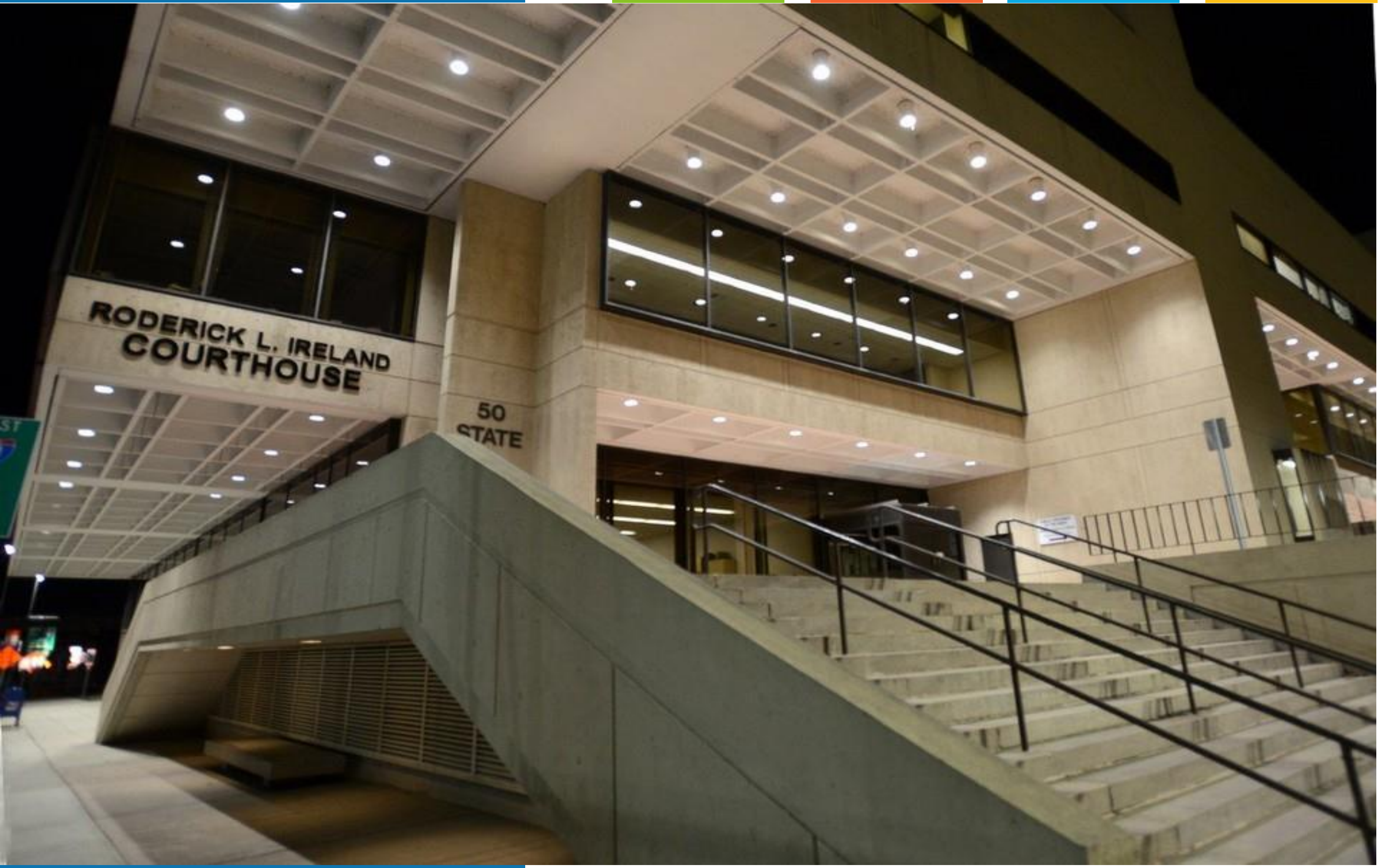

Roderick L. Ireland Courthouse
Springfield, MA

HVAC SYSTEM EVALUATIONS COVID-19

Office of Court Management

September 14, 2021

Tighe&Bond

Section 1
Existing Conditions and Site Observations

Tighe & Bond visited the Roderick L. Ireland Courthouse in Springfield on October 6, 2020. While on site, we inspected the air handling units and other associated heating and cooling equipment and toured the occupied portions of the building to determine if the spaces generally matched usage noted on the architectural plans.

Site Visit Attendees:

- Office of Court Management:
  - William Lyne, Facilities Systems Supervisor
  - Kurt Taylor, Facilities (Springfield)
  - Michael Lane, Environmental Health and Safety
- Tighe & Bond:
  - Sean Pringle, PE, Project Mechanical Engineer
  - Timothy Bill, Staff Engineer

UPDATE: Tighe & Bond returned for a second visit to the Roderick L. Ireland Courthouse in Springfield on July 13, 2021. While on site, we re-inspected the air handling units, the condition of the reheat coils, and a representative perimeter fan coil unit. This report corrects the assessments of air handling unit coils that were misidentified in earlier reports.

1.1 Existing Ventilation System Description

The Courthouse is a five-story building (including basement), constructed in 1976, with a floor area of approximately 227,000 gross square feet. The building is served by four large, constant volume custom air handling units (AHU). Each air handler has an air mixing section, 2" MERV 13 filters, a supply air fan, and a single hot/chilled water coil, as well as an associated external return air fan and exhaust damper. Both fans are powered by variable speed drives, set to a fixed speed. The air handlers are generally in fair condition. Many components appear to have been replaced over time, including the several of the water coils. Facilities staff indicated the filters were recently upgraded to MERV 13.

The hot/chilled water coil for AHU-1 is in very poor condition and should be replaced. The outside air dampers for AHU-4 were not working at the time of the visit, possibly due to a linkage issue. All coils were dirty and in need of cleaning. The MERV 13 filters were also dirty and starting to bend. All AHU's were set to a minimum outside air actuator position of 20%, but some outside air dampers appeared to be just starting to open at this actuator position. This indicates that the outside air being provided may be less than the design flow rate.

Each AHU serves many building zones. Each zone has a hot water reheat coil in the supply air ductwork serving the zone, controlled by a local thermostat. While onsite, we observed a representative reheat coil through an access panel. The coil was fairly dirty, but appeared to be in relatively good condition.

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

TABLE 1
Existing Air Handlers

Unit	Original Design Airflow (CFM)	Original Design Min. O.A. (CFM)	Filters	Condition
AHU-1	64,000	25,500	2" MERV 13	Fair
AHU-2	42,000	8,500	2" MERV 13	Fair
AHU-3	58,000	13,000	2" MERV 13	Fair
AHU-4	64,000	20,000	2" MERV 13	Fair

The building is heated with hot water fed from a central boiler plant near the Juvenile/Housing Court building. Cooling is provided by a pair of 600-ton York chillers.

The building was originally heated with electric heat. In 1997 hot water boilers were added and the existing chilled water distribution was converted to a two-pipe system. The electric reheat coils were replaced with hot water coils, eliminating the possibility of reheating when the two-pipe system is providing chilled water. Because the AHU's are constant flow, this has left the building without any effective means of controlling individual zone temperatures in the summer and shoulder seasons and resulted in humidity issues within the building, as discussed in detail in the January 2020 report by EH&E.

According to staff, the AHU supply air temperature is generally set to 65-68°F depending on the season. This is a high supply air temperature for cooling during the summer, which limits the ability of the AHU's to dehumidify the air. The air handlers supply air at a constant airflow rate regardless of the space temperature. We presume the elevated supply air temperature was implemented to prevent overcooling. Staff mentioned that the duct mounted reheat coils are difficult to control and may not be balanced correctly.

The perimeter of the building is heated and cooled with fan coil units. The fan coils also utilize the two-pipe hot/chilled water distribution. The filters have been recently changed to 1" pleated MERV 13. According to staff, the airflow was not noticeably impacted.

The basement lockup area is provided with supply air from AHU-3 through two constant airflow boxes. Air is supplied through the corridors and exhausted from the cells through the toilet exhaust duct risers. The attorney/client interview rooms, control rooms, corridor and other similar spaces within the secure area have supply and return registers from AHU-4.

AHU-3 supplies air to the secure areas on the first, second, and third floors to the cells through linear diffusers along the exterior cell walls, as well as to the common areas and attorney/client interview rooms. Air is exhausted from the cells through a toilet exhaust duct riser. The open space in the secure area has return air grilles which return air back to the AHU. The linear diffusers in the cells provide significantly more supply air than is exhausted from each cell area, presumably to address the wall and glass heat gains/losses along the perimeter. Only the third floor secure area is still in use. The first and second floor areas are currently used as storage areas.

In many areas, walls appear to have been built or reconfigured to allow for different uses. Generally, the new uses appear to be similar to the original intended use, such as creating private offices out of open offices or splitting open offices into multiple open offices. The select rooms that we observed appeared to have at least one diffuser. We were not provided with any as-built or design drawings that reflect the space reconfiguration work. Reviewing these changes in detail will be difficult and will require additional time beyond this initial assessment to complete.

Many open office areas appear to have significantly higher occupant densities than the default values noted in the 2015 International Mechanical Code (IMC). In addition, several offices that appear to have been intended as single private offices are being used for two employees. It is not clear if these high occupant densities were intended as part of the original design, or a result of a reduction in available space over time. While these areas appear to have adequate ventilation for the current number of occupants, there doesn't appear to be adequate room for proper social distancing if these spaces are fully occupied.

The large conference room identified on the 1973 plans as "Board of Commissioners" appears to be under-ventilated for its current use as a conference room. The current ventilation rate of 260 cfm provides the code-required ventilation for 12 people at a supply airflow rate of 22 cfm/person.

Photo 1 –Typical Air Handler and Return Fan

Photo 2 –AHU-1 Water Coil

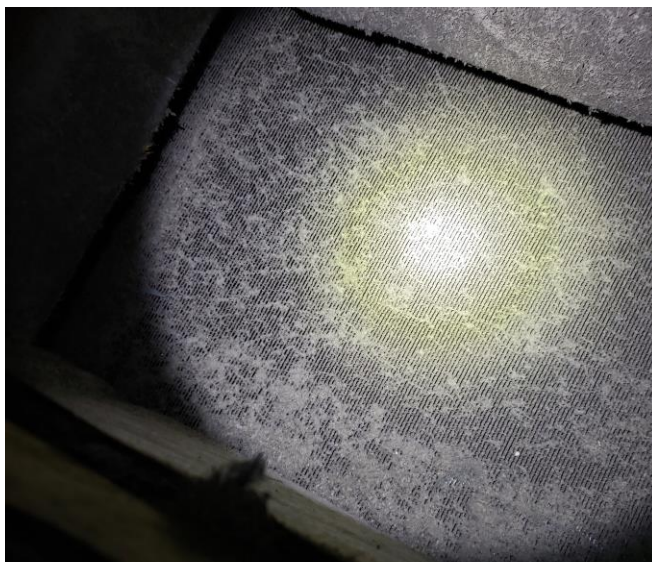

Photo 3 –Dirty Reheat Coil

1.2 Existing Control System

The Courthouse has a Schneider SmartStruxure building management system (BMS) that controls most HVAC equipment throughout the Courthouse. This system was installed in 2013 and replaced much of the original pneumatic controls. This system does not control the reheat coils or the fan coils, which still use local pneumatic controls.

According to staff, the occupancy schedule has been extended from 4:00AM to 11:00PM Monday through Friday in response to COVID-19, as well as an occupied period from 8:00AM to 12:00PM on Saturday.

Section 2 Recommendations

Below is a list of recommendations that we propose for the Roderick L. Ireland Courthouse. Please refer to the "Master Recommendation List" for further explanation and requirements of the stated recommendations.

2.1 Filtration Efficiency Recommendations

The filters in the air handlers and fan coils were recently upgraded with MERV 13 filters. The use of 2" MERV 13 filters for the AHU's and 1" MERV 13 filters for the fan coils meets the ASHRAE recommendations for filtration during the pandemic. We recommend maintaining the current level of filtration. However, we recommend that a testing and balancing Contractor test and document the static pressure profile of all AHU's and select representative fan coil units, as outlined in recommendation RF-1 in the Overview of Recommendations document. This will help determine if the equipment can accommodate the increase in system static pressure with the addition of the MERV 13 filters.

We also recommend the following measures to ensure that the filters are replaced when necessary:

RF-3: *Install a differential pressure sensor (switch) across the filter banks.*

We recommend this measure for the air handers, not the fan coil units.

RF-3b: *Pressure sensor (switch) shall have a display and be connected to the BMS system.*

2.2 Testing & Balancing Recommendations

According to staff, the supply airflow rates were rebalanced after installing the MERV 13 filters, and the VFD speed was increased slightly to compensate for the additional pressure drop. This was performed by staff by using flow hoods over representative air outlets served by each of the AHU's. It is unknown to Tighe & Bond when the last time the air handlers and the whole system was tested and balanced. It is possible this was last performed as part of the 1997 improvements. Also, the code required outside air flow rates that were used to design the system in 1976 are different than the 2015 IMC and ASHRAE Standard 62.1. Prior to any rebalancing efforts, all controls including dampers, actuators, and pneumatic systems should be tested to ensure they are operating correctly.

We recommend the following measures be implemented:

RTB-1: *Test and rebalance air handling unit supply air and minimum outside air flow rates.*

We recommend rebalancing the air handlers to the recommended minimum O.A. values shown in Table 2. After rebalancing, the spaces should be monitored during peak heating and cooling conditions to confirm space temperature can be maintained.

TABLE 2
Recommended Air Handling Equipment 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-1	64,000	25,500	10,400	25,500
AHU-2	42,000	8,500	7,300	8,500
AHU-3	58,000	13,000	11,000	13,000
AHU-4	64,000	20,000	13,000	20,000

Where the outside airflows calculated by Tighe & Bond are less than the original design values, we recommend using the original designed values, as these exceed the calculated code minimums and will likely result in improved indoor air quality (IAQ).

Note that the calculated outdoor air requirements above attempt to account for the increased occupant densities found in many open office areas in this building. For open office areas, an occupant density of eight people per 1000 square feet was used, instead of the standard five people per 1000 square feet.

The airflow rate per person is shown below in Table 3. These values are based on the recommended outdoor airflow and the original design supply airflow rates shown in Table 2 above. The airflow rate per person also assumes a diversity factor of 70%, meaning the maximum number of occupants assumed to be in all zones at all times equates to 70% of the code required.

TABLE 3
Average Airflow Rate Per Person

	All Spaces	***Courtrooms***	***Non-Courtroom spaces***
Total Occupancy (People)	2,980	1,420	1,560
Total Supply Air (CFM/Person)	77	45	105
Outdoor Air (CFM/Person)	23	18	27

TABLE 4
Airflow Rate per Person (Full Occupancy)

Courtroom	Total People	Total Air: Supply Airflow (CFM)	Total Air: Airflow Rate (CFM/Person)	Outdoor Air: Outside Airflow (CFM)	Outdoor Air: Airflow Rate (CFM/Person)
Jury Pool Room	245	6,260	26	1,270	5
District Courtroom 1,2	163	5,000	31	2,000	12
District Courtroom 3-10	88	2,800	32	1,120	13
Superior Courtroom 1	156	5,600	36	2,230	14
Superior Courtroom 2	156	5,000	32	2,000	13
Superior Courtroom 3-6	90	2,800	31	1,120	12
Probate Courtroom 1,2	91	3,000	33	1,200	13
Probate Courtroom 3,4	72	2,200	31	900	12

Note: Courtroom occupancy 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 scheduled determined by the Office of Court Management, is shown below in Table 4a. The airflow rate per person assumes the full supply airflow is being delivered to the room. At times when the supply airflow is reduced due to the space temperature being satisfied, the airflow rate per person will also be reduced.

TABLE 4a
Airflow Rate per Person (Reduced Occupancy)

Courtroom	Total People (Reduced Occupancy)	Total Air: Supply Airflow (CFM)	Total Air: Airflow Rate (CFM/Person)	Outdoor Air: Outside Airflow (CFM)	Outdoor Air: Airflow Rate (CFM/Person)
Jury Pool Room	125	6,300	50	1,270	10
District Courtroom 1	30	5,000	167	2,000	66
District Courtroom 2	34	5,000	147	2,000	59
District Courtroom 3-5	20	2,800	140	1,120	56
District Courtroom 6	21	2,800	133	1,120	53
District Courtroom 7-9	20	2,800	140	1,120	56
District Courtroom 10	18	2,800	165	1,120	62
Superior Courtroom 1	32	5,600	175	2,230	70
Superior Courtroom 2	35	5,000	143	2,000	57
Superior Courtroom 3-6	20	2,800	140	1,120	56
Probate Courtroom 1,2	18	3,000	167	1,200	66
Probate Courtroom 3	22	2,200	100	900	40
Probate Courtroom 4	20	2,200	110	900	44

RTB-3: *Increase outside air flow rate beyond minimum under non-peak conditions*.

The air handlers were designed to provide more outdoor air than the currently adopted code requires. Regardless, we recommend increasing the outdoor air flow rate beyond the recommended outdoor air flow rates under non-peak conditions. We do not believe this would cause a threat of a potential coil to freeze based on the total percentage of outside air vs. the total amount of outside air, however cold spots on the coil may develop due to poor mixing.

Refer to the Control System upgrades section for the required controls to implement this strategy.

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

We recommend rebalancing all constant volume airflow boxes, as well as all air inlets and outlets throughout the building, as it is unknown when this was last performed. Floor layouts and occupant densities have been changed in many areas since the original design and balancing. Prior to rebalancing, we recommend verifying the chiller and boiler plants are maintaining the correct supply water temperatures. Incorrect supply water temperatures may be contributing to the temperature control complaints instead of a lack of airflow.

If the reconfigured spaces were not engineered to determine the proper airflow for each space, we recommend performing heating, cooling, and ventilation air calculations for these areas. Consider reviewing the use of each space and developing a revised airflow plan to better reflect the current area occupancies.

RTB-6: *Test and balance hot/chilled water control valves.*

We recommend rebalancing the control valves for all four air handlers at a minimum.

Consider also rebalancing the duct mounted reheat coils and fan coil units throughout the building, especially in areas with frequent comfort complaints during the winter.

2.3 Equipment Maintenance & Upgrades

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

Replace dampers and actuators that are not functioning.

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

RE-5b: *Provide a local freeze stat alarm and an alarm signal to the BMS.*

The current freeze stats are wired to cause a local shutdown and are not visible on the BMS, except indirectly via the fan status.

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

2.4 Control System

We recommend the following control system strategies be implemented into the existing control system:

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

We understand that the programmed occupied periods for the air handlers have already been adjusted to run before and after the actual occupied periods. include more time before and after typical occupied periods. Staff should confirm that the system is in occupied mode for three hours before and after the typical occupied period.

RC-3: *Install controls required to introduce outside air beyond the minimum requirements in a stepped approach.*

The existing BMS appears sophisticated enough to implement this type of sequence.

RC-4: *Confirm the economizer control sequence is operational.*

RC-5: *Monitor space relative humidity.*

Due to the ongoing humidity issues within the building, we recommend installing humidity sensors in the return air ductwork for each air handler to allow better economizer operation and to monitor for high space humidity conditions when operating at outside air flows above that recommended in Table 2. If the relative humidity in the return air rises above 55%, reduce the outside air back to the values in Table 2 in a stepped approach.

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.

2.2 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. We are not aware if this building was constructed to handle a humidification system.

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.

While it appears this building was originally designed to operate with steam humidifiers within the AHU, the steam generators were removed many years ago. The humidifier systems are still present on each AHU but are likely no longer useable, and they cannot function without the steam generators.

2.7 Other Recommendations

2.7.1 Replace the AHU-1 Water Coil, and Professionally Clean the Remaining AHU Coils

The water coil for AHU-1 is in very poor condition and should be replaced. The fins are very corroded and breaking off the tubing in several areas.

The test and balance reports indicated air low airflows and coil air pressure drops roughly three times higher than design on AHU's 2-4. We recommend that these coils be professionally cleaned. Because these are relatively deep (8 row) coils, inadequate cleaning can cause debris to build up in the middle rows of the coil. If professional cleaning cannot restore airflow performance to acceptable levels on any of these AHU's, consider replacing the coils.

2.7.2 Inspect and Clean Reheat Coils.

Based on the reheat coil we observed, it is likely that many of the reheat coils are dirty, and that the buildup is affecting airflow. Consider cleaning all reheat coils.

As the hot water reheat coils regulate the supply air temperature delivered to each space. we also recommend verifying control operation of each reheat coil by adjusting the thermostat serving each space during the heating season and verifying that the supply air temperature varies in response.

2.7.3 Replace Air Handlers and Convert the Air Distribution System to Variable Air Volume (VAV)

The existing AHU's are approaching 50 years old and at the end of their expected useful life. The current constant volume arrangement is inefficient and contributes humidity and thermal comfort issues in the building. The humidity issues are discussed in greater detail in the January 2020 report by EH&E.

The use of a VAV system would allow the air handlers to provide a discharge air temperature of 55°F during the summer, resulting in better control of space humidity. At each zone, the quantity of air delivered can be varied to accommodate the cooling or heating needs of the space for more precise temperature control and improved comfort. As part of this project, the existing duct arrangement and airflows should be reviewed, and revisions made where necessary to accommodate current space uses and floor plans. At minimum, each constant airflow box will need to be replaced with a VAV box. Because many boxes serve multiple zones with individual reheats, certain areas will likely require additional VAV boxes for optimal control.

As part of this project, additional energy saving measures could be explored including the use of energy recovery from the toilet exhaust air to preheat incoming outdoor air, and demand-controlled ventilation (post COVID-19) to adjust the supply of outdoor air to each space in response to actual occupancy.

The new air handlers will be large and would most likely have to be provided as built-up type units, meaning they are shipped in pieces and constructed on site. While a complete air handler replacement is the preferred approach, it may also be possible to make upgrades within the existing AHU chassis, which are in good condition and insulated. This approach may limit some options due to space constraints.

The conversion of the existing duct system to VAV will require a substantial and invasive construction project. Due to the constraints of the existing building construction in an occupied building, this project will be challenging and require relocating personnel.

2.7.4 Upgrade Remaining Pneumatic Controls to Electronic Controls

Facilities staff have indicated that the existing reheat coils and fan coil units are currently controlled by pneumatic thermostats, and that these systems do not control space temperatures accurately. Replacing these pneumatic controls with electronic controls connected to the BMS will improve space temperature control and eliminate maintenance that is associated with a pneumatic system.

2.7.5 Install a Heating Piping Loop to Serve the Reheat Coils

This measure is only recommended if the constant airflow systems are to remain. This approach would likely improve comfort and humidity issues and restore the original intended operation of this system, at a lower capital cost compared to converting the system to variable airflow. However, constant airflow systems with reheat are very inefficient as the supply airflow cannot be reduced, and reheat is the only means of controlling individual space temperatures during the summer where the boiler system would otherwise be turned off.

As the building is currently configured, the moisture removal capability of the air handlers is extremely limited. Without being able to vary the supply air to each zone with VAV boxes, the AHU supply temperature is kept relatively high (65-70°F) to avoid overcooling, which does not allow for adequate dehumidification of the supply air. Where present, the fan coils in each space provide cooling to maintain space temperature, but do not provide sufficient dehumidification.

It appears that the reheat piping branches off from main risers at the same location on each floor. The addition of a dedicated hot water riser in this area to serve the reheat distribution would allow the reheats to operate in heating while the fan coils and AHU’s operate in cooling. To minimize the operating cost, it may be worthwhile to install a small dedicated “summer boiler” to serve these reheats, rather than connect to and operate the main boilers.

2.2.6 Replace Fan Coil Units

We recommend replacing the fan coil units within the next five years. The average life of a fan coil unit is approximately 35 years. The fan coil units appear to be original and are approaching 50 years old, exceeding their expected useful life.

Section 3
Testing & Balancing Results

On November 25, 2020 Wings Testing & Balancing visited the Roderick Ireland Courthouse to test the airflow rates of the air handling units and the exhaust fans. The Office of Court Management's Automatic Temperature Controls (ATC) Contractor was also on site to assist in the balancing process. A summary of the tested airflow rates versus the design airflow rates are shown below in Tables 5 and 6. The full testing and balancing report is attached.

On September 7, 2021, Wings Testing & Balancing returned to test the water flow of the chilled water coils. As the air side of the chilled water coils had been cleaned the previous week, they also took airflow and static pressure readings. However, because damper and duct repairs were being made when the measurements were made, these values likely do not accurately represent normal operating conditions.

TABLE 5
Air Handler Testing & Balancing Results

	Design			Actual		
Unit	**Total Supply Fan Airflow (CFM)**	**Recommended Outdoor Airflow (CFM)**	**Return Fan Airflow (CFM)**	**Supply Fan Airflow (CFM)**	**Outdoor Airflow (CFM)**	**Return Fan Airflow (CFM)**
AHU-1	64,000	25,500	38,500	42,576	16,218	26,358
AHU-2	42,000	8,500	31,500	35,100	7,314	27,786
AHU-3	58,000	13,000	45,000	40,680	8,756	31,924
AHU-4	64,000	20,000	44,000	42,202 (32,400)*	13,770 (10,500)*	28,432

* Additional Readings taken on September 7, 2021.

TABLE 6
Exhaust Fan Testing & Balancing Results

Unit	**Serving**	**Design Return/Exhaust Airflow (CFM)**	**Actual Return/Exhaust Airflow (CFM)**
EF-1	Lock Up	16,000	16,720
EF-6	Toilet Exhaust	6,000	3,249

TABLE 7
Hot / Chilled Water Coil Testing and Balancing Results

Unit	Design Chilled Water Flow (GPM)	Actual Chilled Water Flow Rate (CFM)
AHU-1	510	608
AHU-2	354	301
AHU-3	685	498
AHU-4	630	462

In reviewing the airflow report data, the following should be noted:

1. All handling units are operating well below design flowrate while operating at 60hz. The supply and outdoor airflows ranged from 12% to 35% below the original design rates. It appears that there is some additional motor horsepower capacity, but not enough to bring the airflow to design conditions. The total static pressure of the system appears to be very high. The most notable contributors to the high static pressure are the AHU water coils, and the supply distribution ductwork. The cause of the low flow / high static pressure should be investigated further.
    a. The design air pressure drop over the AHU water coils ranges from 1.0 to 1.2 inches water column (“ WC) The measured pressure drop ranged from 1.9” to 3.5” WC, with the lowest pressure drop being over AHU-1. According to staff, the coil in this unit was replaced approximately one year ago. The reduced airflow in AHU’s 2-4 is likely primarily due to the high pressure drop over the AHU water coils. We having these coils professionally cleaned. If cleaning cannot restore performance, we recommend replacing these three coils, and matching the original design parameters, to help reduce the pressure drop in the system.
        i. On September 7, 2021, new measurements were made that appear to indicate a significant reduction in the pressure drop across all coils. However, because of the work being performed at the time, pressure drop and airflow should be tested under normal operating conditions to verify the improvement.
    b. In addition to the AHU coil, the 1997 conversion from electric reheat coils to hot water reheats caused added pressure drop (approximately 1.0” WC) in the air distribution system. While we do not recommend removing these reheat coils, they should be inspected and cleaned, to ensure they are not causing excessive air pressure drop in the system.
    c. The recent addition of a 2” filter rack to replace the original roll filters also resulted in some added pressure drop, but is likely resulting only a minor impact relative to the issues noted above.
    d. The low supply and outdoor airflows for AHU-4 (50% of design) taken on September 7, 2021 may have been due to dirty filters or work being

performed at the time. We recommend retesting under normal operating conditions with clean filters.

2. After cleaning or replacing the coils in AHU's 2-4, and inspecting/cleaning the reheat coils, the supply and return ductwork may still need to be rebalanced to minimize air restriction. If this does not reduce the distribution pressure drop enough for adequate airflow, then motor and fan improvements may also be required.
3. After cleaning/replacing all coils and rebalancing, it is still possible the motor size will have to be increased to handle the added pressure drops from the filters and reheat coils. Based on current conditions, much larger motors (150-300 HP) and likely new fans would be required to generate the required design airflow. These larger motors would require new electrical circuits. With the coil replacements and rebalancing, the required increase in motor size would be significantly reduced.
4. EF-6 had a loose belt at the time of the visit causing the low air flow readings. The belt should be repaired, and the fan rebalanced.
5. The chilled water coils in the AHU's are operating at approximately 84%, 110%, 88%, and 81% of the design water flows, respectively.
    a. The AHU coils that are operating at less than 90% of the design water flow should be adjusted to meet the design chilled water flow. As the airflow in each AHU is also below design, this reduced flow is not likely impacting the coil performance currently. However, if the airflows are restored to design values, the chilled water flows should be adjusted to match
    b. It should be noted that the chilled water coils were tested at full flow, one at a time, with the other three and all other coils operating automatically. If the pump and piping capacity is limited, these measurements may not accurately represent coil flows at design conditions with all equipment calling for full or near-full flow simultaneously.

Wings Testing and Balancing also noted the following findings in their report:

1. There were no flow stations to calibrate in the AHU's.

Table 8 shows updated reduced occupancy airflow rates. This table is identical to Table 4a, except it is based on measured AHU supply and outdoor airflows from the TAB report. This gives a more realistic representation of the actual airflows, since they are substantially different from the design values, and immediate term improvements are not possible.

TABLE 8
Airflow Rate per Person (Reduced Occupancy with TAB airflow rates)

		Total Air		***Outdoor Air***	
Courtroom	***Total People (Reduced Occupancy)***	***Supply Airflow (CFM)***	***Airflow Rate (CFM/Person)***	***Outside Airflow (CFM)***	***Airflow Rate (CFM/Person)***
Jury Pool Room	125	5,200	42	1,080	9
District Courtroom 1	30	3,300	110	1,250	42
District Courtroom 2	34	3,300	97	1,250	37
District Courtroom 3-5	20	1,900	95	720	36
District Courtroom 6	21	1,900	90	720	34
District Courtroom 7-9	20	1,900	95	720	36
District Courtroom 10	18	1,900	106	720	40
Superior Courtroom 1	32	3,700	116	1,410	44
Superior Courtroom 2	35	3,300	94	1,250	36
Superior Courtroom 3-6	20	1,900	95	720	36
Probate Courtroom 1,2	18	2,000	111	760	42
Probate Courtroom 3	22	1,500	68	570	26
Probate Courtroom 4	20	1,500	75	570	29

At the request of the courts, we re-evaluated the ventilation systems based on the measured supply airflows to determine if code-required ventilation can be provided to the building with the current supply airflow. Note that this evaluation only considers ventilation rates, and does not consider the potential impact to heating, cooling, and dehumidification capacity. Based on our evaluation, we found that the majority of the spaces can be adequately ventilated with the current supply airflow available, with minor adjustments to the outdoor air quantity from the current operation. The recommended outdoor air flows are shown in Table 9. To meet current code and keep the outdoor air percentage reasonable, the rooms noted in Table 10 below will need to use a reduced occupancy. If coil cleanings and other measures can increase the airflow beyond the last testing, then the allowable occupancy of these rooms will be increased.

TABLE 9
Recommended Air Handling Equipment O.A. Flow Rates - Based on Current Supply Airflows.

Unit	**Previously Tested Supply Airflow (CFM)**	**Previously Tested O.A. (CFM)**	**Current Code Min. O.A. Requirements (CFM)***	**Recommended Minimum O.A. (CFM)**
AHU-1	43,000	16,200	12,600	12,600
AHU-2	35,000	7,300	7,500	7,500
AHU-3	40,700	8,800	9,800	9,800
AHU-4	42,000	13,800	12,600	12,600

* Code Minimum O.A. requirements are based on the occupancy reductions noted in Table 9 below.

TABLE 10
Recommended Occupancy During COVID-19 Pandemic

Room & Associated AHU	***2015 IMC Permitted Occupancy (# of People)***	***Recommended Occupancy (# of People)***
AHU-3		
Conference Room 141	11	7
Conference Room 142	14	10
Jury Room 313	17	9
Jury Room 314	17	9
Jury Room 315	17	9
AHU-4		
1st Floor Public Prosecutor's Office	9	3
2nd Floor Commissioner's Room	39	4
Conference Room 245	9	7
2nd Floor Stenographer	5	2
Employee Lounge 371	20	8

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.

J:\M\M1671 Comm. of MA Court System\011 - COVID-19 Courthouse Evaluations\Report_Evaluation\Draft Reports\Roderick L. Ireland - Springfield\Roderick Ireland Courthouse Report.docx

Roderick Ireland Courthouse
Additional Testing
CHW and Unit Flows

* * * *

Tighe & Bond
Attn: Jason Urso
53 Southampton Road
Westfield, MA 01085

September 7, 2021

94 North Branford Road • Suite One • Branford, CT 06405
(203) 481-4988 • Fax (203) 488-5634 • wings@wingstesting.com

WING'S TESTING & BALANCING CO., INC.

Tighe & Bond
Attn: Jason Urso
53 Southampton Road
Westfield, MA 01085

September 7, 2021

Re: Roderick Island Courthouse/Chilled Water Measurements

Dear Jason,

Additional testing of flow rates at the above referenced location has been completed, as noted on our attached data sheets.

We measured chilled water flow at all four AHU's (1 through 4). Each measurement was taken with only the ATC valve of the unit being tested forced to 100%; the other three units remained operating in auto. We also recorded all the requested temperatures and pressures as shown on the attached chart.

Total airflow readings were taken on AHU-4 was taken with a 36" Pitot tube. We noted that the outside air damper did not move when commanded to 20% open; see attached picture. Unit 4 was the only fan system we verified the total airflow on. During the testing, we also recorded new supply fan static pressures for all 4 systems.

The following pages are your record of current operating conditions. **All newly tested items are in the data sheets immediately following.** If you have any questions, or if we can be of further service, please do not hesitate to call.

Very truly yours,

Wing's Testing & Balancing Co., Inc.
ICB Certified Contractor for:
TABB—Commissioning—Fire/Life Safety L1&L2—Sound & Vibration

Marek Sadowski
Certified TABB Technician #BB1083468T
CT SM-2 License #7078
MA SM-2 4508
HVAC Fire Life Safety Level 1 Tech FLS11083468T
EPA Universal Technician AA2804U0003

International Certification Board — TABB — ANSI — Marek Sadowski — TABB Technician — BB1083468T — June 30, 2022 — Certified Technician

International Certification Board — ICB/TABB — Matthew Cole — Wings Testing and Balancing — TABB Supervisor — BB10007245 — December 31, 2022 — Certified Supervisor

Roderick Island Courthouse
September 7, 2021

Field Temperature, Pressure Readings

AHU #	Entering Air Temp		Leaving Air Temp		Water Temps	
	DRY B °F	WET B °F	DRY B °F	WET B °F	In °F	Out °F
1	69	59	51.7	47.5	42.1	46
2	71.5	60.6	48	42.8	42.2	46.5
3	71.7	61	64	43	46.5	49
4	72	60	53.2	46.4	45	49

CHW Temperatures at Chiller

Entering Water Temperature 46° F
Leaving Water Temperature 42.5° F

Pressure Drop Across Coils

UNIT	Entering Pressure	Leaving Pressure	ΔP
AHU-1	3.95"	3.36"	.59"
AHU-2	8.05"	4.87"	3.18"
AHU-3	6.35"	6.1"	.25"
AHU-4	4.3"	4.1"	.2"

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Roderick Island Courthouse
September 7, 2021

Outside Air Damper – AHU-4
Position when commanded 20%

HYDRONIC FLOW ELEMENTS

PROJECT: Roderick Ireland Courthouse	**DATE:** 9/7/21
AREA SERVED: Various	**TECH:** MS

LOCATION	NO.	ELEMENT	MFG.	SIZE	DESIGN GPM	TEST I POS.	TEST I PR.DIF	TEST I GPM	FINAL POS.	FINAL PR.DIF	FINAL GPM	NOTES
Chilled Water												
AHU-1	1	Pipe	Steel	8"	510	---	U-sound	608				(1)
AHU-2	2	Pipe	Steel	5"	354	---	U-sound	301				(1)
AHU-3	3	Pipe	Steel	6"	685	---	U-sound	498				(1)
AHU-4	4	Pipe	Steel	6"	630	---	U-sound	462				(1)

REMARKS

(1) Control valve open 100% during testing, other valves on auto mode.

VELOCITY PRESSURE READINGS

PROJECT: Roderick Ireland Courthouse — **DATE:** 9/7/21

AREA SERVED: Various — **TECH:** MS

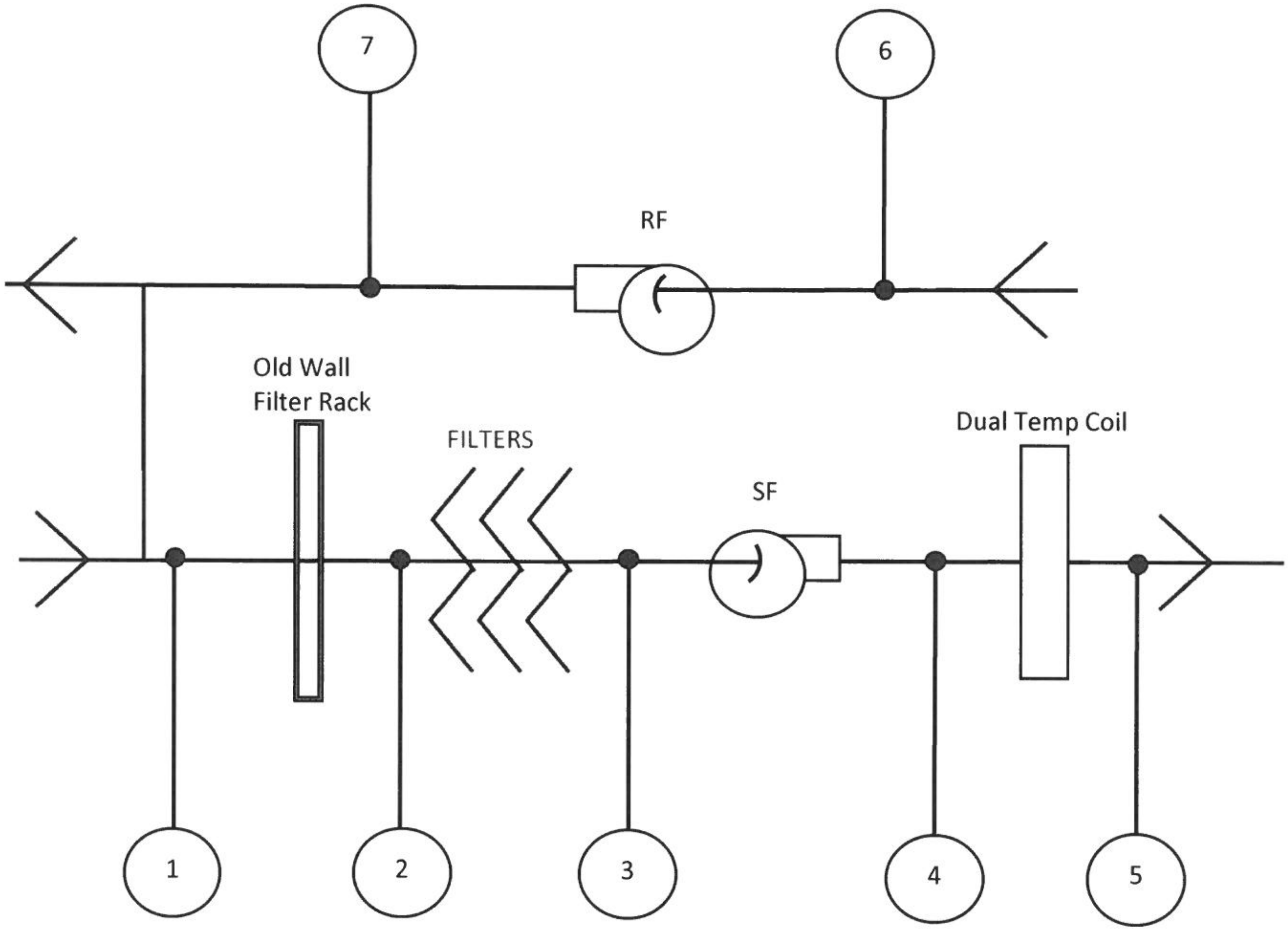
TRAVERSE LOCATIONS	DUCT SIZE "	AREA SQ.FT.	DESIGN FPM	DESIGN CFM	CENTERLINE STATIC PRES."	TEST FPM	TEST CFM	NOTES
AC-4 Supply	52"Ø	14.74	---	60000	+2.97	2191	32,413	(1,2)
AC-4 OA	72" x 106"	51.0	---	20000	w/velgrid	206	10,506	(3)

REMARKS

(1) Supply and return fan at 60Hz. Recorded some negative readings.
(2) Taken with 36" Pitot tube
(3) Outside air damper was set to 20% by in-house mechanic, as on attached picture we can see damper was open maybe 5%

SYSTEM STATIC PRESSURE PROFILE

PROJECT: Roderick Ireland Courthouse | **DATE:** 9/7/21
SYSTEM/AREA SERV: AC-1 | **TECH:** MS



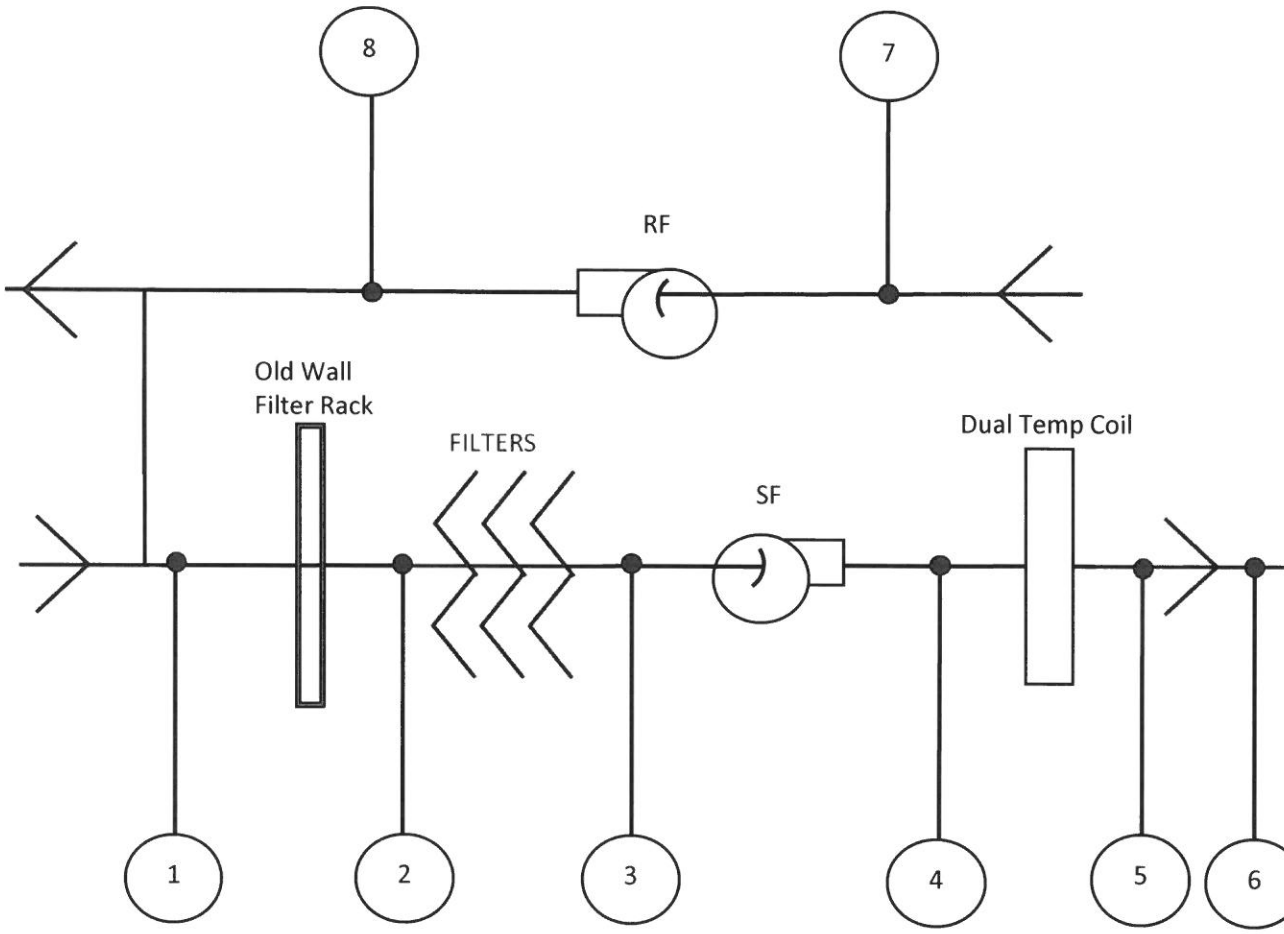
STATIC PRESSURE READINGS "wc

POS. (+) / NEG.(-)	1	2	3	4	5			
Supply	-0.96"	-1.03"	-1.28"	+3.95"	+3.36"			
	6	7						
RF								

REMARKS

SYSTEM STATIC PRESSURE PROFILE

PROJECT: Roderick Ireland Courthouse	**DATE:** 9/7/21
SYSTEM/AREA SERV: AC-2	**TECH:** MS



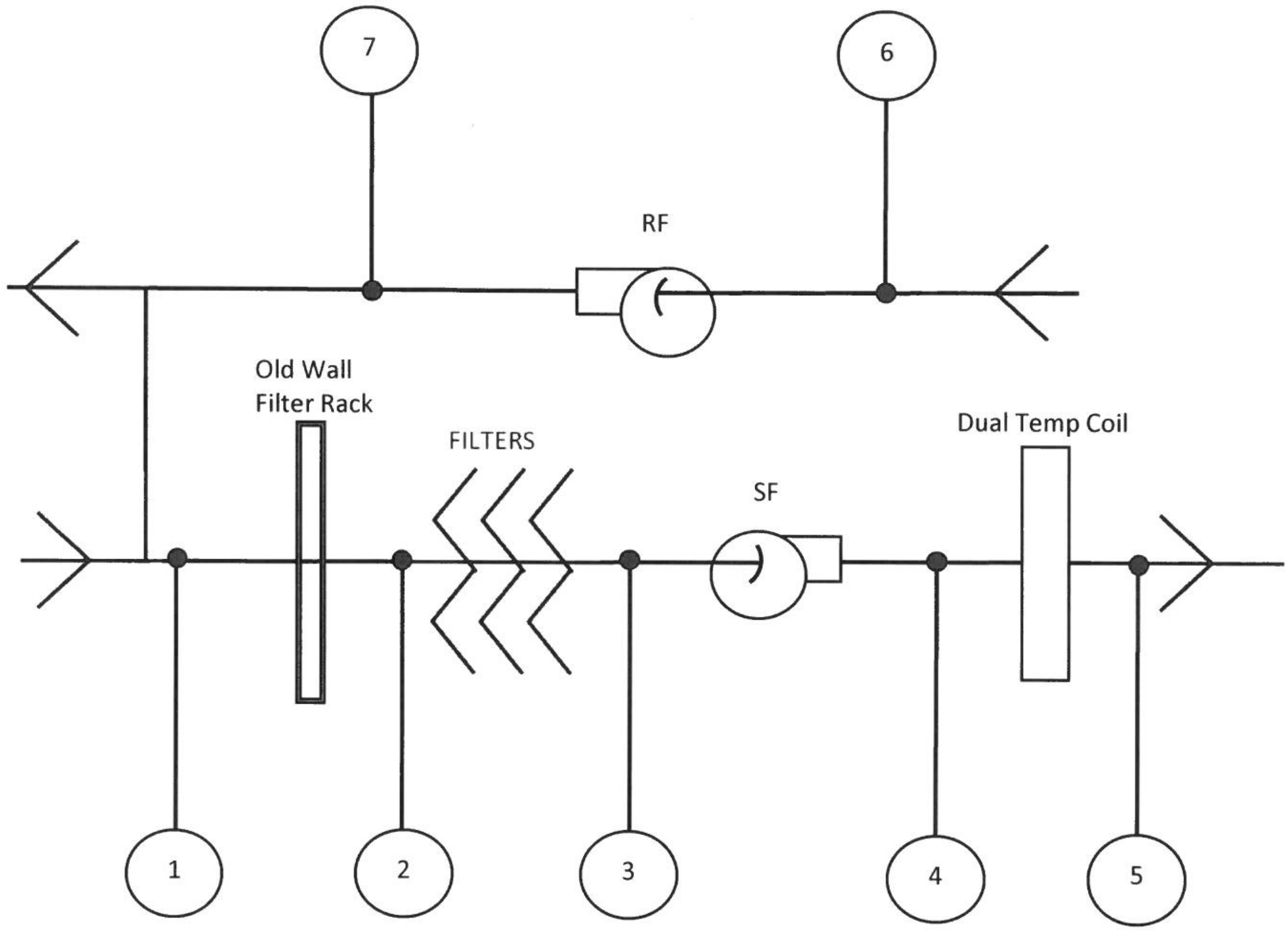
STATIC PRESSURE READINGS "wc

POS. (+) / NEG.(-)	1	2	3	4	5	6		
Supply	-0.24"	-0.28"	-0.55"	+8.05"	+4.87"	+7.2"		
	7	**8**						
RF								

REMARKS

SYSTEM STATIC PRESSURE PROFILE

PROJECT: Roderick Ireland Courthouse	**DATE:** 9/7/21
SYSTEM/AREA SERV: AC-3	**TECH:** MS



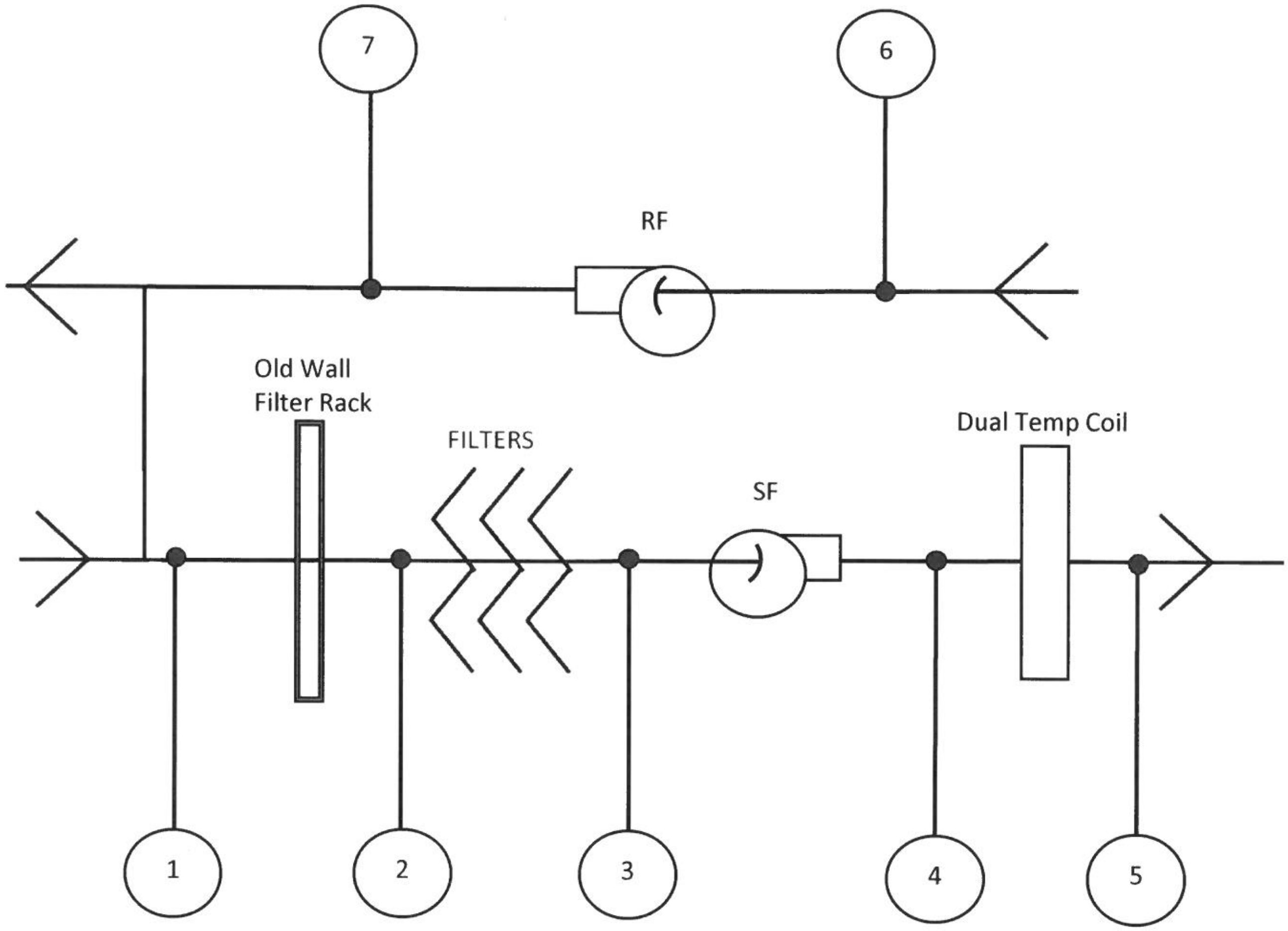
STATIC PRESSURE READINGS "wc

POS. (+) / NEG.(-)	1	2	3	4	5			
Supply	-0.53"	-0.58"	-0.84"	+6.35"	+6.1"			
	6	**7**						
RF								

REMARKS

SYSTEM STATIC PRESSURE PROFILE

PROJECT: Roderick Ireland Courthouse	**DATE:** 9/7/21
SYSTEM/AREA SERV: AC-4	**TECH:** MS



STATIC PRESSURE READINGS "wc

POS. (+) / NEG.(-)	1	2	3	4	5			
Supply	-1.46"	-1.5"	-5.2"	+4.3"	+4.1"			
	6	**7**						
RF								

REMARKS

Roderick Ireland Courthouse
HVAC/Outside Air Survey

* * * *

Tighe & Bond
Attn: Jason Urso
53 Southampton Road
Westfield, MA 01085

November 25, 2020

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www.wingstesting.com

Tighe & Bond
Attn: Jason Urso
53 Southampton Road
Westfield, MA 01085

November 25, 2020

Re: Roderick Island Courthouse/HVAC Outside Air Survey

Dear Jason,

Our HVAC/Outside Air Survey for the above referenced has been completed. While onsite, we worked with William Lyne, the in-house technician. Through our testing we found that EF-6 has a loose belt. Also, we are not able to get a pressure drop across any of the Annubar flow meter stations. None of the AHU's make design flow at 60 Hz. There was no flow station in the AHU's to calibrate.

This report has been updated to include Brake Horsepower (BHP) calculations. When a motor has a VFD, we take the amperage measurements from there. When we calculate from volts and amps, it means there has to be a nameplate on the motor. Many times, these are missing or illegible. If BHP is not listed for an individual motor, this is because we don't have enough information to calculate it. It should be noted that that the older a motor is, the less likely it is to follow the affinity laws for BHP- since the efficiency degrades over time. We have used accepted constants for efficiency and the power factor, which should result in fairly close calculations, but are not as accurate for older motors.

The following pages are your record of the tested conditions. If you have any questions or if we can be of further assistance, please do not hesitate to call.

Very truly yours,

Wing's Testing & Balancing Co., Inc.

ICB Certified Contractor for:

TABB—Commissioning—Fire/Life Safety L1&L2—Sound & Vibration

Barry Stratos

Certified TABB Technician BB996928T

SUPPLY FAN REPORT

PROJECT: Roderick Ireland Courthouse				**DATE:** 11/25/20		
AREA SERVED: AC-1				**TECH:** BS		
FAN DATA						
FAN NUMBER	AC-1		AC-1 RF			
LOCATION	5th Fl Mechanical		5th Fl Mechanical			
AREA SERVED	All Court Rooms		All Court Rooms			
MANUFACTURER	Carrier		Carrier			
MODEL OR SIZE	27-CD-445		27-CD-445			
	DESIGN	**ACTUAL**	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**
TOTAL CFM	64000	42576	38500	26358		
RETURN AIR	38500	26358	---	---		
OUTSIDE AIR	25500	16218	---	---		
DISCH. STATIC	---	+4.04	---	+1.01	---	
SUCTION STATIC	---	-0.51"	---	-2.02	---	
TOTAL STATIC	8.0	455	---	NA		
FAN RPM	940	821	---	NA		
PULLEY O.D.	18 1/2" x 3 11/16"		NA			
ESP	---		---			
VFD SPEED	60 Hz		60 Hz			
O.A.D.MIN POS	40%		---			
MOTOR DATA						
MANUFACTURER	Baldor		Baldor			
MODEL OR FR.	405T		324T			
HORSEPOWER	125	125	40	40		
MOTOR RPM	1775	1775	1775	1775		
VOLTAGE / PH.	460/3	460/3	460/3	460/3		
AMPS LEG 1	143.0	102.4	46.0	35.5		
AMPS LEG 2	---	101.1	---	35.1	---	
AMPS LEG 3	---	103.6	---	35.0	---	
SHEAVE O.D.	11 1/2" x 2 7/8"		NA			
BELTS - QTY / SIZE	5/Vx1120		NA			
SHEAVE POSITION	Fixed		NA			
BHP	89.5		30.6			

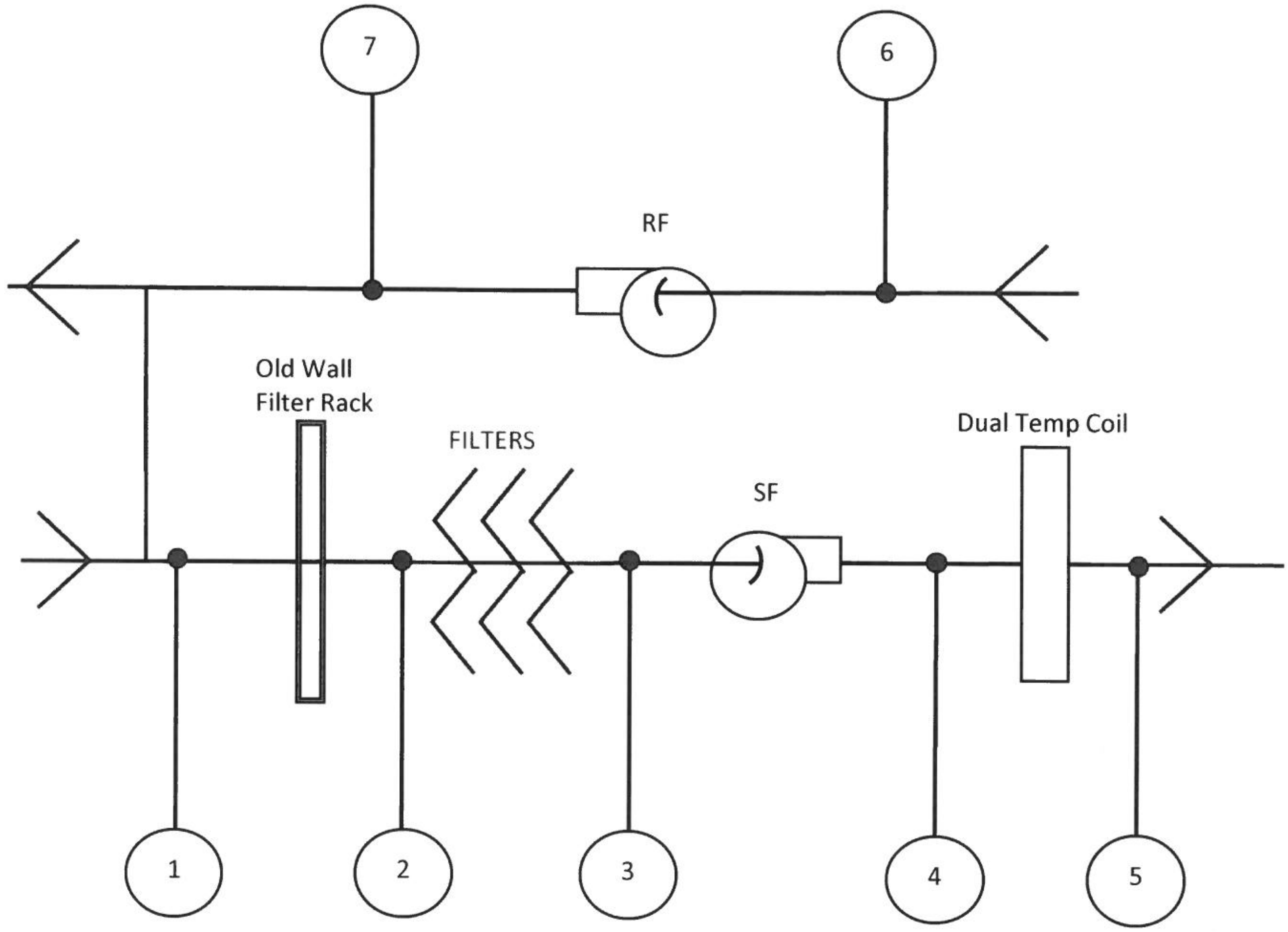
REMARKS

NA-Not Available
ND-No Design DD-Direct Drive

SYSTEM STATIC PRESSURE PROFILE

PROJECT: Roderick Ireland Courthouse | **DATE:** 11/25/20

SYSTEM/AREA SERV: AC-1 | **TECH:** BS



STATIC PRESSURE READINGS "wc

POS. (+) / NEG.(-)	1	2	3	4	5			
Supply	-0.24"	-0.28"	-0.51"	+4.04"	+2.11"			
	6	7						
RF	-2.02"	+1.01"						

REMARKS

SUPPLY FAN REPORT

PROJECT: Roderick Ireland Courthouse | **DATE:** 11/25/20

AREA SERVED: AC-2 | **TECH:** BS

FAN DATA						
FAN NUMBER	AC-2		AC-2 RF			
LOCATION	4th Fl Mechanical		4th Fl Mechanical			
AREA SERVED	4th Floor		4th Floor			
MANUFACTURER	Carrier		Carrier			
MODEL OR SIZE	27-CD-365		27-CD-365			
	DESIGN	**ACTUAL**	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**
TOTAL CFM	42000	35100	33500	27786		
RETURN AIR	33500	27786	---	---		
OUTSIDE AIR	8500	7314	---	---		
DISCH. STATIC	---	+8.03"	---	+0.88"	---	
SUCTION STATIC	---	-0.53"	---	-1.52"	---	
TOTAL STATIC	8.5	8.58	---	2.40		
FAN RPM	1160	1425	---	NA		
PULLEY O.D.	14" x 1 7/8"		NA			
ESP	5.16"		2.4"			
VFD SPEED	60 Hz		60 Hz			
O.A.D.MIN POS	30%		---			
MOTOR DATA						
MANUFACTURER	Baldor					
MODEL OR FR.	404T		284T			
HORSEPOWER	100	100	25	25		
MOTOR RPM	1780	1780	1770	1770		
VOLTAGE / PH.	460/3	460/3	460/3	460/3		
AMPS LEG 1	112.0	83.8	30.0	20.5		
AMPS LEG 2	---	82.0	---	20.9	---	
AMPS LEG 3	---	84.1	---	20.8	---	
SHEAVE O.D.	11 1/2" x 2 7/8"		9" x 1 7/8"			
BELTS - QTY / SIZE	5/Vx1180		3/B105			
SHEAVE POSITION	Fixed		Fixed			
BHP	74.4		17.3			

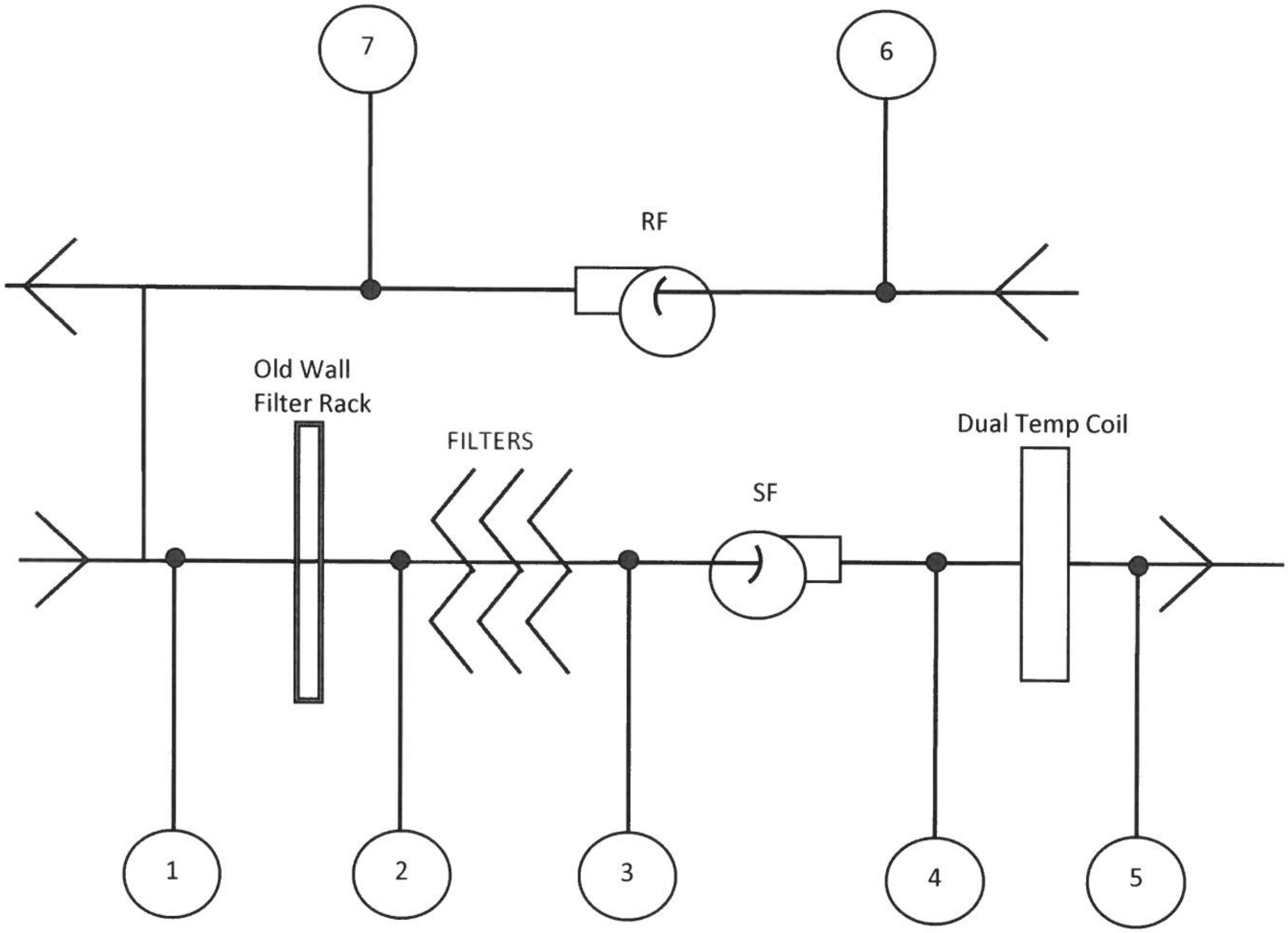
REMARKS

NA-Not Available

ND-No Design DD-Direct Drive

SYSTEM STATIC PRESSURE PROFILE

PROJECT: Roderick Ireland Courthouse	**DATE:** 11/25/20
SYSTEM/AREA SERV: AC-2	**TECH:** BS



STATIC PRESSURE READINGS "wc

POS. (+) / NEG.(-)	1	2	3	4	5			
Supply	-0.24"	-0.28"	-0.55"	+8.03"	+4.92"			
	6	**7**						
RF	-1.52"	+0.88"						

REMARKS

SUPPLY FAN REPORT

PROJECT: Roderick Ireland Courthouse				**DATE:** 11/25/20		
AREA SERVED: AC-3				**TECH:** BS		
FAN DATA						
FAN NUMBER	AC-3		AC-3 RF			
LOCATION	Basement		Basement			
AREA SERVED	West Side		West Side			
MANUFACTURER	Carrier		Carrier			
MODEL OR SIZE	---		---			
	DESIGN	**ACTUAL**	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**
TOTAL CFM	58000	40680	45000	31924		
RETURN AIR	45000	31924	---	---		
OUTSIDE AIR	13000	8756	---	---		
DISCH. STATIC	---	---	---	---	---	
SUCTION STATIC	---	---	---	---	---	
TOTAL STATIC	8.5	---	---	---		
FAN RPM	920	1296	---	NA		
PULLEY O.D.	11" x 3 3/8"		NA			
ESP	---		---			
VFD SPEED	60 Hz		60 Hz			
O.A.D.MIN POS	20%		---			
MOTOR DATA						
MANUFACTURER	Marathon		Baldor			
MODEL OR FR.	405T		324T			
HORSEPOWER	125	125	40	40		
MOTOR RPM	1785	1785	1780	1780		
VOLTAGE / PH.	460/3	460/3	460/3	460/3		
AMPS LEG 1	142.0	87.0	48.0	33.9		
AMPS LEG 2	---	84.5	---	34.2	---	
AMPS LEG 3	---	82.9	---	34.9	---	
SHEAVE O.D.	8" x 2 3/8"		10 1/2" x 2 1/8"			
BELTS - QTY / SIZE	8/5Vx850		3/Cx112			
SHEAVE POSITION	Fixed		100% Closed			
BHP	74.6		28.6			

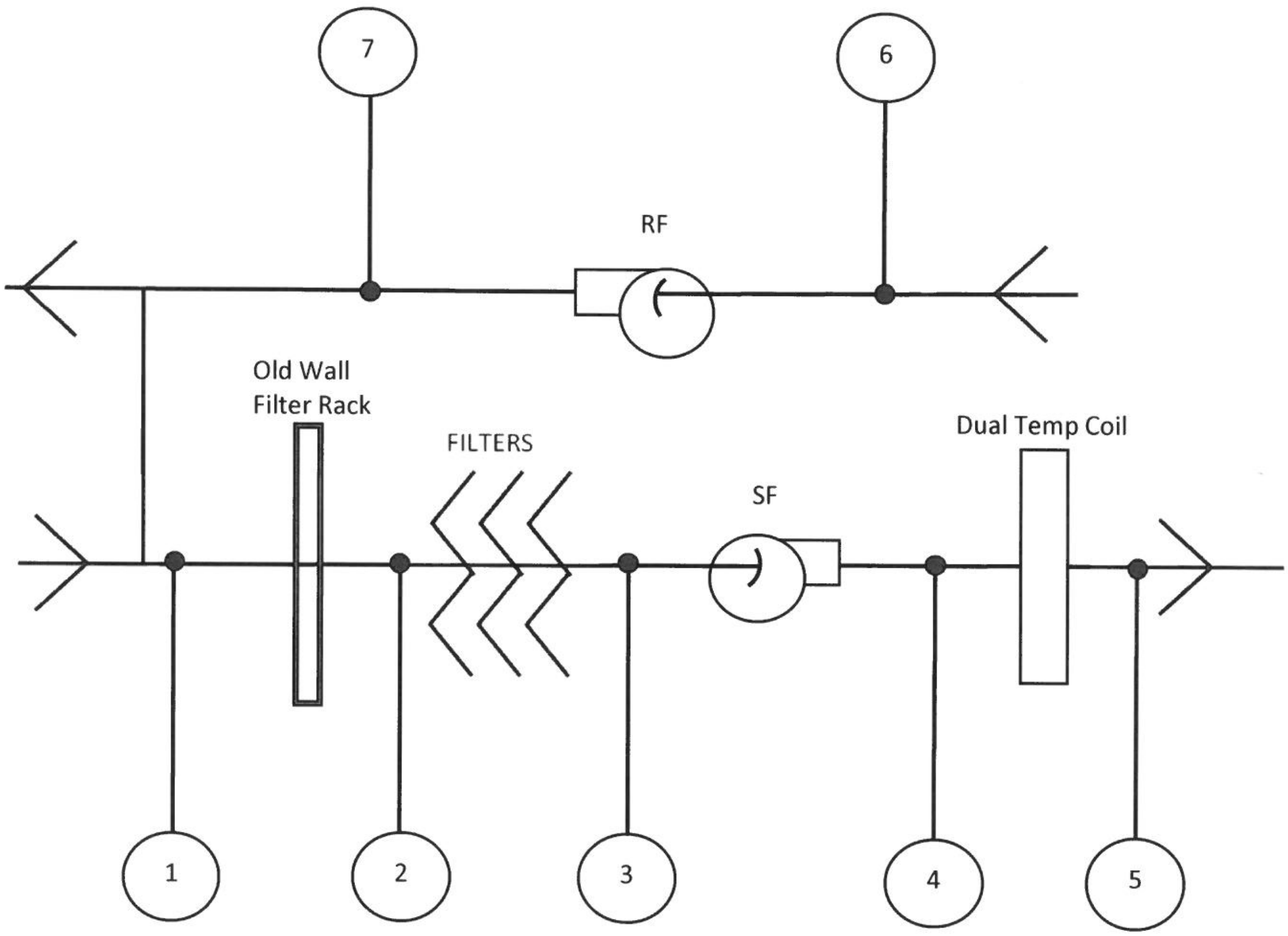
REMARKS

NA-Not Available
ND-No Design DD-Direct Drive

SYSTEM STATIC PRESSURE PROFILE

PROJECT: Roderick Ireland Courthouse | **DATE:** 11/25/20

SYSTEM/AREA SERV: AC-3 | **TECH:** BS



STATIC PRESSURE READINGS "wc

POS. (+) / NEG.(-)	1	2	3	4	5			
Supply	-0.53"	-0.58"	-0.84"	+6.31"	+3.74"			
	6	7						
RF	-2.10"	+1.16"						

REMARKS

SUPPLY FAN REPORT

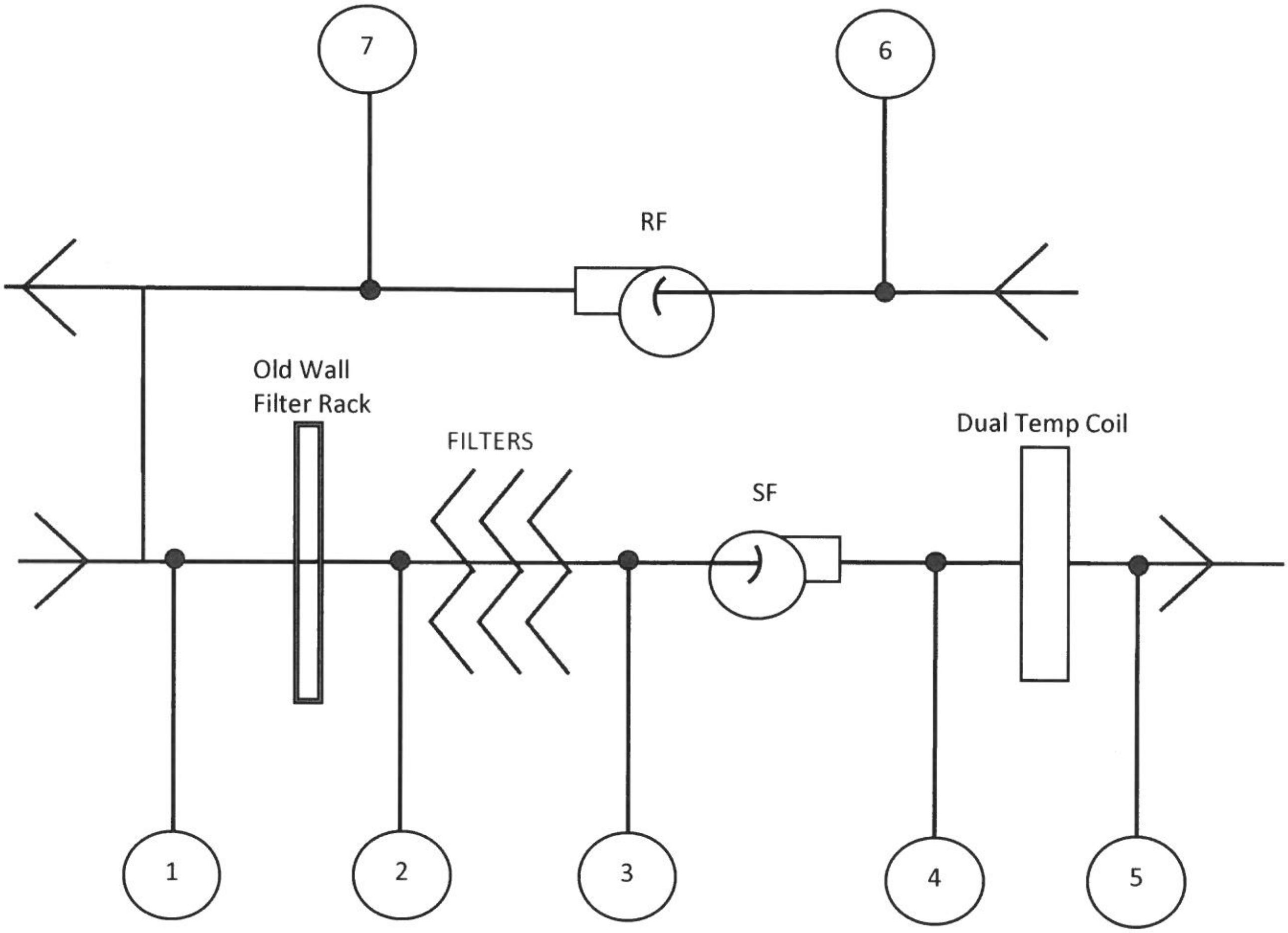
PROJECT: Roderick Ireland Courthouse					**DATE:** 11/25/20	
AREA SERVED: AC-4					**TECH:** BS	
FAN DATA						
FAN NUMBER	AC-4		AC-4 RF			
LOCATION	Basement		Basement			
AREA SERVED	East Side		East Side			
MANUFACTURER	Carrier		Carrier			
MODEL OR SIZE	27-CD-445		27-CD-445			
	DESIGN	**ACTUAL**	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**
TOTAL CFM	64000	42202	44000	28432		
RETURN AIR	44000	28432	---	---		
OUTSIDE AIR	20000	13770	---	---		
DISCH. STATIC	---	---	---	---	---	
SUCTION STATIC	---	---	---	---	---	
TOTAL STATIC	8.5	---	---	---		
FAN RPM	950	1203	---	NA		
PULLEY O.D.	16" x 3 5/8"		NA			
ESP	---		---			
VFD SPEED	60 Hz		60 Hz			
O.A.D.MIN POS	20%		---			
MOTOR DATA						
MANUFACTURER	Marathon		Baldor			
MODEL OR FR.	405T		324T			
HORSEPOWER	125	125	40	40		
MOTOR RPM	1785	1785	1775	1775		
VOLTAGE / PH.	460/3	460/3	460/3	460/3		
AMPS LEG 1	140	105.6	46.0	33.2		
AMPS LEG 2	---	102.3	---	30.8	---	
AMPS LEG 3	---	103.1	---	31.9	---	
SHEAVE O.D.	11" x 2 13/16"		NA			
BELTS - QTY / SIZE	5/5Vx1060		NA			
SHEAVE POSITION	Fixed		NA			
BHP	92.6		27.8			

REMARKS

NA-Not Available
ND-No Design DD-Direct Drive

SYSTEM STATIC PRESSURE PROFILE

PROJECT: Roderick Ireland Courthouse	**DATE:** 11/25/20
SYSTEM/AREA SERV: AC-4	**TECH:** BS



STATIC PRESSURE READINGS "wc

POS. (+) / NEG.(-)	1	2	3	4	5			
Supply	-1.51"	-1.58"	-1.88"	+6.36"	+3.88"			
	6	**7**						
RF	-2.34"	+1.28"						

REMARKS

VELOCITY PRESSURE READINGS

PROJECT: Roderick Ireland Courthouse						**DATE:** 11/25/20		
AREA SERVED: Various						**TECH:** BS		
TRAVERSE LOCATIONS	**DUCT SIZE "**	**AREA SQ.FT.**	**DESIGN**		**CENTERLINE STATIC PRES."**	**TEST**		**NOTES**
			FPM	**CFM**		**FPM**	**CFM**	
AC-1 Supply (Right)	40"Ø	8.72	---	32000	+1.61	2305	20105	
AC-1 Supply (Left)	40"Ø	8.72	---	32000	+1.24	2577	22471	
AC-1 OA	72" x 102"	51.0	---	25500	w/velgrid	318	16218	
AC-2 Supply	108" x 156"	117.0	---	42000	w/velgrid	300	35100	
AC-2 OA	72" x 106"	53.0	---	8500	w/velgrid	138	7314	
AC-3 Supply	52"Ø	15.9	---	58000	3.09	2558	40680	
AC-3 OA	72" x 106"	51.0	---	13000	w/velgrid	171	8756	
AC-4 Supply	52"Ø	14.74	---	60000	4.99	2863	42202	
AC-4 OA	72" x 106"	51.0	---	20000	w/velgrid	270	13770	
EF-1	48" x 40"	13.33	---	NA	-1.39	1254	16720	
EF-2	38" x 16"	4.75	---	NA	-0.25	684	3249	

REMARKS

EXHAUST FAN REPORT

PROJECT: Roderick Ireland Courthouse					**DATE:** 11/25/20	
AREA SERVED: Various					**TECH:** BS	
FAN DATA						
FAN NUMBER		EF-6	EF-1			
LOCATION		Penthouse	Penthouse			
AREA SERVED		Lock Up	Restroom			
MANUFACTURER		Carrier	Aerovent			
MODEL OR SIZE		27DC270KB	ATA-1764-15			
TOTAL	DESIGN	NA	NA			
CFM	ACTUAL	3249	16720			
FAN	DESIGN	NA	NA			
RPM	ACTUAL	440	NA			
PULLEY	O.D.	9" x 1 5/8"	NA			
SERVICE		1.15	NA			
MOTOR DATA						
MANUFACTURER		US Motors	NA			
MODEL NUMBER		184T	NA			
MOTOR	DESIGN	5	15			
HP	ACTUAL	5	15			
MOTOR RPM		1750	NA			
VOLTAGE/PHASE		460/3	460/3			
	DESIGN	6.7	18.8			
MOTOR	ACT. LEG 1	3.2	16.2			
AMPS	ACT. LEG 2	3.0	16.0			
	ACT. LEG 3	3.0	16.1			
SHEAVE		7" x 7/8"	NA			
BELTS-QTY/SIZE		1/Bx65	NA			
SHEAVE POSITION		50% Open	NA			
BHP		2.3	12.8			
REMARKS						

HYDRONIC FLOW ELEMENTS

PROJECT: Roderick Ireland Courthouse | **DATE:** 11/25/20

AREA SERVED: Various | **TECH:** BS

LOCATION	NO.	ELEMENT	MFG.	SIZE	DESIGN GPM	TEST I POS.	TEST I PR.DIF	TEST I GPM	FINAL POS.	FINAL PR.DIF	FINAL GPM	NOTES
AHU-1	1	Annuber	---	6.085	510	---	---	---	---	---	---	(1)
AHU-2	2	Annuber	---	5.047	354	---	---	---	---	---	---	(1)
AHU-3	3	Annuber	---	6.085	685	---	---	---	---	---	---	(1)
AHU-4	4	Annuber	---	6.095	630	---	---	---	---	---	---	(1)

REMARKS

(1) We are not reading any pressue drop across the annuber flow meter stations.