAS unit supply fans are not more than 72% loaded with most of them falling between 50% and 60% loaded without consideration for Motor Safety Factor. The installed filters are 4" thick, MERV-8 filters. We recommend the Using Agency search for a 4" thick MERV-13 filter that has a maximum dirty filter pressure drop of not more than 1" and exchange the 4'" thick MERV-8 filters for a 4" thick MERV-13 filter. There are many other filters in the unit, each of which is 2" thick with a MERV-8 rating; these filters serve various functions and can remain in service with the possible exception of the filter upstream of the energy recovery wheel as presented in STRATEGIES, Item 4 above. The proposed 4" MERV-13 filters will serve as a final supply air filter, removing particulate matter before air is delivered to the resident rooms. Concentrations of bioaerosols in outdoor air is expected to be significantly less than in indoor air; given that the DOAS unit is 100% outdoor air there is an argument to be made that a MERV-8 filter is a reasonable approach; our thinking is that given the virulent nature of the COVID virus, it is more prudent to achieve as high a filter efficiency as can be gained within the limits of fan horsepower. The DOAS units are so tightly constructed that it is doubtful they can accept the addition of UV light and/or bi-polar ionization; mounting these devices in all of the roof-top mounted supply air ducts does not appear feasible nor necessary if filtration is achieved as recommended.
2. Supply fan motor horsepower at AHU-1 is small, less than 3 HP. However, the original design documents indicate the filter thickness for this unit to be 2" with a MERV rating of 13; the specification states that the maximum clean pressure drop of the MERV-13 filters is .2" w.c.; the maximum dirty filter pressure drop is 1.0" w.c. Given these specifications, we believe the Using Agency should change out the filter to a 2" MERV-13 filter but be vigilant about pressure drop; the test and balance report indicated the supply fan was drawing 4.7 amps against a design of 5.2 amps, without consideration of service factor.
3. The Packaged Terminal Heat Pump units in the Resident Rooms and elsewhere have simple, thin, aluminum, washable filters. These cannot be changed. The unit is 100% recirculating. Best strategy is to wash the filters frequently and apply approved biocide appropriate for nursing home environment.

DOCUMENTATION

Building Name: Fifer Skilled Care Facility, Quincy Veterans' Home

Basic HVAC System Description: 4-pipe, zoned air handling units, chilled water and heating water. Perimeter fan coil units. Building HVAC system has been modified to provide isolation.

HVAC UNIT DESCRIPTION AND MARK	SAF HP	OA Available Y/N	Damper Position O/C	Damper Operable Y/N	Existing Filter Size	VFD	Existing MERV	Should MERV be increased Y/N	Proposed MERV and Thickness	Initial APO Proposed
AHU-1, 2, 4	5.0 1.15 SF	Y	O	Y	2"	N	NA	Y	2" - 13	TBD
AHU-3	10.0 1.15 SF	Y	O	Y	2"	N	NA	Y	2"-13	TBD
AHU-5	15.0 1.15 SF	Y	O	Y	2"	N	NA	Y	2"-13	TBD
Resident Room FCU's	Fractional	N	NA	NA	1"	N	NA			

IS THERE REASON TO BELIEVE THAT UNFILTERED OA IS ENTERING THE BUILDING? (SPACE PRESSURIZATION REQUIRED)	Y	N	COMMENTS:	
CAN OA BE INCREASED	Y	N	COMMENTS:	Likely but would need to rerun coil calculations
10 FT SEPARATION AT OA AND EA	Y	N	COMMENTS:	
IS ADDITIONAL PURIFICATION BENEFICIAL TO THE BUILDING	Y	N	COMMENTS:	We recommend additional HEPA filtration at gathering locations; e.g., dining, conference rooms.
ERU PRESENT	Y	N	COMMENTS:	
CAN HVAC EQUIPMENT BE OPERATED 24/7	Y	N	COMMENTS:	
IS DCV LIKELY PRESENT	Y	N	COMMENTS:	

NOTES:	

STRATEGIES AND CHALKBOARD

STRATEGIES

1. Replace existing AHU filters with 2" thick MERV-13 filters; monitor pressure relationships so as to keep negative pressure relationships intact.
2. Locate portable HEPA filters with UV protection in gathering areas.
3. Consider changing Resident Room FCU filter to 1" thick HERV-13 filters; caution is the FCU motor is fractional HP.

CHALKBOARD

(Not applicable)

DOCUMENTATION

Building Name: Markword Infirmary, Quincy Veterans' Home

Basic HVAC System Description: 2-pipe zoned fan-coil system served by a DX condensing unit with remote chiller evaporator barrel in basement and steam to hot water heat exchanger. Primary/secondary pumping scheme. An air handling unit is located in the attic; this air handler provides ventilation for the building, air exchange and outdoor air, and heating and cooling of common spaces; it has a single heating and cooling coil operated via manual change-over from chilled to heating water, filter section, and a supply fan. A separate return fan provides return air ducted to the air handling unit. Of importance, this unit recirculates air.

HVAC UNIT DESCRIPTION AND MARK	SAF HP	OA Available Y/N	Damper Position O/C	Damper Operable Y/N	Existing Filter Size	VFD	Existing MERV	Should MERV be increased Y/N	Proposed MERV and Thickness	Initial APO Proposed
Attic AHU	7.5 HP 1.15 SF	Y	NA	NA	2"	N	NA	Y	2" – 13	TBD
Resident Room FCU's	Fractional	N	NA	NA	1"	N	7	13	1" – 13	TBD

IS THERE REASON TO BELIEVE THAT UNFILTERED OA IS ENTERING THE BUILDING? (SPACE PRESSURIZATION REQUIRED)	Y	N	COMMENT:	
CAN OA BE INCREASED	Y	N	COMMENT:	Possibly; the OA opening looks as if intended for economizer however, the return fan discharges directly into the OA plenum box so there is a concern for backpressure of return air against outside air. The design is not standard.
10 FT SEPARATION AT OA AND EA	Y	N	COMMENT:	NA
IS ADDITIONAL PURIFICATION BENEFICIAL TO THE BUILDING	Y	N	COMMENT:	In gathering spaces (e.g., dining rooms and conference rooms)
ERU PRESENT	Y	N	COMMENT:	
CAN HVAC EQUIPMENT BE OPERATED 24/7	Y	N	COMMENT:	
IS DCV LIKELY PRESENT	Y	N	COMMENT:	

NOTES:	

STRATEGIES AND CHALKBOARD

STRATEGIES

1. Change filters in attic AHU to 2" MERV-13.
2. Consider experimenting with 1" MERV -13 filters in the fan coil units. This will significantly increase the effectiveness of filtering within the rooms; the caution is the motor horsepower is fractional.
3. Given the discourse addressing bubbles and the fact that air handling units serve areas adjacent to resident rooms, providing MERV-13 minimum filters at the air handling units in addition to portable HEPA filters with UV-C within the breathing zone of resident rooms and in gathering areas is prudent.

CHALKBOARD

(Not Applicable)

DOCUMENTATION

Building Name: Anderson Barracks (Sommerville Barracks identical), Quincy Veterans' Home

Basic HVAC System Description: Air handling unit system with DX cooling and steam humidification; two air handling units are located in the basement, two are located in the attic. These systems provide cooling for the building. These air handling units are not operated in the winter time.
Heating is steam based perimeter type. There is no mechanical ventilation for this building in the winter.

HVAC UNIT DESCRIPTION AND MARK	SAF HP	OA Available Y/N	Damper Position O/C	Damper Operable Y/N	Existing Filter Size	VFD	Existing MERV	Should MERV be increased Y/N	Proposed MERV and Thickness	Initial APO Proposed
AHU-1, 2, 3 and 4	2.5 HP 1.15 SF	Y	O	Y	2"	N	8	N		

IS THERE REASON TO BELIEVE THAT UNFILTERED OA IS ENTERING THE BUILDING? (SPACE PRESSURIZATION REQUIRED)	Y	N	COMMENTS:	Bathroom exhaust will draw a negative pressure on the building in the winter since no mechanical ventilation is present.
CAN OA BE INCREASED	Y	N	COMMENTS:	OA is presently minimum, duct size is approximately 14" by 8"; can be changed but will require redesign of OA ducting and evaluation of coil capacity.
10 FT SEPARATION AT OA AND EA	Y	N	COMMENTS:	NA
IS ADDITIONAL PURIFICATION BENEFICIAL TO THE BUILDING	Y	N	COMMENTS:	Given that no mechanical ventilation exists during the winter and only a minimal amount of ventilation air can be drawn in the summer, and that filter change is unlikely due to small fan horsepower, we recommend portable HEPA with UV be considered in each resident room and within gathering areas.
ERU PRESENT	Y	N	COMMENTS:	
CAN HVAC EQUIPMENT BE OPERATED 24/7	Y	N	COMMENTS:	
IS DCV LIKELY PRESENT	Y	N	COMMENTS:	

NOTES:	

STRATEGIES AND CHALKBOARD

STRATEGIES

1. Given the discourse addressing bubbles and the fact that air handling units serve areas adjacent to resident rooms, providing MERV-13 minimum filters at the air handling units in addition to portable HEPA filters with UV-C within the breathing zone of resident rooms and in gathering areas is prudent.
2. Strategies are limited in this building due to small supply fans and minimal OA ducting. A discussion ought to ensue to develop an understanding of the history of infection; perhaps larger capital investment is warranted.

CHALKBOARD

(Not Applicable)

DOCUMENTATION

Building Name: Schapers Hospital, Quincy Veterans' Home

Basic HVAC System Description: 4 – pipe chilled water, steam to heating water zoned air handling units. No perimeter heat; all-air system.

HVAC UNIT DESCRIPTION AND MARK	SAF HP	OA Available Y/N	Damper Position O/C	Damper Operable Y/N	Existing Filter Size	VFD	Existing MERV	Should MERV be increased Y/N	Proposed MERV and Thickness	Initial APO Proposed
S-1	7.5 1.15 SF	Y	O	Y	2"	N	8	Y	2" – 13	TBD
S-2	5.0 1.10 SF	Y	O	Y	2"	N	8	Y	2" - 13	TBD
S-3	10.0 1.15 SF	Y	O	Y	Roll	N	TBD	N		

IS THERE REASON TO BELIEVE THAT UNFILTERED OA IS ENTERING THE BUILDING? (SPACE PRESSURIZATION REQUIRED)	Y	N	COMMENTS:	
CAN OA BE INCREASED	Y	N	COMMENTS:	Subject to coil capacity verification.
10 FT SEPARATION AT OA AND EA	Y	N	COMMENTS:	
IS ADDITIONAL PURIFICATION BENEFICIAL TO THE BUILDING	Y	N	COMMENTS:	We recommend additional HEPA filtration at gathering locations; e.g., dining, conference rooms.
ERU PRESENT	Y	N	COMMENTS:	
CAN HVAC EQUIPMENT BE OPERATED 24/7	Y	N	COMMENTS:	
IS DCV LIKELY PRESENT	Y	N	COMMENTS:	

NOTES:	

STRATEGIES AND CHALKBOARD

STRATEGIES

1. Increase filtration to 2" MERV-13 at AHU's S-1 and S-2. Due to its roll filter, modification of AHU-3 will be required to increase efficiency. A discussion ought to ensue to consider capital investment.
2. Given the discourse addressing bubbles and the fact that air handling units serve areas adjacent to resident rooms, providing MERV-13 minimum filters at the air handling units in addition to portable HEPA filters with UV-C within the breathing zone of resident rooms and in gathering areas is prudent.

CHALKBOARD

(Not Applicable)

DOCUMENTATION

Building Name: Adjutant Illinois Veterans' Home, Anna, IL

Basic HVAC System Description: Resident Rooms: Through-the-wall Heat Pump Units with outside air capability (70 CFM each) and thin plastic mesh filters. Bathroom exhaust is controlled via a time switch. Common areas are served by 5 rooftop units providing heating and cooling for the space served; each RTU was designed for introduction of outside air; these are recirculating type units.

HVAC UNIT DESCRIPTION AND MARK	SAF HP	OA Available Y/N	Damper Position O/C	Damper Operable Y/N	Existing Filter Size	VFD	Existing MERV	Should MERV be increased Y/N	Proposed MERV and Thickness	Initial APO Proposed
Resident Room Heat Pump	Fractional	Y	NA	NA	¼"	N	NA	N		
RTU's -1, 2, 3, 4 and 5	Largest is 3 HP	Y	O	Y	2"	N	8	N		

IS THERE REASON TO BELIEVE THAT UNFILTERED OA IS ENTERING THE BUILDING? (SPACE PRESSURIZATION REQUIRED)	Y	N	COMMENTS:	
CAN OA BE INCREASED	Y	N	COMMENTS:	
10 FT SEPARATION AT OA AND EA	Y	N	COMMENTS:	Manufactured rooftop units seldom accompany this requirement.
IS ADDITIONAL PURIFICATION BENEFICIAL TO THE BUILDING	Y	N	COMMENTS:	
ERU PRESENT	Y	N	COMMENTS:	
CAN HVAC EQUIPMENT BE OPERATED 24/7	Y	N	COMMENTS:	
IS DCV LIKELY PRESENT	Y	N	COMMENTS:	This was not determined on the site visit; follow-up is required.

NOTES:	

STRATEGIES AND CHALKBOARD

STRATEGIES

1. We believe the original design intent is for introduction of outside air to come through the through-the-wall heat pump units, providing make-up air for bathroom exhaust. The bathroom exhaust is on a time switch; outdoor air will come through the heat pump whenever it is operating, which is subject to the room thermostat, so when the room thermostat is not calling for heating or cooling, there is no outdoor air being introduced via the heat pump unit; given the bathroom exhaust is on a timer switch and outdoor air only comes into the resident room only when the heat pump is operating, there is not a constant exchange of air within the room nor a constant source of code-required outdoor air coming into the room. Filter upgrade within the resident room heat pump unit is not possible. Therefore, there is a concern that viral load will increase within the resident room; portable HEPA filters with UV-C are recommended. Long-term, the ventilation scheme within the room should be further considered for replacement.
2. The largest fan motor size for the roof top units is 3 HP, therefore we do not believe change of filters from MERV-8 to MERV-13 is appropriate.
3. Because of approaches taken with the original HVAC system design, 1) various components lack ability to make improvements (e.g., resident room heat pump units and common area rooftop units do not have sufficient fan horsepower to accept high-efficiency filters); 2) due to the space thermostat cycling on/off the heat pump unit, the airflow exchange rate within resident rooms is not constant; 3) various components cannot take on extra outside air (since they are smaller DX units, the rooftop units cannot accept appreciably higher rates of outdoor air in order to dilute concentration of contaminants and increase the air exchange rate within the building); and 4) because the resident room heat pump units are not bringing in a constant volume of outdoor air and the toilet exhaust is not constant therefore room air exchange rate ranges vary from minimal to zero, the Facility Manager is left without a layered approach incorporating multiple infection control measures to mitigate airborne pathogens that cannot be reduced by one method to become reduced by another method. Therefore, in addition to the portable HEPA filters with UV-C, we recommend installing UV-C disinfection systems in the return ducts of the rooftop units if the engineering analysis proves it feasible; i.e., velocity analysis is required as is validating adequate length of duct run necessary to produce disinfection residence time. Recall that the rooftop units likely provide a positive pressure in the corridors which pushes air into the residence rooms; this fact places a higher degree of concern for air quality at the rooftop units.

CHALKBOARD

1. The Roof Top Units only serve common areas; they do not distribute air to the resident rooms. Outdoor air is coming into each RTU, as follows: RTU-1, 900 CFM; RTU-2, 650 CFM; RTU-3, 1,700 CFM; RTU-4, 1,000 CFM; RTU-5, 750 CFM. We assume the outdoor air will positively pressurize the corridors relative to resident rooms; this is a favorable condition relative to airborne transmission of bioaerosols if the assumption is increasing viral load is more likely within the resident rooms than within common spaces. The original design may have utilized outdoor air available from the roof top units as a way to offset bathroom exhaust in the event the through-the-wall heat pump unit is off; air would have to make its way into the room via undercut of the door or other viable means. In any event, the design intent seems to be for the corridors to be positively pressurized relative to the resident rooms.
2. Anna has constructed an isolation ward; residents exhibiting COVID-19 symptoms are moved to this building; this building is separate from the rest of the facility. This reduces the likelihood of build-up of viral load in a shared resident room or other parts of the main facility.
3. Roof top units are DX based thus the ability to increase outdoor air rates without causing other problems is doubtful.
4. Staff reported five confirmed cases of COVID-19 in May of 2020, one in September and one in November of 2020.

DOCUMENTATION

Building Name: Resident R1, Resident R2, Resident R3 and Resident R4, Manteno Veterans' Home

Basic HVAC System Description:

Resident Wing Air Handling Systems

Original Design: Five air handling systems per Resident Building; four of the air handling systems serve respective resident wings and each serves half of the adjacent nursing station. A fifth air handling unit serves the common area between the two wings. Each air handling unit is 4-pipe chilled water, heating water, located in a crawl space under the building serving its respective wing; air distribution is constant volume with hot water reheat coils. A room thermostat will modulate the heating water valve of the hot water reheat coil to add heat to the incoming air stream in the event the quantity of air exceeds that required for satisfying the cooling load. Heating in the resident rooms is accomplished by ceiling mounted radiant heating panels; control is thought to be interfaced with the thermostat serving the VAV box and reheat coil. Each air handling unit has a supply fan; a separate return fan draws air from the return duct system and discharges into the rear of the air handling unit. Neutral pressure is provided in resident rooms; positive pressure is provided in adjacent corridors; air is returned to the air handling unit from resident rooms and adjacent corridors. Exhaust systems in each wing receive make-up air from the air handling unit, including the resident room bathroom; outside air is introduced at the air handling unit. Filters reside at the air handling unit and these are rated MERV-8. Resident Buildings R3 and R4 have retained this design since their construction. Supply air fan is 10 HP; return air fan motor sizes vary, most are 5 HP, a couple are 7.5 HP.

Isolation Design: Buildings R1 and R2 have undergone modification; the original design scheme as described above is a possible operation strategy. However, the air handler serving each of the following wings has been modified so it can also be operated in isolation mode.

- R1: West Wing, South
- R1: East Wing, South
- R1: West Wing, North
- R2: West Wing, North
- R2: East Wing, North
- R2: East Wing, South
- R2: West Wing, South

To ascertain the sequence of operation in the isolation mode, we began with an analysis of the air exchange rate within each resident wing.

Air quantities were measured and recorded for the air handling systems providing isolation service; the company performing the test and balance work is International Test & Balance; figures are recorded in their report. We could not find a comprehensive date on the report; dates which are included in the report are anticipated to be dates of measurement and extend from April 18, 2020 to November 24, 2020. The author is not aware if this report has been accepted by the A/E of Record. This report only includes measured air quantities for the air handling units converted to isolation; we have no other measured values for the many other air handling systems operating at Manteno. With the exception of R1 East Wing, South, the rate of outside air as a percentage of supply air is about

20%; R1 East Wing, South is at 30%; unit modification did not extend to making these air handling units capable of 100% of outdoor air; the author was informed by the Chief Engineer that conversion was contemplated but the cost and time to reconstruct all of these air handling units was deemed infeasible. Of note, in the isolation mode, four of the six air handling systems which can operate in an isolation mode are drawing in less outdoor air than when operating in the non-isolation mode; pertaining to the other two air handlers capable of operating in an isolation mode, more outdoor air is drawn into the air handling unit in the isolation mode than when in the non-isolation mode, albeit not significantly more. We conclude that the designer intended for the air handling systems to draw air from other parts of the building when trying to create additional air exchanges within resident rooms, such that air moved into a given isolation wing from adjacent parts of the building (the entire building is interconnected so it's a viable strategy), rather than increasing outdoor air rates at each air handling units as a means of increasing air exchange rates within the resident rooms. When in the non-isolation mode of operation, the rate of outside air is very similar at each air handling unit. All of this background is to inform the reader that we believe the designer may have considered increasing outdoor air rates as a tool to dilute contaminants within the resident rooms but came to the conclusion that it was not feasible, choosing instead to employ HEPA filtration and UV disinfection; we believe given the need for expediency and working as best possible with the constraints presented to them by the HVAC system design, the approach is prudent. To accomplish this mode of operation, each of the five air handling systems were modified as follows:

- Upon review of the International Test & Balance report for the 7 air handling systems which were converted to isolation function, it appears the intent of the design is for the resident room to be of neutral pressure when in the non-isolation mode of operation; after balancing, the resident rooms are slightly negative. In the isolation mode of operation, the supply air rate into the resident rooms closely approximates the supply air rate when in the non-isolation mode; the return air rate is increased significantly more than when in the non-isolation mode, increasing air exchange rates in the isolation mode and routing return air through ceiling mounted HEPA filters which were installed as part of the conversion to isolation capability. The air handling unit has not been converted to 100% outdoor air; it appears the intent is to increase air exchange rates as much as possible and filter air with through high-efficiency HEPA filters; the air handling unit remains recirculating. Return fan motor sizes were not changed from the original design to account for more air pressure drop associated with addition of the HEPA filters; motor size listed in the International report is the same size whether in non-isolation mode or isolation mode (written this way for the non-HVAC educated reader), the smallest of which is 5 HP, a couple are 7.5 HP. The fact that return motors were not changed in the isolation air handling systems despite the additional pressure drop associated with HEPA filters gives reason to believe that the motors had additional capacity to take on this additional pressure drop; this gives reason to believe the supply and return fan system can absorb additional air pressure drop associated with MERV-13 minimum filters recommended for change at the mixing box (replacing MERV-8 filters) as hereinafter mentioned. 75% of resident rooms have more than one resident; given the concern for bubble formation around breathing zones, we are recommending portable HEPA filters with UV-C in non-isolation wings; to be consistent, we are also recommending to operate the isolation wing air handling systems in isolation mode, returning air through HEPA filters, throughout the pandemic. The isolation air handling units also have UV-C lights installed in them. With this approach, equity is attained in all resident rooms; HEPA filtration and UV disinfection.
- A damper was installed in the return duct connected to the original return grille; this damper closes when the air handling unit is operating in the isolation mode, forcing all return air from the resident rooms through the ceiling mounted HEPA filters.
- An electric heating coil was installed to heat incoming supply air, presumably because the designer was trying to increase the air exchange rate in the room due to the change to isolation and the existing hot water reheat coil was insufficiently sized. We speculate it was easier use electric heat than it was to find additional boiler capacity or find room for a new boiler room.
- Variable frequency drives were added to the supply and return air fans, presumably to increase the speed of the fan to drive increasing air exchange rates within the wing. Supply air fan motors remained at 10 HP; return air fan motors remained at 5 HP or 7.5 HP.
- Ultraviolet lights were added; upstream of the return air fan and downstream of the cooling coil. We speculate the addition of UV is thought to provide an

additional infection control measure (in addition to HEPA filters) to account for the inability to bring in 100% outdoor air (thereby reducing the concentration of contaminants in the resident rooms) and perhaps also to account for not achieving as many air exchanges in the room as hoped for due to keeping the existing HVAC system components intact. Placement of the UV light downstream of the cooling coil is a common approach in healthcare; the thought is in this location, UV light will disinfect the surface of the cooling coil which is often wet across its entire face, thus a breeding ground for mold, bacteria and other microorganisms. At this location, because UV loses its effectiveness in airstreams which are colder and possessing high relative humidity, selection of the appropriate intensity and determining an appropriate lamp installation array is imperative. I suspect the UV upstream of the return air fan is more effective than the UV downstream of the cooling coil but it must also be said that the UV upstream of the return fan is treating air after the HEPA filters, which should be 99.99% efficient at .3 micron or less particle capture.

- Resident room bathroom exhaust and other exhaust within the isolation wing are collected into a duct system and expelled to the ambient, requiring the air to pass through a HEPA filter upstream of the exhaust fan. Exhaust airflow rates from resident rooms remained unchanged; meaning, the rate of bathroom exhaust, in CFM, is identical for both isolation and non-isolation modes of operation. This further establishes that the intent of design was to achieve additional exchange rates through the recirculating, i.e., return side of the air handling system, and not via introduction of more outdoor air, thereby enabling an increase in exhaust rates.
- MERV-8 filters were left in the air handling unit.
- Most isolation resident rooms are double resident, some are single resident and a few are four residents per room.

Alzheimer's Wing

This air handling unit is 4-pipe chilled water, heating water; air distribution is constant volume with hot water reheat coils. A room thermostat modulates the heating water valve of the hot water reheat coil to add heat to the incoming air stream in the event the quantity of air exceeds that required for cooling. The air handling unit has a supply fan; a separate return fan draws air from the return duct system and discharges into the rear of the air handling unit. Neutral pressure is provided in resident rooms; positive pressure is provided in adjacent corridors; air is returned to the air handling unit from resident rooms and adjacent corridors. Exhaust systems in each wing receive make-up air from the air handling unit, including the resident room bathroom; outside air is introduced at the air handling unit. Filters reside at the air handling unit and these are rated MERV-8. Supply air fan is 20 HP; return air fan is 15 HP.

HVAC UNIT DESCRIPTION AND MARK	SAF HP	OA Available Y/N	Damper Position O/C	Damper Operable Y/N	Existing Filter Size	VFD	Existing MERV	Should MERV be increased Y/N	Proposed MERV and Thickness	Initial APD Proposed
R1, R2, R3, R4, R5 (per building)	10	Y	O	Y	2"		8	Y	MERV-13, 2"	
Alzheimer's Wing AHU-01	20	Y			2"		8	Y	MERV-13, 2"	

IS THERE REASON TO BELIEVE THAT UNFILTERED OA IS ENTERING THE BUILDING? (SPACE PRESSURIZATION REQUIRED)	Y	N	COMMENTS:	
CAN OA BE INCREASED	Y	N	COMMENTS:	
10 FT SEPARATION AT OA AND EA	Y	N	COMMENTS:	
IS ADDITIONAL PURIFICATION BENEFICIAL TO THE BUILDING	Y	N	COMMENTS:	
ERU PRESENT	Y	N	COMMENTS:	
CAN HVAC EQUIPMENT BE OPERATED 24/7	Y	N	COMMENTS:	
IS DCV LIKELY PRESENT	Y	N	COMMENTS:	

NOTES:	

STRATEGIES AND CHALKBOARD

STRATEGIES

1. Operate the isolation capable air handling systems in isolation mode. Doing so will utilize the ceiling mounted HEPA filters, cleansing the air. UC disinfection will also assist in cleansing the air. If for some reason, there is resistance to this tactic, change the MERV-8 filters in the mixing box to MERV-13 minimum and continue to operate the UV disinfection.
2. Change the MRV-8 filters in all air handling systems, isolation and non-isolation, to MERV-13 minimum; there is no other means of higher efficiency removal of contaminants by filtration or disinfection by UV in the outdoor air stream. Supply fan motors are of the size that we have had success implementing this strategy at other institutions.
3. Driven by a concern that bubbles of higher viral load can exist within the resident room because air exchange rates and outdoor air rates within the breathing zone are meant to control but not assure asepsis, with the conviction that every prudent measure possible is being taken, install portable HEPA filters with UV-C as close as possible to the breathing zone. We considered installing a UV array in the return air system, similar to what was done in the isolation wings, a prudent additional disinfection measure. In the isolation wings, an attempt has been made to increase the air exchange rate within the resident room; this has not been done in non-isolation air handling systems. We believe installing the portable HEPA filter with UV-C disinfection offers the opportunity to increase the air exchange rate at the breathing zone, something that is not equally attainable with the central HVAC system. We believe increasing the air exchange rate within the breathing zone is of "higher order of importance" than installing UV disinfection in the return air system with its lower rate of air exchange….simply, if HEPA filtration, UV disinfection and a higher rate of air exchange can be achieved in the breathing zone, why consider less-than-HEPA filtration efficiency and a lesser rate of air exchange, albeit UV disinfection can be achieved in both instances? The advantages of portable HEPA filtration with UV disinfection are obvious. MERV-13 minimum filters at the air handling unit pertain to both scenarios so their advantage is not unique. Given our conviction that increasing outdoor air rates was deemed infeasible; additionally changing fan drive assemblies to achieve more airflow or installing variable frequency drives to increase the speed of fans to drive increasing air exchange rates will take time, we believe the most expedient and efficacious measure is to install portable HEPA filters with UV-C disinfection located within the breathing zone of the resident rooms. This approach is recommended for air handling systems serving the Resident Buildings R1, R2, R3, R4 and R5 and the Alzheimer's Wing.
4. Ensure demand controlled ventilation strategies are disabled during the pandemic.

CHALKBOARD

1. Of interest, when on site, I came to the understanding through conversation with the Chief Engineer, that HEPA filters were installed in the ceiling of resident rooms within isolation units, and that these filters were connected to the air handling system return air system. A review of the conditions pertaining to the 5 HP return fan motor in the isolation air handling system serving R1, West Wing, South reveals that the duct static pressure in the non-isolation mode of operation was recorded as -1.2 inches of water column; VFD was set at 42 Hz. For the same motor operating in the isolation mode of operation, duct static pressure was recorded as -1.32 inches of water column; VFD was set at 43.3 Hz. We do not know the characteristics of the installed HEPA filter nor if duct conditions were improved but we would normally expect much more air pressure drop for the system when operating in the isolation mode due to significantly more air pressure drop associated with HEPA filtration. Inasmuch as the aforementioned evaluation is largely based on our understanding that bonafide HEPA filtration is indeed installed in the return system for the resident rooms, confirmation of the installed product and its characteristics is prudent. It may be such that in the non-isolation mode, some return air draws through the HEPA filters and some draws through the non-isolation mode return air grille. The author will follow-up with the Chief Engineer.

DOCUMENTATION

Building Name: LaSalle Veterans' Home

Basic HVAC System Description:

Resident Wing D & F and Office Wing E

There are four main elements to the HVAC system serving these portions of the LaSalle Veterans' Home, as follows:

1. Recirculating HVAC system serving the corridors and common spaces of each resident wing and office wing. The recirculating HVAC system serving Resident Wing D and the western half of the Office Wing E (identified as AHU 02W) is identical to the HVAC system serving Resident Wing F and the eastern half of Office Wing E (identified as AHU 03E). Each HVAC systems is a standard variable air volume system comprised of four-pipe heating and cooling coils, hot water reheat coils in the VAV boxes, filter/mixing box, supply fan and return fan separate from the air handling unit with its own filtration system located in the discharge of the return fan. The outdoor air rate for each air handling unit is set at approximately 30% of the supply air rate. Effective June 1, 2020, Facility Management changed filters in the air handling unit mixing/box to MERV-14 and also changed the 2" filters in the Farr Glide Pak filter box located at the discharge of the return fan to MERV-14. The introduction of outdoor air at this air handling unit will positively pressurize corridors adjacent to resident rooms.
2. 100% outdoor air system, constant volume, providing code required outdoor air and makeup air for bathroom exhaust in all resident rooms of Resident Wings D and F. Unit is DX, with hot water preheat section with face and bypass control, reheat coil to accomplish dehumidification cycle and adjust discharge air temperature, 5 HP supply fan, and flat filter box housing 2" MERV-7 filters.
3. A four-pipe, vertical fan-coil unit is located in each resident room, near the exterior wall. Originally, a 4" duct brought outdoor air into the unit, connecting a louver through the wall to the fan-coil unit. Likely when the 100% outdoor air unit was installed (as addressed above in Item 2.) this duct was removed and a cap installed at the louver. Heating and cooling is controlled by a room thermostat. This unit will discharge air at about a 7' level, returning through a grille located about 2' above the finished floor. Each fan-coil unit has a 1" filter; supply fan motor HP is fractional.
4. Bathroom exhaust within resident rooms and other spaces requiring exhaust is connected to a common duct, connected to a constantly operating exhaust fan discharging to ambient.

Resident Wings A (AHU-01) and C (AHU's-05 and 06)

Each air handling unit serving these two wings is a constant volume 100% outside air unit, providing heating and cooling and code required outdoor air for the resident rooms within this wing; it also provides make-up air for bathroom exhaust and other exhaust requirements within the wing. The unit has a chilled water coil and a heating water coil located downstream of the chilled water coil; both coils are located downstream of an energy recovery wheel section, exchanging heat from exhaust air streams from the wing to incoming outdoor air in the winter and absorbing heat into the exhaust airstream from incoming outdoor air during summer. Given the location of the heating coil, it is expected that it also provides reheat control during a dehumidification cycle. The unit also has a flat filter on the incoming outdoor air stream and a filter section upstream of the cooling coil; 6 HP supply fan and a separate 3 HP exhaust fan. Facility Maintenance have expressed a preference for installation of an additional heating coil upstream of the chilled water coil to protect the chilled water coil from freezing in the event of failure of the energy recovery wheel and the uncertainty whether or not the heating coil has the capacity to heat air from -10 degree F. (or less) to 90 degrees F. (or more) as required for space heating; this author agrees with this concern for all three air handling units. Presently, the practice is to drain the chilled water coil in the winter as a freeze-prevention measure; this requires refilling the coil in the spring, venting air, and adjusting water chemical treatment; all of this could be avoided and only done in a fail-safe mode if a preheat heating coil was installed. Effective June 1, 2020, Facility Management changed filters in outdoor airstream flat filter box and in the air handling unit filter box to MERV-14.

Recently, C wing has become an isolation wing; Air Handling Units 05 and 06 were unaltered in function and sequence of operation. However, modifications were made to the resident rooms, as follows:

- Installation of an exhaust system which is comprised of an exhaust grille in the resident room. This grille is now ducted to the bathroom exhaust grille; the two of them are connected to an exhaust fan on the roof. In the duct connecting the new resident room exhaust grille, a motorized open or closed damper was installed the purpose of which is to allow the resident room to operate in isolation mode or in non-isolation mode. When in non-isolation mode, the only exhaust from the exhaust system is bathroom exhaust; make-up air for bathroom exhaust is provided by transfer of outdoor air coming into the resident room from AHU-05 or AHU-06. Although not able to verify by actual measured and recorded airflows and pressure readings, presumably this exhaust system keeps the resident rooms under negative pressure relative to surrounding spaces within the building.
- Two new grilles were placed in each resident room; one is drawing air from the room and the other is supplying air to the room. Both grilles are connected by the same simple U-shaped duct system; a fan resides in the center of the horizontal leg of the "U"; on the discharge side of the fan is a HEPA filter, supplying very clean air to the room. The purpose of this system is to increase the air exchange rate in the resident room and move the air through a high-efficiency HEPA filter.
- The Nursing Station remained under positive pressure, thus the corridors adjacent to the resident rooms and other rooms in this wing, remain under positive pressure relative to the resident rooms.
- Although not observed, it is presumed the building automation system was enhanced to provide digital control of required pressure relationships.

<u>Dining and Administration</u>

Three air handling systems serve these two areas; each combines units with 100% outdoor air capability with recirculating type units.

HVAC UNIT DESCRIPTION AND MARK	SAF HP	OA Available Y/N	Damper Position O/C	Damper Operable Y/N	Existing Filter Size	VFD	Existing MERV	Should MERV be increased Y/N	Proposed MERV and Thickness	Initial APO Proposed

IS THERE REASON TO BELIEVE THAT UNFILTERED OA IS ENTERING THE BUILDING? (SPACE PRESSURIZATION REQUIRED)	Y	N	COMMENTS:	
CAN OA BE INCREASED	Y	N	COMMENTS:	Building is chilled water however experience informs that although there may be some capacity to increase outdoor air, it will very limited.
10 FT SEPARATION AT OA AND EA	Y	N	COMMENTS:	
IS ADDITIONAL PURIFICATION BENEFICIAL TO THE BUILDING	Y	N	COMMENTS:	
ERU PRESENT	Y	N	COMMENTS:	
CAN HVAC EQUIPMENT BE OPERATED 24/7	Y	N	COMMENTS:	
IS DCV LIKELY PRESENT	Y	N	COMMENTS:	

NOTES:	

STRATEGIES AND CHALKBOARD

STRATEGIES

1. We do not believe it feasible to install 1" MERV-13 filters in the resident room fan-coil units; this may be trialed on an experimental basis to see if the fractional fan motor can sustain operation.

   However, given the concern for bubble formation around breathing zones in resident rooms, we are recommending portable HEPA filters with UV-C in non-isolation wings; to be consistent, we are also recommending to operate the isolation wing air handling systems in isolation mode throughout the pandemic. With this approach, equity is attained in all resident rooms; increasing air exchange at the breathing zone, and HEPA filtration with UV disinfection.

2. Change filters on incoming outdoor air intakes to 2" MERV-14; this pertains to all 100% outdoor air systems. Monitor supply fan for possible overloading conditions and also delivered supply air quantities; adjustment of supply fan drive assembly may be necessary.
3. Ensure demand controlled ventilation strategies are disabled during the pandemic.

CHALKBOARD

1. Given the existence of 100% outdoor air units in all resident room applications, there is nothing more that can be done with increasing outdoor air rates to dilute contaminants.
2. Facility Maintenance have already changed filters at most existing filter racks housing 2" filters to MERV-14; HVAC system operation has continued successfully since replacement. This knowledge circumvents the need to assess existing motor sizes and make a corresponding recommendation for filter change.
3. The facility has made a decision to install UV disinfection in several air handling units. On December 29, the Facility Chief Engineer, Mr. Rodney Wangelin called the author asking for recommendations as to where to locate new UV arrays. On December 31, the author spoke with Mr. Wangelin recommending locations for UV disinfection; Mr. Wangelin was in agreement with the recommendations, as follows:

   a. AHU 02W and 03E: within main return duct before connection to air handling unit, given assessment of airstream velocity and available space. We acknowledged the existence of MERV-14 filters at the air handling unit, which would normally lead to a diminished need for UV disinfection right upstream of the filter however, in the interest of doing everything reasonably possible to prevent airborne transmission, we agreed to pursue the approach. We also discussed installation of a UV array downstream of the cooling coil. We acknowledge UV has benefit in this application but that it's a much more challenging installation due to the restricted space, the cool airstream (driving the need for greater intensity) and the higher relative humidity (also driving the need for greater intensity) so assessment of constraints imposed thereof relative to benefit ultimately obtained should be conducted before a final decision is made to install UV disinfection at this location; it may be in the final analysis, a UV array at this location may prove more beneficial against mold development and other microorganism survivability than against COVID-19 virus survivability.

4. 100% outdoor air handling units: accompanying AHU 02W and 03E; AHU-01; AHU's-05 and 06 in the Isolation, or C-Wing; and air handling units serving Dining and Administration: within main exhaust duct before connection to energy recovery wheel section of the air handling unit, given assessment of airstream velocity and available space within the exhaust duct. A UV array at this location will reduce survivability of microorganisms which may otherwise land intact on the incoming side of the wheel during exhaust only to become buoyant again in the incoming outdoor airstream. The energy recovery wheels at LaSalle do not otherwise have the capacity for 2" MERV-14 filter placement upstream of the wheel.

DOCUMENTATION

Building Name: Chicago Veterans Home

Basic HVAC System Description: Resident Rooms: 4 DOAS rooftop units with energy recovery and chilled and heating water coils provide code required ventilation and bathroom exhaust make-up air; four pipe fan coil unit provide heating and cooling for resident room space temperature control.

HVAC UNIT DESCRIPTION AND MARK	EAF HP	OA Available Y/N	Damper Position O/C	Damper Operable Y/N	Existing Filter Size	VFD	EA Existing MERV	Should MERV be increased Y/N	Proposed MERV and Thickness	Initial APD Proposed
DOAS RTU 1, 2, 3, and 4	10	Y	O	Y	2"	Y	8	Y	13 - 2"	TBD

IS THERE REASON TO BELIEVE THAT UNFILTERED OA IS ENTERING THE BUILDING? (SPACE PRESSURIZATION REQUIRED)	Y	N	COMMENTS:	
CAN OA BE INCREASED	Y	N	COMMENTS:	
10 FT SEPARATION AT OA AND EA	Y	N	COMMENTS:	Separation is not achieved at DOAS units; exhaust is filtered but with MERV-8. This is a manufactured item.
IS ADDITIONAL PURIFICATION BENEFICIAL TO THE BUILDING	Y	N	COMMENTS:	We recommend additional HEPA filtration at gathering locations on floors.
ERU PRESENT	Y	N	COMMENTS:	OA has MERV-13 filters.
CAN HVAC EQUIPMENT BE OPERATED 24/7	Y	N	COMMENTS:	It is controlled to operate 24/7. Purge is constant.
IS DCV LIKELY PRESENT	Y	N	COMMENTS:	

NOTES:	

STRATEGIES AND CHALKBOARD

STRATEGIES

1. Change DOAS exhaust air (upstream of energy recovery wheel) filters to 2" thick MERV-13; refer to CHALKBOARD discussion which follows. This will protect the heat recovery wheel from capturing bioaerosols which can then be released into the incoming outdoor air stream.
2. Given the discourse addressing bubbles, providing portable HEPA filters with UV-C within the breathing zone of resident rooms and in gathering areas is prudent. Where resident rooms are single occupancy, installation of a 1" MERV-13 filter in the fan coil unit should be explored. If there are more than one resident per room consider portable HEPA with UV-C units located within the breathing zone.

CHALKBOARD

1. Concentrations of bioaerosols in outdoor air is expected to be significantly less than in indoor air; given that the DOAS unit is 100% outdoor air there is an argument to be made that a MERV-8 filter is a reasonable approach; our thinking is that given the virulent nature of the COVID virus, it is more prudent to achieve as high a filter efficiency as can be gained within the limits of fan horsepower. The DOAS units are so tightly constructed that it is doubtful they can accept the addition of UV light and/or bi-polar ionization; mounting these devices in all of the roof-top mounted supply air ducts does not appear feasible nor necessary if filtration is achieved as recommended.