Falmouth District Court
Falmouth, MA

HVAC SYSTEM EVALUATIONS COVID-19

Office of Court Management

August 23, 2021

Tighe&Bond

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Section 1
Existing Conditions & Site Observations

Tighe & Bond visited the Falmouth District Courthouse on May 6th, 2021. While on site we inspected the air handling equipment located in the mechanical rooms and on the roof and toured the facility to determine if the spaces generally matched usages noted on the architectural plans. Tighe & Bond was provided with mechanical design plans from 1995 and 2004. Our analysis is based on these drawings and our one day on site.

Site Visit Attendees:

- *Office of Court Management:*
  - Tony Arruda Courthouse Facilities Staff
- *Tighe & Bond*
  - Sean Pringle, PE, Project Engineer
  - Matt Mancini, Staff Mechanical Engineer

1.1 Existing Ventilation System

The Falmouth District Courthouse was constructed as an armory in 1955 and was converted to a courthouse in 1995. It is approximately 12,000 square feet in size. Four constant volume air handling units (AHU) and six constant volume rooftop air handling units (RTU) provide ventilation air to the building.

AHU-A contains a mixing box, 2" MERV 8 filters, hot water heating coils, a supply fan, and downstream duct mounted direct expansion refrigerant (DX) cooling coils. According to staff, this unit is original to the building and originally served the target range. The space is now primarily a records area, but also includes an office area for a single person. Based on the drawings, the DX cooling coil was added in 2004. The damper and valve actuators also appear to be original and the staff has indicated that this unit is rarely used. It appears to be in poor condition, however, at the time of the visit, we switched the unit on, but it did not run.

AC-1 (1995) contains 1" pleated filters with no visible MERV rating, DX cooling coils, electric heating coils, and a supply fan. The unit appears to be designed to accept either 1" or 2" filters. Outdoor air is drawn through a fixed opening on the return air duct. The unit is in poor condition.

AC-2 (1995) is a rooftop unit and contains a mixing box, 1" pleated filters with no visible MERV rating, DX cooling coils, electric heating coils, and a supply fan. This unit also appears to be designed to accept either 1" or 2" filters. The unit is in poor condition. The cooling coils were fairly dirty at the time of the visit, and the outdoor air damper was fully closed.

AC's-1&2 (2004) contain a mixing box, 2" MERV 8 filters, DX cooling coils, hot water heating coils, and a supply fan. The units appear to be in good condition. Due to the mounting height, we were unable to inspect the interior of these units.

RTU's 1-5 contain a mixing box, 2" MERV 8 filters, DX cooling coils, a supply fan, and a natural gas furnace. In several of these units, the outdoor air dampers were mostly or fully closed. The units are generally in fair condition.

While RTU's 1-5 are single speed, constant airflow units, the areas served operate as variable air volume (VAV) systems. Each room has diffuser VAV's controlled by a local thermostat. In addition, there is a modulating bypass damper for each system that opens in response to rising duct pressure as the VAV's close.

According to staff, there are four exhaust fans for the building. Three fans serve toilet rooms and one fan serves the lockup area. All fans were running at the time of our site visit. The exhaust fan that serves the lockup area (TX-2) is only seven feet away from the outdoor air opening on AC-2 (1995). Code requires a ten foot separation between powered intake and exhaust openings.

A 1,000 MBTU/h hot water boiler plant provides hot water to several AHU's and perimeter heating equipment. All cooling is provided via individual DX condensing units or DX condensing units integral to packaged RTU's.

Table 1 summarizes the air handling units' designed airflow rates, the MERV rating of the installed filters, and the condition of the units.

TABLE 1
Existing Air Handling Units

Unit	Original Design Airflow (CFM)	Original Design Min. O.A. (CFM)	Filters	Condition
AHU-A	800	800	2" MERV 8	Poor
AC-1 (1995)	2,250	1,000	1" Pleated	Fair
AC-2 (1995)	900	415	1" Pleated	Poor
RTU-1	2,000	200	2" MERV 8	Fair
RTU-2	2,400	240	2" MERV 8	Fair
RTU-3	1,700	160	2" MERV 8	Fair
RTU-4	1,200	120	2" MERV 8	Fair
RTU-5	1,200	120	2" MERV 8	Fair
AC-1 (2004)	8,000	800	2" MERV 8	Good
AC-2 (2004)	8,000	800	2" MERV 8	Good

Conference room 145 appears as a single room on the plans. However, it has been split into two rooms: a smaller conference room and also a single occupant office for the facilities staff. The office portion did not appear to have any source of ventilation.

The changing area in the women's room did not appear to have any source of exhaust or supply ventilation.

Within the open area near the courtroom, there are eight enclosed offices without any supply air ventilation. A toilet exhaust fan has been installed in the five rooms with drop ceilings, to increase air transfer from the surrounding space. The remaining three rooms do not have ceilings. The use of transfer air from one space to another to meet ventilation requirements is not permitted by current code. In addition, the distribution from AC-1 & AC-2 (2004) is the only source of ventilation for the open area, and does not provide adequate distribution to this portion of the space as the only supply diffusers are in the main lobby area.

Photo 1 – Representative Air Handler

Photo 2 – Representative Rooftop Air Handler

1.2 Existing Control System

The HVAC equipment installed in 2004 is controlled by an Automated Logic building management system (BMS). This includes the AHU's, RTU's, and the boiler system. These units operate continuously during occupied periods.

The remainder of the AHU's, VAV diffusers, and supplementary heating and cooling are controlled via local thermostats. While onsite, we observed that AC-1 (1995), which serves the main courtroom, is configured to cycle the fan in response to demand for heating and cooling.

Section 2
Recommendations

Below is a list of recommendations for the Falmouth District Courthouse. Please refer to the "Overview of Recommendations" report for further explanation and requirements of the stated recommendations.

As noted above, there are several areas without any ventilation. Building areas without adequate ventilation and filtration significantly increase the risk of spreading viruses like Coronavirus (SARS-CoV-2), especially areas with high occupant density and where people occupy the same space for relatively long periods of time. Consider significantly reducing occupancy or relocating occupants to other areas with adequate ventilation.

2.1 Filtration Efficiency Recommendations

We recommend the following measures be implemented for the existing air handling units:

RF-1: *Replace filters with MERV-13 filters.*

The TAB Contractor and/or Engineer shall verify that the air handlers can accommodate a MERV-13 filter per Appendix A in the overview of recommendations report. Filter racks should be inspected and adjusted to ensure that filters fit tightly and that end spacers are in place to minimize filter bypass.

RF-3: *Install a differential pressure sensor with a display across the filter bank.*

The DDC controllers for AHU's and RTU's installed in 2004 appeared to have spare analog inputs that could be used for this purpose.

RF-3a: *Connect the pressure sensor to the BMS system and/or a local alarm.*

Maximum differential pressure should be set per manufacturer's recommendation based on air velocity to ensure filters are within their service lives. Typically, this is not more than 1.0" w.g.

Provide local alarms for the older AHU's that are not connected to the BMS.

2.2 Testing & Balancing Recommendations

The air handling units vary in age from approximately 17 to 65 years old. It is unknown to Tighe & Bond when the last time the units were tested and balanced. Also, the code requirements to determine the outdoor air flow rates that were used to design the original system may be different than the 2015 International Mechanical Code (IMC) and current ASHRAE Standard 62.1 requirements.

We recommend the following testing and balancing measures be implemented:

RTB-1: *Test and balance air handling unit supply air and minimum outdoor air flow rates.*

We recommend testing and balancing the outdoor air flow rates for all air handling units to the recommended minimum O.A. rates listed in Table 2.

TABLE 2
Recommended Air Handler O.A. Flow Rates

Unit	Original Supply Airflow (CFM)	Original Design Min. O.A. (CFM)	Current Code Min. O.A. Requirements (CFM)	Recommended Minimum O.A. (CFM)
AHU-A	800	800	70	**100**
AC-1 (1995)	2,250	1,000	600	**1,000**
AC-2(1995)	900	415	270	**415**
RTU-1	2,000	200	350	**350**
RTU-2	2,400	240	160	**240**
RTU-3	1,700	160	160	**160**
RTU-4	1,200	120	240	**240**
RTU-5	1,200	120	85	**120**
AC-1 (2004)	4,000	400	200	**400**
AC-2 (2004)	4,000	400	200	**400**

Note: Although the ASHRAE Position Document on Infectious Aerosols recommends using the latest published standards and codes as a baseline for minimum ventilation, the mechanical code in effect at the time the HVAC systems were designed and constructed is what governs the required outdoor air flowrate for the HVAC equipment, if there have been no additions, renovations, alterations or changes in occupancy to the building. The 2015 International Mechanical Code does not prevent the continued use of existing systems.

Our ventilation air analysis discovered that several spaces were not receiving the correct quantity of outdoor air based on today's code requirements at full occupancy. The calculations indicate that the quantity of outdoor air required per code would result in a significant increase in outdoor air for some air handlers, increasing the load on the heating and cooling coils. These loads appear to exceed the capacity of the units. We recommend temporarily reducing the occupancy of the spaces that are not receiving the code required ventilation air. Table 3 lists the spaces that would require a reduced occupancy. The recommended outdoor air flow rates listed in Table 2 reflect the outdoor air requirements based on a reduced occupancy shown in Table 3.

TABLE 3
Recommended Occupancy During COVID-19 Pandemic

Room & Associated AHU	***2015 IMC Permitted Occupancy (# of People)***	***Recommended Occupancy (# of People)***
RTU-1		
Lounge 121	11	6
RTU-4		
Jury Pool Room 136	15	12
Second Session Courtroom 138	30	18

During the pandemic, we recommend maintaining the outdoor airflows at the original designed values where they exceed the code minimums calculated by Tighe & Bond. Supplying more outdoor than required by code will provide better indoor air quality.

For the RTU's with bypass VAV systems, there was no minimum VAV airflow indicated for each zone. To be able to calculate the O.A. requirements for each space and the system overall, the minimum ventilation rate cannot be zero. For the purposes of this calculation, that VAV minimum airflows were assumed to be 40% of the maximum airflow indicated on the plans.

For AHU-A, we recommend reducing the outdoor airflow rate to better reflect the current use of the space. The space served by AHU-A is predominantly storage, with only one office within the space. Over-ventilating this space would likely create humidity issues within the space.

Where we recommend increasing the outdoor air beyond the original design, it appears the cooling and heating coils should be able to provide space conditions similar to the original design under peak outdoor air conditions, assuming the coils are clean and their performance has not degraded significantly over time. Space temperatures should be monitored to ensure they are not dropping below design values. If the heating/cooling space temperature do drop below/above the design values, the outdoor airflow rate should be reduced, but not below the originally designed outdoor air flow rates.

The average airflow rate per person is shown below in Table 4. These values are based on the original full design supply airflow rate and the recommended outdoor airflow rates shown in Table 2. The airflow rate per person assumes a diversity factor of 70%, meaning the maximum number of occupants assumed to be in any zones at a given time equates to 70% of the code required occupancy for that zone.

TABLE 4
Average Airflow Rate per Person

	All spaces	*Courtrooms*	*Non-Courtroom Spaces*
Total Occupancy (People)	144	71	72
Total Supply Air (CFM/Person)	143	43	241
Outdoor Air (CFM/Person)	24	15	33

The airflow rate per person for each Courtroom and the Jury Pool Room is shown below in Table 5. These values are based on full occupancy without taking diversity into account, the original full design supply airflow rate, and the recommended outdoor airflow rate. The airflow rate per person assumes the full supply airflow is being delivered to the room. For VAV systems serving the second session courtroom and jury pool room, when the supply airflow is reduced due to the space temperature being satisfied, the airflow rate per person will also be reduced.

TABLE 5
Airflow Rate per Person (Full Occupancy)

		Total Air		*Outdoor Air*	
Courtroom	*Total People*	*Supply Airflow (CFM)*	*Airflow Rate (CFM/Person)*	*Outdoor Airflow (CFM)*	*Airflow Rate (CFM/Person)*
Jury Pool Room 136	15	480	32	96	6
First Session Courtroom	72	1,880	26	836	12
Second Session Courtroom	30	720	24	144	5

Note: Courtroom occupant density is based on 70 people/1,000 square feet, per the 2015 International Mechanical Code

The airflow rate per person for each Courtroom and the Jury Pool Room, based on a reduced occupancy schedule determined by the Office of Court Management, is shown below in Table 5a. The airflow rate per person assumes the full supply airflow is being delivered to the room. For VAV systems serving the second session courtroom and jury pool room, when the supply airflow is reduced due to the space temperature being satisfied, the airflow rate per person will also be reduced.

TABLE 5a
Airflow Rate per Person (Reduced Occupancy)

		Total Air		Outdoor Air	
Courtroom	Total People	Supply Airflow (CFM)	Airflow Rate (CFM/Person)	Outdoor Airflow (CFM)	Airflow Rate (CFM/Person)
Jury Pool Room 136	4	480	120	96	24
First Session Courtroom	17	1,880	110	836	49
Second Session Courtroom	9	720	80	144	16

Note: If occupancy is further reduced, the airflow rate per person will increase, assuming full airflow is being delivered to the space.

RTB-4: *Test and balance VAV diffuser flow rates.*

We recommend testing and balancing the VAV diffusers to ensure each space is being supplied the proper quantity of air. Note that no minimum airflows are identified on the design documents. As part of this effort, minimum airflows should be established. These should be established to maintain the code required ventilation rates at the minimum airflow.

RTB-5: *Test and balance all air inlets and outlets.*

If the airflow to each space has not been recently tested, we recommend testing the airflow rates in the holding cells, control room, Courtrooms, Jury Pool room, and other densely occupied areas as a minimum. The airflow rate delivered to and returned from these spaces may not match the original design intent.

If specific areas within the Courthouse experience regular cooling and heating comfort complaints this may be an indication of a lack of airflow to the space. We recommend testing and balancing the air inlets and outlets serving those spaces to the designed values. Prior to rebalancing the building, we recommend verifying the boiler and condenser systems are operating at the correct temperatures. Incorrect fluid temperature may be contributing to the temperature control complaints instead of a lack of airflow.

RTB-6: *Test and balance all air handler coils.*

Testing and balancing the air handler hot water coils will help ensure the coils are receiving the proper water flow rates. Due to the age of the coils, the coils may not perform as required to properly temper the supply air. Coils become fouled over time, which degrades the performance.

Confirm that the air handler's refrigerant system is operating correctly to ensure the DX coil is receiving full refrigerant flow.

2.3 Equipment Maintenance & Upgrades

We recommend the following equipment maintenance and upgrades:

RE-1: *Test existing air handling system dampers and actuators for proper operation*.

Replace dampers and actuators that are not functioning properly.

RE-2: *Clean air handler coils and drain pans.*

RE-4: *Inspect VAV diffusers and controllers.*

VAV diffusers regulate the supply air delivered to each space. At a minimum, we recommend cycling the damper positions and testing the airflow to verify the maximum and minimum airflow rates are being delivered as designed. Consider cleaning the airflow stations. Any diffusers not delivering the expected airflow rates should be rebalanced or replaced.

RE-5: *Confirm the existing freeze stat is working correctly on each air handling unit.*

This applies to AHU-A and AC-1&2 (2004) only.

RE-7: *Test the existing air handler control valves and actuators for proper operation.*

This applies to AHU-A and AC-1&2 (2004) only.

2.4 Control System Recommendations

We recommend the following for the control system:

RC-1: *Implement a pre and post-occupancy flush sequence.*

RC-2: *Install controls required to introduce outdoor air beyond the minimum requirements.*

This measure is limited to the AHU's and RTU's connected to the BMS. The existing BMS appears to be sophisticated enough to implement this type of sequence, although new control sequences must be defined.

The remaining air handling equipment is not connected to the BMS, so this measure would not be feasible for these units unless they are replaced and the new units are integrated into the BMS. Refer to Section 2.7.5.

RC-4: *Confirm the economizer control sequences are operational.*

2.5 Additional Filtration and Air Cleaning

We recommend the installation of the following air cleaning devices:

RFC-1: *Install portable HEPA filters.*

If the Courthouse is to operate at a high capacity (i.e. 50% occupancy or greater), we recommend installing portable HEPA filters in high traffic areas, such as entrance lobbies. They should also be considered for Courtrooms, depending on the occupancy of the room and how much noise is generated from the filters. The noise levels will vary depending on the manufacturer. Refer to the "Overview of Recommendations" document for further guidance on installing portable HEPA filters.

2.6 Humidity Control

Installing duct mounted or portable humidifiers can help maintain the relative humidity levels recommended by ASHRAE. The feasibility of adding active humidification is determined by the building envelope. Buildings that were not designed to operate with active humidification can potentially be damaged due to a lack of a vapor barrier, adequate insulation, and air tightness.

Duct mounted humidifiers must be engineered, integrated into the building control system, tested, and commissioned. They are available in many configurations but require substantial maintenance and additional controls. They also run the risk of adversely affecting IAQ from growing microorganisms, or leaking water through poorly sealed ductwork damaging insulation and ceilings. Portable humidifiers are easier to install and require less maintenance, but still have the potential to damage the building envelope.

While active humidification is not recommended as a whole building solution due to high installation costs, operational costs, potential to damage the building envelope and adversely affect poor IAQ, it may be warranted as a temporary solution in some areas.

2.7 Other Recommendations

2.7.1 Run Supply Fans Continuously During Occupied Hours

During the site visit, AC-1 (1995) was set to run the fan in "auto" mode, which causes the supply fan to only run when the unit is actively heating or cooling. This should be checked on each of the systems ensure the supply fans continuously during occupied periods, to supply ventilation air to the spaces. Note that this may cause comfort issues because supply air temperature can fluctuate as the heating and cooling is staged on and off, and the systems may not have been designed to operate in this manner originally.

2.7.2 Add Ventilation to All Occupied Areas

The interior office spaces surrounding the main courtroom do not have operable windows or any direct supply air ventilation. Several areas use exhaust fans to increase transfer air through the spaces, but this is not permitted by current codes. Consider adding a system to provide direct supply air ventilation to all occupied areas.

Also consider adding exhaust to the changing area if space is still in use.

2.7.3 Repair AHU-A

AHU-A is approximately 65 years old, is in poor condition, and was not operational at the during our visit. We recommend repairing this unit in the short term if possible.

2.7.4 Raise Lockup Exhaust Fan discharge

We recommend raising the discharge of the lockup area exhaust fan (TX-2) to be 36" higher than the outdoor air intake opening of AC-2. Code requires a ten foot separation between powered intake and exhaust openings, unless the exhaust is 36" higher than the intake opening.

To accomplish this, we recommend replacing the existing downblast fan with an equivalent upblast type and providing an extended curb adapter if needed to attain the 36" vertical separation.

2.7.5 Replace Original and 1995 Air Handling Units

Indoor air handling units similar to AHU-A and AC-1 (1995) have a life expectancy of 35-45 years. Packaged rooftop units similar to AC-2 (1995) have a life expectancy 20-25 years.

AC-1 and 2 are approximately 36 years old and are in fair condition. Both units use electric resistance coils for heat, which is inefficient and costly to operate. Additionally, AC-1 does not have a true mixing box and as a result cannot make use of economizer or demand-controlled ventilation functionality. Consider selecting replacement units that use hot water coils or electric heat pumps for heating.

Consider replacing these units in the next 5 years. If AHU-A cannot be satisfactorily repaired, it should be replaced as soon as possible. Any added units should be integrated into the existing BMS. This recommendation is an energy saving measure and does not increase the indoor air quality of the building.

Disclaimer

Tighe and Bond cannot in any way guarantee the effectiveness of the proposed recommendations to reduce the presence or transmission of viral infection. Our scope of work is intended to inform the Office of Court Management on recommendations for best practices based on the guidelines published by ASHRAE and the CDC. Please note that these recommendations are measures that may help reduce the risk of airborne exposure to COVID-19 but cannot eliminate the exposure or the threat of the virus. Implementing the proposed recommendations will not guarantee the safety of building occupants. Tighe & Bond will not be held responsible should building occupants contract the virus. The Office of Court Management should refer to other guidelines, published by the CDC and other governing entities, such as social distancing, wearing face masks, cleaning and disinfecting surfaces, etc. to help reduce the risk of exposure of COVID-19 to building occupants.