2/17/2020

Ventilation Assessment for

Unitarian Church of Montpelier

Montpelier, Vermont

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I. Introduction

Cx Associates (CxA) conducted a site visit of the Unitarian Church of Montpelier (UCM), in Montpelier, Vermont to assess the building's needs with respect to reducing the transmission of COVID-19 and addressing indoor air quality (IAQ) concerns related to the lack of ventilation (fresh air) supply of the heating air conditioning systems.

This report summarizes the findings of our study and proposed recommendations for IAQ improvements associated with the mechanical systems. We have also added general industry guidelines and recommendations based on current best practices from the CDC[1] and ASHRAE[2] as shown in Appendix A. Although many of these guidelines do not apply to the UCM, we include them as a background to what the industry and the CDC are advising on a variety of mechanical systems.

BACKGROUND

The February 11, 2021 walk-through of the UCM included a review of heating equipment and the interior spaces with three members of the Board of Trustees. The goal of this site visit was to assess the current ventilation and filtration operation and building-wide heating, ventilation, air conditioning (HVAC) issues in order to address COVID-19 transmission mitigation and IAQ concerns. The church has not been holding meetings, events, or services since March 2020 as there is no ventilation (fresh) air supply to the building. UCM is investigating how to address the COVID pandemic ventilation requirements so as to return to small in-person meetings and limited-capacity services. Additionally, they have checked CO_2 levels during past full occupancy periods and know that the levels are much higher than is recommended by the industry (ASHRAE), which is uncomfortable and could be unhealthy.

[1] Center for Disease Control (CDC)

[2] American Society of Heating, Ventilation, Refrigeration and Air Conditioning Engineers (ASHRAE).

SUMMARY OF RECOMMENDATIONS

This report details our findings of the existing systems and has developed recommendations for HVAC system improvements. In summary, we recommend:

- Installing heat recovery units (HRVs) at the UCM to bring fresh air into the buildings for comfort as well as for COVID transmission mitigation. HRVs are plate heat exchangers which use exhaust building air to pretreat (either heating or cooling) the incoming outside air. These units are +85% efficient at capturing the drybulb temperature of the building exhaust air and HRVs do not mix exhaust air with ventilation supply air so there is no chance of cross contamination. HRVs will improve the efficiency of introducing ventilation air into the building immensely. They are also eligible for Efficiency Vermont incentives.

- Installing MERV 13 filters in the existing heating units.

Of note: the building has remained open since March 2020 and there is no concern for potable water contamination due to stagnant water in the system. For this reason, we have not addressed this potential issue of the COVID pandemic.

Cx Associates developed the following recommendations and initial high-level cost estimates:

Table 1: Summary of Recommendations

ID	Measure Description	Estimated Cost
M-1	Design and install (4) HRVs plus ductwork and controllers	$30,000 - $40,000
M-2	Increase AHU filtration and confirm no filter bypass (includes cost of (3) replacement filters)	$1,250 - $1,800
M-3	Operate exhaust fans with HRVs during the pandemic	-

These are high-level costs estimates and are highly dependent on the contractor's design time and the current cost of materials. These costs do not include estimates for in-house staff assistance time.

Cx Associates calculated the minimum airflow requirement of each proposed HRV using the maximum space occupancy levels, space square footage, and ASHRAE Standard 62.1[3] minimum ventilation requirements, These calculations are shown in Table 2 below and should be used by the design/build mechanical contractor for proper equipment selection.

Table 2. Ventilation Airflow Calculations

Room	Square Feet	Maximum Occupancy	ASHRAE 62.1 Requirement	Space CFM	HRV Sizing (CFM)
Kitchen	323	8	7.5 CFM/per + 0.12 CFM/sf	99	217
Fireplace Room	306	20[1]	5 CFM/per + 0.06 CFM/sf	118	
Vestry	1785	150	5 CFM/per + 0.06 CFM/sf	857	857
Sanctuary	2400[2]	230	5 CFM/per + 0.06 CFM/sf	1,294	1,294
Bell Tower Classroom	214	14	10 CFM/per + 0.12 CFM/sf	166	166
Total	5,028	422		2,534	2,534

[1]Based on 15sf/person
[2]Estimated from building drawings

[3] ASHRAE Standard 62.1 '*Ventilation for Acceptable Indoor Air Quality*' prescribes the amount of ventilation air in cubic feet per minute (CFM), which is calculated as CFM per person plus CFM per square foot, based on the space type.

The remainder of this report describes the findings of the site visit as well as the recommendations listed in Table 1 in more detail.

II. Existing Conditions

- The 1983 addition has hot water baseboard and the rest of the church is served by (2) hot air furnaces that circulate 100% building return air. Hot water for the mechanical equipment is served by an oil boiler.

- The domestic hot water is provided by a new 80 gallon Rheem heat pump water heater.

- The building has recently undergone an energy audit and UCM has implemented energy efficiency measures. Efficiency VT conducted a blower door test before and after the efficiency work which showed the overall air leakage was reduced from 9866 CFM_{50} to 6695 CFM_{50}. Subsequent to the blower door testing, UCM performed additional air sealing of air leakage locations identified during the blower door tests. Efficiency Vermont further recommended installing a ventilation unit that can supply 1250 CFM of outside air, but it is unsure if this value is based on maximum occupancy or building area.

- The existing ductwork is more than 70 years old, is dirty and is sealed with asbestos tape. Ductwork has not been reviewed as to whether it is sized properly to provide sufficient airflow according to current industry standards. The future proposed renovation is slated to replace this ductwork.

- As the existing equipment does not bring fresh air into the building, pre-pandemic CO_2 levels were measured at over 3,000 ppm toward end of the second Sunday church service and 4,000 ppm toward end of a (full house) 2-hour choral concert. This is an indication that, even without a pandemic, the building and its occupants would benefit from ventilation air.

- The Board has analyzed the facility's energy use and has implemented very effective energy saving behaviors, such as reducing the space temperature setpoint to 55°F when the building is unoccupied. This has resulted in an oil consumption of less than 2,000 gallons per year; this is as much as 1/3 of what would be expected from the building's U values.

- The church is currently not being used except for (1) person in the office from 9:00-5:00 Monday-Friday and an occasional, socially-distant meeting with a small number of people. There are stand-alone HEPA filters in these spaces.

- The Board was prepared to move forward with an addition, the replacement of the existing heating systems and ductwork, and the addition of cooling capacity for the entire building. This renovation/addition was put on hold due to the pandemic and it is uncertain as to when it will be revived. It is, however, a priority for the Board.

III. Recommendations

In the meeting we discussed the existing mechanical systems, the future plans for the infrastructure, and the options for adding ventilation units. Although the pandemic has brought the lack of ventilation air to the forefront, the Board is aware the facility and its occupants would benefit from consistent fresh air introduction during times of substantial occupancy. The goal of this meeting was to determine the best option for adding this capability while minimizing the impact of increased energy costs.

We strongly recommend installing heat recovery units (HRVs) at the UCM to bring fresh air into the buildings for comfort as well as for COVID transmission mitigation. HRVs are plate heat exchangers which use exhaust building air to pretreat (either heating or cooling) the incoming outside air. These units are +85% efficient at capturing the drybulb temperature of the building exhaust air and HRVs do not mix exhaust air with ventilation supply air so there is no chance of cross contamination. HRVs will improve the efficiency of introducing ventilation air into the building immensely. They are also eligible for Efficiency Vermont incentives.

The following are the details of our recommendations, as listed in Table 1 above.

A. Measure 1: Ventilation Installation

At our meeting we discussed two options for the addition of ventilation and it is Cx Associates' recommendation to pursue the second of these two options. We have included the description of Option 1 for documentation of our discussion.

1. *Heat recovery in the existing furnaces:* It is possible to design a ventilation component to be added to the existing furnaces; however, it is the intent of the church to replace the existing ductwork and furnaces within the relatively near future. For this reason, and due to the issues related to the existing condition of the ductwork, Cx Associates is not recommending this option. If, however, the Board would like to pursue this option, we recommend the following steps:
    a. Clean the inside of the ductwork
    b. Determine if the asbestos tape is penetrating the ductwork.
        i. If it is penetrating the duct, have the tape removed using all the industry precautions for asbestos abatement.
        ii. If it is not penetrating the duct, seal the tape using all the industry precautions for asbestos containment.
    c. Hire a contractor to design and install the ventilation addition to the existing furnaces. This includes a heat recovery ventilator (HRV) unit, new air intake and exhaust ductwork, new building penetrations for intake and exhaust ductwork, new connection to each of the existing hot air furnaces. HRVs should be sized for maximum occupancy and adhere to ASHRAE Standard 62.1 Ventilation Air Requirements (see Cx Associates' ventilation requirement calculations Table 2, above).
    d. Furnace fans should be programmed to operate 2 hours prior to occupancy, all throughout the occupied times, and 2 hours after occupancy. This allows for 'purging' of the building before and after occupancy and ensures fresh air is introduced all throughout occupancy. This control may require a new controller of

each furnace, as it is likely these furnaces are currently only controlled on space temperature.

2. ***Heat recovery in high use portions of building:*** this option installs HRVs for the Vestry, Sanctuary, Fireplace Room, Bell Tower Classroom, and Kitchen and it is the option we recommend pursuing. The remaining spaces can remain sparsely used until the end of the pandemic and then will receive ventilation under the future renovation/addition. This measure includes a heat recovery ventilator (HRV) unit, new air intake and exhaust ductwork, new building penetrations for intake and exhaust ductwork for each space.

   HRVs should be sized for maximum occupancy and adhere to ASHRAE Standard 62.1 Ventilation Air Requirements (see Cx Associates' ventilation requirement calculations in Table 2 above). HRVs should also be programmed to operate 2 hours prior to occupancy, all throughout the occupied times, and 2 hours after occupancy. This allows for 'purging' of the spaces before and after occupancy and ensures fresh air is introduced all throughout occupancy. HRVs can be installed with local programmable timeclocks or remote controls that can be scheduled and monitored.

   In our site visit, we reviewed where the HRV units could be installed and developed the following plan:
   a. Kitchen and Fireplace Room – HRV can be placed at ceiling level in the storage closet behind the two rooms. Outside air intake and exhaust ductwork can potentially follow the existing exhaust duct to minimize building shell penetrations. We recommend the supply and return ducts in each room be placed such that short-circuiting is minimized.
   b. Vestry – HRV can be placed in the basement and ducted through the floor, alongside (or as close to) the supply and return heating grilles. Note: match the HRV and (2) heating supply grilles next to each other and the HRV and (2) heating return grilles next to each other so that supply air temperatures can be mixed, which will minimize cold air complaints. This will also minimize ventilation air short circuiting.
   c. Sanctuary - HRV can be placed in the basement and ducted through the floor, alongside (or as close to) the supply and return heating ducts. Note: match the HRV and (2) heating supply grilles next to each other and the HRV and (4) heating return grilles next to each other so that supply air temperatures can be mixed, which will minimize cold air complaints as well as ventilation air short circuiting.
   d. Bell Tower Classroom – HRV can be placed in the Bell Tower stairwell, with the supply/exhaust ducts going up into the steeple to reach the outdoor air. This suggestion is to minimize building shell penetrations.

   Note: new HRV ductwork in the basement will cause low headroom in spots where new ducts will have to run under existing ductwork. This may be rectified with the future ductwork changes planned under the renovation.

B. Measure 2: Filtration

We recommend installing a MERV 13 filter with a low pressure drop in the existing hot air furnaces. MERV 13 air filters provide close to 90% efficiency for filtering particles between 3 and 10 microns in size (such as mold spores, dusting aids, and cement dust). They also provide between 80% and

85% efficiency for filtering particles between 1 and 3 microns in size (such as legionella, lead dust, humidifier dust, coal dust, and nebulizer droplets) and between 35% and 50% efficiency for filtering particles between 0.30 and 1 micron in size (such as bacteria, most smoke, sneeze nuclei, insecticide dust, copier toner, and face powder). The Corona virus particle size, when aerosolized, is 0.125 microns so it is not captured by these filters, but these filters will capture the virus that has attached to droplets and/or all the particles listed above. HEPA filters are the only filters that capture particulate as small at 0.01 microns, but such filters have a very high pressure drop (because their media is so tight and thick) and require fan power designed to withstand such a high pressure drop. Installing a filter with a high pressure drop will either reduce the airflow or can cause motor failure, so it is important to install a MERV 13 filter with a low pressure drop and it is not possible to install a HEPA filter within the units. The installing contractor can be of assistance with the selection of these filters.

We also recommend the contractor check that there is no air bypass around the filter casing. Any bypass shall be sealed so as to ensure all air is forced through the filter.

The cost shown in Table 1 includes (3) replacement filters for each furnace as these filters will require replacement every (3) months. It is our hope that the pandemic will be over within that time and UCM can go back to the traditional MERV 7-9 filters, if desired.

With some hesitation, we are not recommending UV lights be placed in the ductwork. Although the UCM ductwork is very conducive for such an installation, the technology is proven to be very effective at killing all contaminants and the cost of these installations has gone down, it is the maintenance of these lights that is concerning to us for the UCM. UV light instantly damages a person's eyes; during maintenance there is the potential for an uninformed person to accidentally subject themselves to this light. Additionally, the lights must be replaced every 8.000 hours to remain effective. The constant cost of this replacement, if the UCM wants to maintain it, will be expensive. If, however, the UCM does want to pursue such an installation, we highly recommend the location of the lights be labeled very clearly and the electric disconnect be placed within eyesight of the lights so as to minimize accidental exposure.

C. Measure 3: Operate Exhaust Fans with HRVs

We recommend operating the exhaust fans on the same schedule as the HRVs: 2 hours prior to occupancy, all throughout the occupied times, and 2 hours after occupancy. This will depressurize the building as compared to the outside and will increase infiltration. This will help provide some fresh air to the spaces not being served by the new HRVs.

IV. Next Steps

We recommend hiring a design/build contractor such as Vermont Heating and Ventilating, Vermont Mechanical Inc, or New England Air to design and install the HRVs sized in this report. These firms can also order and install the MERV 13 filters if you do not have a preventative maintenance contract with a mechanical contractor. We also recommend contacting Efficiency Vermont and the City of Montpelier to determine if there are any incentives for installing HRVs during the pandemic. HRVs are the energy efficient manner to introduce ventilation in public spaces and either of these entities may be able to help offset the cost of the installation.

Attached to this report, as an appendix, are general recommendations from the CDC and ASHRAE that may be of interest, although they do not apply to the UCM in particular.

Appendix A:

General CDC and Industry Guidelines

The following general building operation guidelines are consolidated recommendations from the CDC, ASHRAE and ASPE to mitigate the spread of the COVID-19 virus. The majority of recommendations are based on ASHRAE's Building Readiness page, which can be accessed here; https://www.ashrae.org/technical-resources/building-readiness. Note that not every building can incorporate every measure and there is no guarantee that these measures will be effective in stopping the spread of the virus. These measures are the best suggestions at this time.

VENTILATION

- Increase outside air for ventilation in HVAC to the extent possible while still maintaining acceptable indoor conditions during occupied hours. Many systems are not designed to handle 100% outside air and simply opening the outside air damper may cause problems such as overheating/overcooling or even freezing coils. Some control systems can be customized so that outside air is maximized to the extent possible given outside air conditions.
- Demand controlled ventilation, static pressure reset strategies, and the typical supply air temperature reset strategies should be disabled.
- If possible, a daily 'building flush' should be implemented where outside airflow is increased (or kept at maximum) for 2 hours prior and 2 hours post occupancy.
- For unoccupied periods outside of the two hours pre and post occupied schedule, program AHUs to operate at minimum outside airflow or greater; fans should not be turned off during unoccupied hours; this includes fan cycling.
- Check outside air intakes and building exhausts regularly for any potential risk. These can include but are not limited to exhausts in close proximity to intakes, inadequate separation of exhaust from pedestrian walkways or other, similar locations.
- Ensure AHU is working properly. Confirm both intake and exhaust dampers are working properly, fans are controlling properly and operating at correct speeds.
- In buildings with operable windows, when outside air thermal and humidity conditions and outdoor air quality are acceptable, open windows where appropriate during occupied hours. Monitor indoor spaces for possible contaminants entering through the windows such as toilets exhaust located nearby or for windows accessible to public and high traffic on adjacent streets and walkways.

ENERGY RECOVERY WHEELS

Energy Recovery Wheels have the potential to allow return air to leak into the supply air stream. The potential of this type of leakage can be assessed by reviewing the fan arrangement and operating pressures of the fan compartments. This is unusual, and in general, well-designed and well-maintained air-to-air energy recovery systems should remain operating in residences and commercial buildings during the COVID-19 pandemic. When the ERV has been deemed to be well-maintained and at low risk for leakage into the supply airstream, the most appropriate adjustment generally would be to continue operation of the ERV component appropriate to climate conditions and to potentially increase outside air ventilation rates.

EXHAUST

- Consider installing temporary and special exhaust systems to create negative pressure rooms to accommodate infected people. Particulates or aerosols should be captured and filtered or disinfected as close to the source as possible.

- Exhaust system for toilets should run 24/7 or, if you know no one will be in the building during unoccupied hours, the pre- and post-occupancy purge cycles suffice.
- Do not open operable windows in toilets if open windows could lead to re-entrainment of air into other parts of the building.

FILTRATION

- Update or replace existing HVAC air filtration to a minimum of MERV 13 (MERV 14 preferred) or the highest compatible with the filter rack. Install the filters after the coil(s) if there is a filter bank; otherwise install filters in the mixed air stream before the coil(s).
- Seal edges of each filter bank with silicone on the upstream and downstream side of the frame at the AHU wall to limit bypass air.
- Note that filters with differing pressure drops can lead to changes in the unit's airflow. Check manufacturer ratings and if the new filters do have an additional pressure drop, make sure the air handling systems and fans can overcome the additional pressure drop and still maintain air flow at acceptable levels in the following manner.
- UV-C can be effective at killing pathogens on surfaces or in slowly moving airstreams with the proper intensity. Traditionally, commercial HVAC UV-C lights were likely not effective at killing airborne pathogens at the typical velocities within air handlers, but there are new products available that may be more effective.
- Ensure a filter change protocol is in place, or that the differential pressure filter sensor is calibrated. Filters need only be changed when they are dirty.

TEMPERATURE AND HUMIDITY

- Recommend maintaining humidity setpoint between 40-60% but prioritize increasing outside air over humidity. Low humidity is a major concern but note that adding humidification can cause separate indoor air quality issues if not done correctly. Install humidity sensors tied into the BAS or high-quality stand-alone sensors. Alternatively, facilities staff should have a calibrated instrument to periodically check space temperature and humidity.
- Recommended temp range: 68-78°F dry bulb.

Site-Specific Findings and Recommendations:

- We are not recommending adding humidification at this time. Instead, we recommend using a handheld sensor to spot check humidity and temperature. If dry air becomes a serious issue in particular areas, we recommend addressing it with a stand-alone unit and a detailed maintenance plan to avoid bacterial growth.

WATER SYSTEMS

- Keep domestic hot water heating systems circulating and maintain storage temperatures above 140°F to avoid microbial incursion. Do not let circulating hot water temperature drop below 120°F.
- If the hot water recirculating system goes down for extended duration, do a high temperature flush and pull the strainers before going back online. The flushing procedure includes raising the hot water temperature to 160-170°F and maintaining it at that level while systematically flushing each outlet around the system. A minimum runtime of 5 minutes has been recommended by the CDC; however, optimal flush time is not known, and longer flush times

may be necessary. **Cx warning: scalding is VERY possible – make sure the building is completely empty and place safety personnel and/or warning signs in appropriate locations.**

- All potable water systems in buildings that have been vacant or sparsely utilized for weeks or months must be thoroughly flushed prior to being put back into service. ASPE recommends the following 2 options for flushing the potable water system:
    - Option 1: Flushing the systems includes the opening of all water outlet valves, such as faucets and showers, and the flushing of all toilets and urinals. This will allow a high-velocity flow through the system to purge the stagnant water and improve water quality. Outlets at the greatest distance from the service connection should be allowed to flow a minimum of 10 minutes. Also, flush all drinking water fountains, water coolers, bottle fillers, and any other operable end point device for at least five minutes. Extreme care should be taken when flushing stagnant water systems as stagnant water is likely to contain higher levels of Legionella and other pathogens. Personnel doing this work should be advised to open outlets slowly to avoid splashing and the creation of aerosols.
    - Option 2: As an alternative to the above description of flushing the system, fill the system with a mixture of a minimum of 200 parts per million (200 mg/L) of chlorine and allow to stand for 3 hours. Flush the system with clean potable water until the chlorine is purged from the system. Repeat the procedure if a bacteriological examination shows that contamination remains present in the system.
- Additional potable water recommendations are:
    - For ice makers, dispose of old ice and flush the water supply to the ice maker.
    - Another best practice is the removal and cleaning of end-point devices such as faucet aerators and drinking fountain filters. This is particularly important if any disruption of supply pressure occurred or is suspected while the building was shut down. Pressure disruptions can dislodge particulates, including lead, which can get trapped in aerators and filters, spiking lead levels and reducing water quality.
- Water treatment systems and drinking water filters: If there are water treatment or filtration products used in the plumbing system, such systems may need to be regenerated and flushed. It is possible for bacteria to grow in water filters under stagnant water conditions, so replacing water filters is highly recommended. Always consult and follow manufacturer disinfection procedures and recommendations.

OTHER

- Current recommendation is that communal spaces such as staff break rooms, gymnasiums, auditoriums are not to be used. If room use will change, use caution to ensure that rooms are setup with proper ventilation, especially rooms that may have been designed for low occupancy rates (e.g., storage)
- Entryways: Caution should be taken when going through vestibules or air-locks by allowing social distance to “air” the space after the passage of a person. Consider providing signage to inform and direct occupants as to what entrances and exits to use.
- Appropriate PPE protection for building operators, maintenance technicians and anyone else who must inspect or come in contact with any HVAC equipment should be secured.