MIDDLESEX COUNTY SUPERIOR COURT
HVAC SYSTEM EVALUATION SUMMARY

Visited September 28, 2020. Inspected the air handling equipment located on the roof and toured the facility to determine if the spaces generally matched usages noted on the architectural plans. The Middlesex County Superior Court is a leased facility from the property owner, Cummings Properties, LLC. It was constructed in 2008 and is approximately 157,000 square feet in size. Three roof mounted, packaged Aaon heat recovery ventilators (HRV), model "RN" serve the Courtroom and select Jury Deliberation spaces and four roof mounted Greenheck HRVs, model "ERV-581", serve the remaining spaces in the building. Both the Aaon and Greenheck units provide 100% outdoor air to the building. All return air traveling back to all seven air handlers is exhausted to the outdoors. Overall, the Aaon units are in excellent condition and the Greenheck units are in good condition. The dampers and actuators in all units appear to be in good condition and all heating and cooling coils appear to be clean.

1.0 Airflow Rate Per Person (Reduced Occupancy)

		Total Air		*Outdoor Air*	
Courtroom	*Total People*	*Supply Airflow (CFM)*	*Airflow Rate (CFM/Person)*	*Outside Airflow (CFM)*	*Airflow Rate (CFM/Person)*
Jury Assembly Room 304	40	3,000	75	600	15
Civil Courtroom 418	31	3,900	126	1,280	41
Criminal Courtroom 424	37	3,900	105	1,500	41
Criminal Courtroom 440	37	3,900	105	1,500	41
Civil Courtroom 502	29	3,900	134	1,280	44
Civil Courtroom 519	31	3,900	126	1,280	41
Criminal Courtroom 526	37	4,000	108	1,880	51
Criminal Courtroom 539	37	4,000	108	1,380	37
Civil Courtroom 603	29	3,900	134	1,280	44
Civil Courtroom 620	31	3,900	126	1,280	41
Criminal Courtroom 625	37	3,900	105	1,500	41
Civil Courtroom 639	37	3,900	105	1,500	41
Civil Courtroom 703	29	3,900	134	1,280	44
Civil Courtroom 720	31	3,900	126	1,280	41
Criminal Courtroom 725	37	3,900	105	1,500	41
Civil Courtroom 739	37	3,900	105	1,500	41

2.0 Recommendations

Section	Recommendation/Finding	Action
2.1	Filtration Efficiency	
RF-1	Replace filters with MERV-13	Deferred
2.2	Testing and Balancing	

RTB-1	Test and balance RTU supply air and outside air flow rates, and heat pump airflow rates	Deferred
RTB-2	Test and balance system return and exhaust air flow rate	Deferred
RTB-4	Test and balance VAV box flow rates	Deferred
2.3	Equipment Maintenance and Upgrades	
RE-1	Test existing air handling system dampers and actuators for proper operation	Deferred
RE-4	Inspect VAV boxes and controllers to ensure they are in good working condition	Deferred
2.4	Control System	
RC-1	Implement a pre and post-occupancy flush sequence	Deferred
RC-5	Disable demand control ventilation sequence	Deferred
2.5	Additional Filtration and Air Cleaning	
RFC-1	Install portable HEPA filters in high traffic areas – *if courthouse is to operate at a high occupancy (i.e. 50-75% or greater), install portable HEPA filters in high traffic areas.*	Complete
2.6	Humidity Control	
	No actionable items listed – continuous monitoring for seasonal changes	On-going

Middlesex County Superior Court
Woburn, MA

HVAC SYSTEM EVALUATION COVID-19

Office of Court Management

December 4, 2020

Tighe&Bond

100% Recyclable

Section 1
Existing Conditions & Site Observations

Tighe & Bond visited the Middlesex County Superior Court in Woburn, MA on September 24, 2020. While on site we inspected the air handling equipment located on the roof and toured the facility to determine if the spaces generally matched usages noted on the architectural plans.

Site Visit Attendees:

- *Office of Court Management:*
  - Scott Arneil, Manager of Court Facilities – Region 5
  - Cummings Properties, LLC Facilities Staff
- *Tighe & Bond*
  - Jason Urso, PE, Senior Mechanical Engineer
  - Christina Wu, Staff Engineer

1.1 Existing Ventilation System

The Middlesex County Superior Court is a leased facility from the property owner, Cummings Properties, LLC. It was constructed in 2008 and is approximately 157,000 square feet in size. Three roof mounted, packaged Aaon heat recovery ventilators (HRV), model "RN" serve the Courtroom and select Jury Deliberation spaces and four roof mounted Greenheck HRVs, model "ERV-581", serve the remaining spaces in the building. Both the Aaon and Greenheck units provide 100% outdoor air to the building. All return air traveling back to all seven air handlers is exhausted to the outdoors.

The Aaon units contain supply fans, an exhaust fan, a heat recovery wheel, DX cooling, gas heat, 4" MERV 10 pre filters, and 2" MERV 10 final filters. According to the 2007 Construction Drawings, these units were originally designed with 2" 30% filters, however they were recently replaced with MERV 10 filters. These units supply air directly into Courtrooms and are also ducted to heat pumps serving Courtrooms and Jury Deliberation rooms.

The Greenheck HRVs only contain a supply fan, exhaust fan, heat recovery wheel, a 2" MERV 10 filter on the supply and exhaust side of the heat wheel, and provide ventilation air to heat pumps located throughout the building. These units do not contain heating or cooling coils. Further tempering of the supply air is performed at the heat pumps.

Overall, the Aaon units are in excellent condition and the Greenheck units are in good condition. The dampers and actuators in all units appear to be in good condition and all heating and cooling coils appear to be clean.

Water source heat pumps are located above ceilings and provide heating and cooling to each occupied space in the Courthouse. Ventilation air from the rooftop air handling units are ducted to the return section of each heat pump. A variable air volume (VAV) box regulates the outside air from the Aaon units to each heat pump serving the Courtrooms. A VAV box is also located on the exhaust duct serving the Courtrooms. According to the design drawings, ventilation air to all other heat pumps is not regulated with VAV boxes.

Cummings Properties stated that generally, a minimum of 400 cubic feet per minute (CFM) of outdoor air is supplied to all Courtrooms when unoccupied and a maximum of 1,500 CFM of outdoor air while occupied. The equivalent quantity of exhaust air is regulated via the VAV boxes on the exhaust ducts. The occupied airflow rates are triggered by occupancy sensors mounted in each Courtroom.

The heat pumps return air from each room, mixes this return air with outside air from the HRV units, and then supply air back into the zone they serve. Return air filters are located in the ceiling return grilles serving the heat pumps. According to facilities staff, these are MERV 10 filters. Several toilet room exhaust fans are located throughout the building, which appear to be tied into the HRV exhaust air ductwork.

The holding cells appear to have more air supplied to the space than exhausted, creating a positive pressure in these spaces. According to the design drawings, the small holding cells are supplied with 150 CFM. There are no exhaust air flow rate tags for the exhaust grilles serving the cells, but based upon the duct size serving each exhaust grille and the airflow legend in the drawing title block, we presume between 100 and 125 CFM is exhausted from the "RG B3" grilles. The larger group holding cells have a larger positive pressure with 250 CFM being supplied with air being exhausted with the same "RG B3" exhaust grilles connected with a 6"Ø exhaust duct.

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

TABLE 1
Existing Air Handling Units

Unit	Original Design Airflow (CFM)	Original Design Min. O.A. (CFM)	Pre/Final Filters	Condition
HRV-A, B, C & D (Greenheck)	6,600	6,600	2" MERV 10	Good
HRV-E (Aaon)	13,000	13,000	2" MERV 10/ 4" MERV 10	Excellent
HRV-F (Aaon)	13,000	13,000	2" MERV 10/ 4" MERV 10	Excellent
HRV-G (Aaon)	9,600	9,600	2" MERV 10/ 4" MERV 10	Excellent

A 2,000 MBH input gas-fired boiler provides tempered water to the heat pumps during the heating season and a 583 ton cooling tower provides tempered water during the cooling season to the heat pumps.

Photo 1 - Representative Aaon Air Handler

Photo 2 - Representative Greenheck Air Handler

1.2 Existing Control System

A Siemens Metasys Building Management System (BMS) controls the building's HVAC equipment. According to facility staff, this system only provides limited controls. We were not provided any documentation on the existing control system to fully understand the capabilities and limitations of this system.

Section 2
Recommendations

Below is a list of recommendations that we propose for the Middlesex County Superior Court. Please refer to the "Master Recommendation List" for further explanation and requirements of the stated recommendations.

2.1 Filtration Efficiency Recommendations

Our recommendation to install MERV 13 filters in the HVAC equipment is dependent on the testing and balancing exercise of the rooftop air handling units and the heat pumps discussed in Section 2.2. According to Cummings Properties, they have been cautioned against using MERV 13 filters in the roof mounted air handlers and were told the equipment was not designed to operate with filters above MERV 10.

The HRV units are 100% outdoor air units and return air from the building is not mixed into the supply air. Generally, 100% outdoor air systems have a lower risk of spreading airborne pathogens generated within a building, since theoretically all of the supply air is outdoor air. However, there is a concern of crossover air leakage around the heat wheel from the exhaust air stream into the supply air stream, which is dependent on the fan arrangement and pressure profile in the air handler.

We contacted the manufacturer's representative for both Greenheck and Aaon to understand the direction of air leakage in each unit. We received confirmation that the air leakage in the Greenheck units travels from the exhaust into the supply air stream. The direction of the crossover leakage in the Aaon air handlers can occur in either direction and is dependent on which air stream has the higher pressure profile. If the pressure is higher on the supply fan side, then air leakage will travel from the exhaust to the supply air stream. We believe this logic may also apply to the Greenheck units.

Pending the air testing of the HRV units, the final filters in the supply air in the Aaon units may be able to be replaced with MERV 13 filters to filter potential leaked air. The existing 2" filter frame may be able to be replaced with a 4" frame, allowing the use of 4" MERV 13 filters, which will extend the filter life. Exhaust air filters in the Greenheck HRV units may be able to be replaced with MERV 13 filters to filter the air before it passes over the heat wheel. An alternative is to install duct mounted MERV 13 filters in the supply ducts following the Greenheck units, assuming the fans have adequate capacity to overcome this additional pressure drop.

The heat pumps serving each room recirculate room air to the spaces they serve. This presents a risk of recirculating infectious aerosols within the spaces each heat pump serves.

We recommend determining if the HRV units can accommodate MERV 13 filters by the ASHRAE's "Practical Approach to Increase MERV in an AHU" testing and balancing procedure. Please refer to the "Study and Design Services of Mechanical/Electrical System Upgrades / Replacement of Various Buildings and Systems Statewide" report for further information on this approach.

A similar approach is required to understand if the heat pumps can accommodate MERV 13 filters in the return grilles, but this exercise would be very labor intensive due to the

large quantity of heat pumps located throughout the building. Prior to the testing and balancing exercise for the heat pumps, we may be able to analyze the original TAB report for the building in order to understand the fan capacity of the heat pumps. The original TAB report should include specific performance information for each heat pump, such as the fan airflow rate, motor horsepower, static pressure, etc.

2.2 Testing & Balancing Recommendations

In July 2020, Air Balance Services, LLC tested the airflow rates of air outlets located within the occupied spaces that are connected to the heat pumps. In our preliminary review of the report dated July 8, 2020 it appears the heat pumps are providing airflow rates within 5% of the designed airflow rates. It is not clear if the filters in the return grilles were installed prior to this exercise. If the filters were not installed at the time of the balancing, the current airflow rates from the heat pumps may be lower as a result of the added pressure drop from the filters. This report, however, does not document the performance of the rooftop air handling units providing the ventilation air to the building, the airflow rates of the VAV boxes supplying and exhausting ventilation air to the Courtrooms, the fan performance of the heat pumps, or the outside air flow rates provided to each heat pump system.

Based on the Courthouse design drawings that were provided to Tighe & Bond, it is unclear what the designed ventilation air flow rates are for the heat pumps and VAV boxes. There is a legend in the title block that gives an airflow range for each round ductwork size serving the heat pumps, but there are no specific values listed for each specific duct. Moreover, there are no VAV box tags that indicates the exact airflow ranges for the boxes either. The outdoor air flow rates noted below are based on our best judgement of the design intent in regards to the quantity of ventilation air provided to each space.

We recommend the following testing and balancing measures:

RTB-1: *Test and balance roof top unit supply air and outside air flow rates, and heat pump airflow rates.*

We recommend testing and balancing the outdoor air flow rates for all seven HRV units to the recommended minimum O.A. rates listed in Table 2. These values are identical to the supply air flow rates they were originally designed to.

TABLE 2
Recommended Air Handler O.A. Flow Rates

Unit	Original Design Airflow (CFM)	Current Code Min. O.A. Requirements (CFM)	Recommended Min. O.A. (CFM)
HRV-A	6,600	4,000	6,600
HRV-B	6,600	3,400	6,600
HRV-C	6,600	2,400	6,600
HRV-D	6,600	3,500	6,600
HRV-E	13,000	6,200	13,000
HRV-F	13,000	5,600	13,000
HRV-G	9,600	3,600	9,600

The average airflow rate per person is shown below in Table 3. These values are based on the original design supply airflow rate of the heat pumps and the recommended outdoor air flow rates of the heat recovery unit ventilators shown in Table 2 above. The airflow rate per person 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 occupancy.

TABLE 3
Average Airflow Rate per Person

	All spaces	*Courtrooms & Jury Rooms (HRV-E,F,G)*	*Non-Courtroom Spaces (HRV-A,B,C,D)*
Total Occupancy (People)	2,550	1,825	728
Total Supply Air (CFM/Person)	69	38	151
Outdoor Air (CFM/Person)	24	20	36

The airflow rate per person for each Courtroom and the Jury Pool Room is shown below in Table 4. These values are based on full occupancy, the original total design supply airflow rate, and recommended outdoor air flow rates, without taking diversity into account. 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 (if applicable), the airflow rate per person will also be reduced.

TABLE 4
Airflow Rate per Person – Courtrooms (Full Occupancy)

		Total Air		*Outdoor Air*	
Courtroom	***Total People***	***Supply Airflow (CFM)***	***Airflow Rate (CFM/Person)***	***Outside Airflow (CFM)***	***Airflow Rate (CFM/Person)***
Jury Assembly Room 304	125	3,000	24	600	5
Civil Courtroom 418	149	3,900	26	1,280	9
Criminal Courtroom 424	177	3,900	22	1,500	8
Criminal Courtroom 440	170	3,900	23	1,500	9
Civil Courtroom 502	132	3,900	30	1,280	10
Civil Courtroom 519	149	3,900	26	1,280	9
Criminal Courtroom 526	177	4,000	22	1,880	11
Criminal Courtroom 539	170	4,000	24	1,380	8
Civil Courtroom 603	129	3,900	30	1,280	10
Civil Courtroom 620	150	3,900	26	1,280	9
Criminal Courtroom 625	177	3,900	22	1,500	8
Civil Courtroom 639	167	3,900	23	1,500	9
Civil Courtroom 703	132	3,900	30	1,280	10
Civil Courtroom 720	148	3,900	26	1,280	9
Criminal Courtroom 725	176	3,900	22	1,500	9
Civil Courtroom 739	170	3,900	23	1,500	9

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 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 – Courtrooms (Reduced Occupancy)

		Total Air		*Outdoor Air*	
Courtroom	***Total People***	***Supply Airflow (CFM)***	***Airflow Rate (CFM/Person)***	***Outside Airflow (CFM)***	***Airflow Rate (CFM/Person)***
Jury Assembly Room 304	40	3,000	75	600	15
Civil Courtroom 418	31	3,900	126	1,280	41
Criminal Courtroom 424	37	3,900	105	1,500	41
Criminal Courtroom 440	37	3,900	105	1,500	41
Civil Courtroom 502	29	3,900	134	1,280	44
Civil Courtroom 519	31	3,900	126	1,280	41
Criminal Courtroom 526	37	4,000	108	1,880	51
Criminal Courtroom 539	37	4,000	108	1,380	37
Civil Courtroom 603	29	3,900	134	1,280	44
Civil Courtroom 620	31	3,900	126	1,280	41
Criminal Courtroom 625	37	3,900	105	1,500	41
Civil Courtroom 639	37	3,900	105	1,500	41
Civil Courtroom 703	29	3,900	134	1,280	44
Civil Courtroom 720	31	3,900	126	1,280	41
Criminal Courtroom 725	37	3,900	105	1,500	41
Civil Courtroom 739	37	3,900	105	1,500	41

We also recommend testing the airflow rates, static pressure profile, and horsepower of the heat pumps, pending our analysis of the original TAB report and discussion with the heat pump manufacturer. Testing the heat pumps will allow further analysis to determine if MERV 13 filters can be installed.

RTB-2: *Test and balance rooftop air handling units exhaust air flow rate.*

We recommend testing the exhaust air flow rates for all seven roof mounted air handling units to verify they are operating as designed. According to the Heat Recovery Ventilation Schedule on the existing drawings, the exhaust airflow rate for each HRV unit is identical to the supply air. In order to provide an overall positive building pressure to help offset infiltration, less air should be exhausted than is being supplied to the building. It appears this building may be running at a neutral air pressure or a negative air pressure, depending on the dynamic operation of the VAV boxes and toilet room exhaust fans.

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

We recommend testing the occupied and unoccupied supply air and exhaust air flow rates for the VAV boxes serving the Courtrooms, testing the quantity of outside air provided by the seven HRV units to each heat pump throughout the building, and to the supply diffusers in the Courtrooms to ensure each space is getting the proper

quantity of ventilation air. The construction documents that were provided to Tighe & Bond do not state what the occupied and unoccupied flow rates are for the VAV boxes or the ventilation air supply ducts to the heat pumps. The designed air flow rates for this equipment should be confirmed with either the record drawings, the automatic temperature controls drawings and/or sequences, and/or the original testing and balancing reports for the building when the systems were first installed.

Air handling units HRV-F and HRV-G supply air to both Courtrooms and Jury Deliberation rooms. The supply ducts that serve the Courtrooms control airflow via VAV boxes, while there are no VAV boxes controlling the airflow supplied to the Jury Deliberation rooms. Common HVAC system design practice is to provide VAV boxes on all supply ducts in a variable air volume system. Without VAV boxes serving the Jury Deliberation rooms, there is a concern that there may be fluctuations of supply (ventilation) air into these rooms when Courtroom VAV boxes cycle from maximum to minimum position. We do not have any information on how the HRV units are controlled, but we suspect the supply fan varies its speed and the delivered airflow when the dampers in Courtroom VAV boxes modulate open and closed. As the HRV fan speeds up or down, the ventilation airflow rate into these uncontrolled Jury rooms may vary, providing more or less than what is required by code during occupied periods. We recommend installing variable air volume boxes serving the Jury Deliberation rooms served by HRV-F and HRV-G. VAV boxes with properly established minimum damper positions will help maintain the proper quantity of outdoor air into Jury rooms while the HRV fan varies its speed. A similar approach to varying the quantity of outdoor air to Jury Deliberation rooms during occupied and unoccupied periods can be implemented. This will help save HRV fan and air conditioning energy while the Jury rooms are unoccupied.

We do not recommend measure RTB-3, increasing the outdoor air beyond the minimum under non-peak conditions. Each HRV unit is providing a substantial amount of outdoor air beyond what is required by code. Also, these units provide 100% outdoor air. To provide more outdoor air, it would require the HRV units to supply and exhaust more air than it was designed for. This may require larger fans and motors in order to deliver a larger quantity of outside air. The velocity of the outside air entering each air handler is also a concern. The more air that is pulled through the intake air hood, the higher the velocity, which increases the risk of rain and snow entrainment. Also, the size of the ductwork distribution system may not be able to accommodate a higher airflow.

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*.

The damper actuators are twelve years old if they are original. They appear to be in good condition, but we recommend testing the actuators to ensure they are functioning properly. Replace dampers and actuators that are not functioning.

RE-4: *Inspect VAV boxes and controllers to ensure they are in good working condition*.

We recommend inspecting the VAV boxes and cycling the setpoints from maximum to minimum to ensure they are delivering the proper quantity of outside air to the Courtrooms.

2.4 Control System

We recommend the following for the control system:

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

RC-5: *Disable demand control ventilation sequences.*

It is our understanding that the Courtroom VAV boxes increase from a minimum quantity of ventilation air to the maximum based on occupancy, triggered by occupancy sensors. A conservative approach to increasing ventilation air to the building is to schedule the Courtroom VAV boxes to provide the maximum quantity of ventilation air at all times during occupied hours instead of relying on the occupancy sensors. This may be able to be programmed via the exiting BMS. This strategy will provide the maximum quantity of outside air during occupied hours, but will also expend more energy.

Another approach is to schedule only select Courtroom VAV boxes to operate at maximum airflow that coincide with the Courtrooms that will be utilized during the day. If only a few Courtrooms are used throughout the week, while others remain unoccupied, the VAV boxes serving the occupied courtrooms could be scheduled to deliver the maximum airflow throughout the entire day, while the others could vary the airflow based on occupancy sensors. This will create a better balance of supplying the maximum quantity of outdoor air to occupied spaces and also save energy.

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.

2.6 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

We do not have any other recommendations at this time.

Section 3
Testing and Balancing Results

On November 12, 2020 Milharmer Associates, Inc. visited Middlesex County Superior Courthouse to test the airflow rates of the rooftop air handling units. A representative from Cummings Properties, LLC 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 Table 5. Their full testing and balancing report is attached.

TABLE 5
Air Handler Testing & Balancing Results

	Design		Actual	
Unit	Supply Fan Airflow (CFM)	Return Fan Airflow (CFM)	Supply Fan Airflow (CFM)	Return Fan Airflow (CFM)
HRV-A	6,600	6,600	6,193	6,837
HRV-B	6,600	6,600	7,158	6,886
HRV-C	6,600	6,600	6,059	6,481
HRV-D	6,600	6,600	6,143	5,542
HRV-E	13,000	13,000	9,267	8,071
HRV-F	13,000	13,000	7,183	7,018
HRV-G	9,600	9,600	4,406	3,903

Note:

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

1. Milharmer noted that the Cummings Properties, LLC representative was unable to override the VAV boxes to the full cooling position, therefore several units were not able to meet the design airflow. We recommend the control sequences for the VAV boxes be tested by the ATC Contractor to determine why they were not able to command the boxes to the full open position and retest all air handling units that are not meeting the designed supply airflow rates. HRV-E, HRV-F, and HRV-G are delivering significantly less than the specified values. Once the control issues are resolved, we recommend resting the supply and return airflow rates for these units.
2. We recommend balancing the return fans to a value equal to or slightly less than the supply fans to create an overall positive building pressure. This will help combat air infiltration.
3. Considering air handlers HRV-E, HRV-F, and HRV-G are supplying significantly less than the designed airflow rates, the actual outdoor air flowrate per person stated in Table 4a will be less. The exact flow rate per person cannot be determined without further testing and balancing.

Disclaimer

Tighe and Bond cannot in anyway 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\Middlesex-Woburn Superior Court\Middlesex Superior Court Report.docx

MILHARMER ASSOCIATES, INC.
534 New State Highway, Route 44, Suite 3
Raynham, MA 02767
Tel.: 508-823-8500; Facsimile: 508-823-8600

TEST AND BALANCE REPORT

Project: **Middlesex Superior Courthouse**
200 Tradecenter Dr., Woburn, MA

Project No.: **20-550** **Project Date:** **11/12/2020**

MECHANICAL CONTRACTOR
Tighe & Bond

3384

A N.E.B.B. Certified Company

Project:	Middlesex Superior Courthouse		
Address:	200 Tradecenter Dr., Woburn, MA		
Date:	11/12/2020	**Project No.**	20-550

CERTIFICATION

Submitted & Certified by:

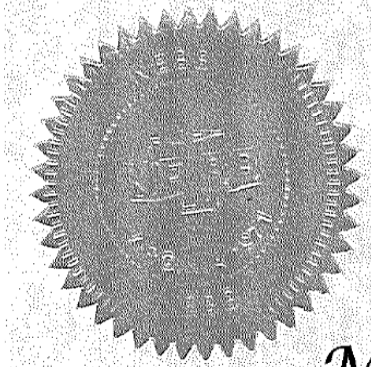
Milharmer Associates, Inc.

Certification No.: ***3384*** Certification Expiration Date: **3-31-21**

The data presented in this Report is a record of system measurements and final adjustments that have been obtained in accordance with the current edition of the ***N.E.B.B. Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.*** Any variances from design quantities which exceed N.E.B.B. tolerances, are noted in the Test-Adjust-Balance Report Project Summary.

N.E.B.B. Qualified TAB Supervisor Name: **Scott F. Miller**

N.E.B.B. Qualified TAB Supervisor Signature:_____



Certification

THIS IS TO CERTIFY THAT

Milharmer Associates, Inc.

HAS MET ALL REQUIREMENTS FOR NEBB CERTIFICATION IN THE FOLLOWING DISCIPLINE

Testing, Adjusting and Balancing of Environmental Systems

FOR THE NEBB BOARD OF DIRECTORS

March 31, 2021

Expiration Date

NEBB President

3384

NEBB Certification Number

NEBB President-Elect

NEBB Certification Board

NEBB Certified Professional

Scott F. Miller

HAS MET ALL THE NEBB REQUIREMENTS FOR NEBB CERTIFIED PROFESSIONAL STATUS IN

Testing, Adjusting and Balancing of Environmental Systems

This Certificate, as well as individual affiliation with a NEBB Certified Firm and associated NEBB Certification Stamp are REQUIRED to provide a NEBB Certified Report. Participation in the NEBB Quality Assurance Program requires the Certificant be affiliated with a NEBB Certified Firm.

March 31, 2021

Expiration Date

23541

NEBB Certificant Number

Richard Fant

NEBB Certification Board Chairman

Cynthia Heath

NEBB Certification Director

The NEBB Certification Board retains sole ownership of all certificates. The NEBB Certification Board Policy Manual governs use of this certificate.

Project:	Middlesex Superior Courthouse		
Address:	200 Tradecenter Dr., Woburn, MA		
Date:	11/12/2020	**Project No.**	20-550

TABLE OF CONTENTS

Project:	Middlesex Superior Courthouse		
Address:	200 Tradecenter Dr., Woburn, MA		
Date:	11/12/2020	**Project No.**	20-550

INSTRUMENT SHEET

The following is a list of Instruments owned and operated by Milharmer Associates, Inc. and used on this project.

Instrument ID Number	Instrument	Calibration Date	Calibration Due Date
1	ADM-870 Digital Multimeter	8-20-20	8-20-21
2	Shortridge Flow Hood	8-20-20	8-20-21
3	Ampmeter	8-20-20	8-20-21
4	Tachometer	8-20-20	8-20-21
5	Airflow Anemometer	8-20-20	8-20-21
6	Digital Thermometers	8-20-20	8-20-21
7	Shortridge Water Meter	8-20-20	8-20-21
8	Sound Meter	8-20-20	8-20-21
9	Vibration Meter	8-20-20	8-20-21

Please Note: Instruments are tested annually at the M.A.I. Lab. and sent back to the factory if deviation exceeds manufacturing tolerance.

Technician:

SYMBOL SHEET

AHU	Air Handling Unit	HEATER O.L.	Thermal Overload
AC or ACU	Air Conditioner Unit		Protection For Motors
ACCU	Air Cooled Condensing Unit		Located at Starter Motor
ADJ P.D.	Adjusted Pitch Diameter		
AMP	Amperage	HEPA	High Efficiency Particulate
AVG	Average		Arrestance
A.D.	Air Density	HOA	Hand/Off/Auto Switch
		H.P.	Horsepower
B.H.P.	Brake Horsepower	HPS	High Pressure Steam
		HRC	Heat (Recovery or Recliam) Coil
CFM	Cubic Feet Per Minute	HVAC	Heating, Ventilation and
CH	Chiller		Air Conditioning
CHWR	Chilled Water Return	HWR	Hot Water Return or
CHW or CHWS	Chilled Water Supply		Heating Water Return
CT	Cooling Tower	HWS	Hot Water Supply or
CWR	Condenser Water Return		Heating Water Supply
CW or CWS	Condenser Water Supply	HX	Heat Exchanger
DB	Dry Bulb	I.D.	Inside Diameter
D.D.	Direct Drive		
DIA	Diameter	LAT	Leaving Air Temperature
		L.D.	Linear Supply Diffuser
EAT	Entering Air Temperature	LPS	Low Pressure Steam
EDC	Electric Duct Coil	L.T.	Light Troffer
EDH	Electric Duct Heater	LWT	Leaving Water Temperature
EF	Exhaust Fan		
EMS	Energy Mgt System	MAU/MUA	Make Up Air Unit
EWT	Entering Water Temperature	MBH	1,000 BTU's per Hour
FCU	Fan Coil Unit	N.A.	Not Accessible
FH	Fume Hood	N/A	Not Applicable
F.L.A.	Full Load Amperage	N.I.	Not Installed
FPB	Fan Powered Box	N.L.	Not Listed
FPM	Feet Per Minute		
FT. HD.	Feet of Head		
GPM	Gallons Per Minute		

SYMBOL SHEET CONTINUED

O.D.	Outside Diameter	TAB	Testing, Adjusting, and Balancing
OA Min	Outside Air Minimum	TSP	Total Static Pressure
OAT	Outside Air Total	TP	Thermally Protected
PF	Power Factor	UH	Unit Heater
PHC	Preheat Coil		
PH	Phase(s)	V	Volts
PSI	Pounds Per Square Inch	VAV	Variable Air Volume
P.T.	Pitot Traverse	VD	Volume Damper
		VFD	Variable Frequency Drive
RA	Return Air	VP	Velocity Pressure
RF	Return Air Fan		
R.G.	Return Grille	W	Watts
RHC	Reheat Coil	WB	Wet Bulb
RPM	Revolutions per Minute	W.D.	Water Density
		W.G.	Water Guage
SA	Supply Air		
SAT	Supply Air Temperature	F	Degrees Fahrenheit
S.D.	Supply Diffuser		
SEF	Smoke Exhaust Fan	ΔP	Differential (Delta) Pressure or Pressure Drop
SF (AIR)	Supply Fan		
S.F.(Elect)	Service Factors		
SHC	Steam Heating Coil	ΔT	Differential (Delta) Temperature, Net Temperature Decrease or Increase
S.P. "W.C."	Static Pressure Measured in Inches of Water Column	#	PSI or Pounds Per Square Inch Decrease or Increase

Project:	Middlesex Superior Courthouse		
Address:	200 Tradecenter Dr., Woburn, MA		
Date:	11/12/2020	**Project No.**	20-550

REPORT SUMMARY

The ventilation for Middlesex Superior Courthouse is provided by 7 Heat Recovery Ventilation Units (HRV's) which serve fresh air to individual heat pumps throughout the facility. The individual Heat Pumps were not tested as part of this survey. The ATC Contractor was on site during the testing of the systems and was unable to override the HRV's to the full cooling position and subsequently, several of the units were not meeting design airflow. Based on the current operating points of these units, the are more than capable of meeting design Outside Air and Exhaust Air flow rates. Additionally, the units have sufficient capacity to increase the filter efficiencies.

It is recommended that all control sequences be verified and tested by the ATC Contractor as he was unable to override to the requested mode of operation. Overall condition of the units appears to be very good.

Project:	Middlesex Superior Courthouse		
Address:	200 Tradecenter Dr., Woburn, MA		
Date:	11/12/2020	**Project No.**	20-550

REPORT SUMMARY

HRV's

UNIT	SUPPLY	EXHAUST	OUTSIDE AIR
HRV-A	6,193 CFM	6,837 CFM	6,193 CFM
HRV-B	7,158 CFM	6,886 CFM	7,158 CFM
HRV-C	6,059 CFM	6,481 CFM	6,059 CFM
HRV-D	6,143 CFM	5,542 CFM	6,143 CFM
HRV-E	9,267 CFM	8,071 CFM	9,267 CFM
HRV-F	7,183 CFM	7,018 CFM	7,183 CFM
HRV-G	4,406 CFM	3,903 CFM	4,406 CFM

Project: Middlesex Superior Courthouse

Address: 200 Tradecenter Dr., Woburn, MA

Date: 11/12/2020 **Project No.** 20-550

FAN DATA SHEET

	FAN NO.	HRV-E	FAN NO.	Exhaust
Serves / Location:	VAV's	Roof	Exhaust	Roof
Manufacturer:	AAON			
Model Number:	RN-050-3-0-BB04-3D9			
Size:	NL			
Serial Number:	200711-BNGW03205			
MOTOR	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Manufacturer:	2@	BALDOR	2@	BALDOR
Frame Number:	NL	254T	NL	213T
Horsepower:	15	15	7.5	7.5
Brake Horsepower:	NL	NA	NL	NA
Safety Factor:	NL	1.15	NL	1.15
Volts/Phase:	4630/3	460/3	460/3	460/3
Motor Amperage:	17.7	24.3	9.6	6.4
Motor RPM:	1765	941	1770	590
Speeds:	VFD	32Hz	VFD	20Hz
Heater Size:	NL	VFD Protected	NL	VFD Protyected
Heater Amps.:	NL	VFD Protected	NL	VFD Protyected
FAN	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Supply Air CFM:	13000	9267 **		
Return Air CFM:				
Exhaust Air CFM:			13000	8071 **
Outside Air CFM:				
Suction Pressure:	NL	-0.52	NL	-0.44
Discharge Pressure:	NL	0.1	NL	0.13
Fan Static Pressure:	NL	NA	NL	NA
External Pressure:	1.5	0.62	1.5	0.57
RPM	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Fan RPM:	NL	DIRECT DRIVE	NL	NA
Motor Drive:	NL	DIRECT DRIVE	NL	1VP68
Motor Size/Bore:	NL	DIRECT DRIVE	NL	1 3/8
Fan Drive:	NL	DIRECT DRIVE	NL	BK100
Fan Size/Bore:	NL	DIRECT DRIVE	NL	1 3/16
Belt Size / Number:	NL	DIRECT DRIVE	NL	BX68x1
Shafts C-C:	NL	DIRECT DRIVE	NL	22.75"
Turns Open:	NL	DIRECT DRIVE	NL	3

Comments: **** ATC technician was unable to overide VAV boxes to full cooling position.**

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-E
Supply

TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)		" DIAMETER			Sq Ft =	0.00
DUCT SIZE (RECT.)	96	" WIDTH x	32	" DEPTH	Sq Ft =	21.33

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	13000
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	9267
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**9272**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	330	501	415	396	536	435	
B	301	366	481	575	316	435	
C	515	345	444	427	464	575	
D	419	314	464	568	300	503	
E							
F							
G							
H							
I							

NO. OF READINGS = 24 AVERAGE FPM = 434

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-E
Exhaust

TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)			" DIAMETER		Sq Ft =	0.00
DUCT SIZE (RECT.)	2x	15	" WIDTH x	30	" DEPTH	Sq Ft =	6.25

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	13000
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	8071
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**8075**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	1832	1027					
B	1755	1008					
C	1031	1095					
D							
E							
F							
G							
H							
I							

NO. OF READINGS = 6 AVERAGE FPM = 1291

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse

Address: 200 Tradecenter Dr., Woburn, MA

Date: 11/12/2020 **Project No.** 20-550

FAN DATA SHEET

	FAN NO.	HRV-F	FAN NO.	Exhaust
Serves / Location:	VAV's	Roof	Exhaust	Roof
Manufacturer:	AAON			
Model Number:	RN-050-3-0-BB04-3D9			
Size:	NL			
Serial Number:	200711-BNGW03206			
MOTOR	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Manufacturer:	2@	BALDOR	2@	BALDOR
Frame Number:	NL	254T	NL	213T
Horsepower:	15	15	7.5	7.5
Brake Horsepower:	NL	NA	NL	NA
Safety Factor:	NL	1.15	NL	1.15
Volts/Phase:	4630/3	460/3	460/3	460/3
Motor Amperage:	17.7	24.3	9.6	6.4
Motor RPM:	1765	971	1770	590
Speeds:	VFD	33Hz	VFD	20Hz
Heater Size:	NL	VFD Protected	NL	VFD Protyected
Heater Amps.:	NL	VFD Protected	NL	VFD Protyected
FAN	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Supply Air CFM:	13000	7183 **		
Return Air CFM:				
Exhaust Air CFM:			13000	7018 **
Outside Air CFM:				
Suction Pressure:	NL	-0.48	NL	-0.39
Discharge Pressure:	NL	0.08	NL	0.11
Fan Static Pressure:	NL	NA	NL	NA
External Pressure:	1.5	0.58	1.5	0.59
RPM	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Fan RPM:	NL	DIRECT DRIVE	NL	NA
Motor Drive:	NL	DIRECT DRIVE	NL	1VP68
Motor Size/Bore:	NL	DIRECT DRIVE	NL	1 3/8
Fan Drive:	NL	DIRECT DRIVE	NL	BK100
Fan Size/Bore:	NL	DIRECT DRIVE	NL	1 3/16
Belt Size / Number:	NL	DIRECT DRIVE	NL	BX68x1
Shafts C-C:	NL	DIRECT DRIVE	NL	22.75"
Turns Open:	NL	DIRECT DRIVE	NL	3

Comments: **** ATC technician was unable to overide VAV boxes to full cooling position.**

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-F Supply
TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)		" DIAMETER			Sq Ft =	0.00
DUCT SIZE (RECT.)	96	" WIDTH x	32	" DEPTH	Sq Ft =	21.33

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	13000
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	7183
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**7187**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	143	385	365	361	367	256	
B	207	368	417	298	269	286	
C	312	361	416	258	377	184	
D	485	435	392	438	414	287	
E							
F							
G							
H							
I							

NO. OF READINGS = 24 AVERAGE FPM = 337

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-F
Exhaust

TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)			" DIAMETER		Sq Ft =	0.00
DUCT SIZE (RECT.)	2x	15	" WIDTH x	30 " DEPTH	Sq Ft =	6.25

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	13000
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	7018
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**7022**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	1574	1729					
B	1410	1328					
C	328	368					
D							
E							
F							
G							
H							
I							

NO. OF READINGS = 6 AVERAGE FPM = 1123

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse

Address: 200 Tradecenter Dr., Woburn, MA

Date: 11/12/2020 **Project No.** 20-550

FAN DATA SHEET

	FAN NO.	HRV-G	FAN NO.	Exhaust
Serves / Location:	VAV's	Roof	Exhaust	Roof
Manufacturer:	AAON			
Model Number:	RN-031-3-0-BB04-3C9			
Size:	NL			
Serial Number:	200711-BNGW03204			
MOTOR	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Manufacturer:	NL	BALDOR	2@	BALDOR
Frame Number:	NL	284T	NL	213T
Horsepower:	15	15	7.5	7.5
Brake Horsepower:	NL	NA	NL	NA
Safety Factor:	NL	1.15	NL	1.15
Volts/Phase:	4630/3	460/3	460/3	460/3
Motor Amperage:	20	11.1	9.6	6.4
Motor RPM:	1180	669	1770	619
Speeds:	VFD	34Hz	VFD	21Hz
Heater Size:	NL	VFD Protected	NL	VFD Protyected
Heater Amps.:	NL	VFD Protected	NL	VFD Protyected
FAN	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Supply Air CFM:	9600	4446 **		
Return Air CFM:				
Exhaust Air CFM:			9600	3903 **
Outside Air CFM:				
Suction Pressure:	NL	-0.68	NL	-0.39
Discharge Pressure:	NL	0.17	NL	0.14
Fan Static Pressure:	NL	NA	NL	NA
External Pressure:	1.5	0.85	1.5	0.53
RPM	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Fan RPM:	NL	DIRECT DRIVE	NL	NA
Motor Drive:	NL	DIRECT DRIVE	NL	1VP68
Motor Size/Bore:	NL	DIRECT DRIVE	NL	1 3/8
Fan Drive:	NL	DIRECT DRIVE	NL	BK105
Fan Size/Bore:	NL	DIRECT DRIVE	NL	H (S) 1 3/16
Belt Size / Number:	NL	DIRECT DRIVE	NL	BX68x1
Shafts C-C:	NL	DIRECT DRIVE	NL	22.75"
Turns Open:	NL	DIRECT DRIVE	NL	4

Comments: **** ATC technician was unable to overide VAV boxes to full cooling position.**

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-G
Supply

TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)		" DIAMETER			Sq Ft =	0.00
DUCT SIZE (RECT.)	96	" WIDTH x	32	" DEPTH	Sq Ft =	21.33

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	9600
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	4446
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**4449**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	203	275	226	179	275	211	
B	212	290	168	162	230	152	
C	197	325	216	161	192	148	
D	205	227	200	154	180	214	
E							
F							
G							
H							
I							

NO. OF READINGS = 24 AVERAGE FPM = 208

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-G TRAVERSE NUMBER : T1
Exhaust TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)			" DIAMETER		Sq Ft =	0.00
DUCT SIZE (RECT.)	2x	15	" WIDTH x	30	" DEPTH	Sq Ft =	6.25

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	9600
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	3903
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**3905**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	647	519					
B	621	711					
C							
D							
E							
F							
G							
H							
I							

NO. OF READINGS = 4 AVERAGE FPM = 625

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse

Address: 200 Tradecenter Dr., Woburn, MA

Date: 11/12/2020 **Project No.** 20-550

FAN DATA SHEET

	FAN NO.	HRV-A	FAN NO.	Exhaust
Serves / Location:	Supply	Roof	Exhaust	Roof
Manufacturer:	GREENHECK			
Model Number:	ERV-581H-30-B-ES			
Size:	NL			
Serial Number:	10958057			
MOTOR	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Manufacturer:	NL	RELIANCE	NL	RELIANCE
Frame Number:	NL	184T	NL	184T
Horsepower:	5	5	7.5	5
Brake Horsepower:	NL	NA	NL	NA
Safety Factor:	NL	1.15	NL	1.15
Volts/Phase:	208/3	208/3	208/3	208/3
Motor Amperage:	14.6	7.1	14.6	6.2
Motor RPM:	1745	1747	1745	1749
Speeds:	NL	1	NL	1
Heater Size:	NL	CB	NL	CB
Heater Amps.:	NL	CB	NL	CB
FAN	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Supply Air CFM:	6600	6193		
Return Air CFM:				
Exhaust Air CFM:			6600	6837
Outside Air CFM:				
Suction Pressure:	NL	-1.1	NL	-0.92
Discharge Pressure:	NL	0.37	NL	0.09
Fan Static Pressure:	NL	NA	NL	NA
External Pressure:	1.2	1.47	1.2	1.01
RPM	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Fan RPM:	NL	NA	NL	NA
Motor Drive:	NL	VP56	NL	VP56
Motor Size/Bore:	NL	1 1/8	NL	1 1/8
Fan Drive:	NL	BK77	NL	BK80S
Fan Size/Bore:	NL	1"	NL	1"
Belt Size / Number:	NL	BX54x1	NL	BX60x1
Shafts C-C:	NL	19"	NL	21 1/2
Turns Open:	NL	2.5	NL	2.5

Comments:

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-A
Supply

TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)		" DIAMETER			Sq Ft =	0.00
DUCT SIZE (RECT.)	55	" WIDTH x	31	" DEPTH	Sq Ft =	11.84

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	6600
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	6193
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**6197**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	595	564	580	348			
B	589	593	553	386			
C	596	640	447	386			
D							
E							
F							
G							
H							
I							

NO. OF READINGS = 12 AVERAGE FPM = 523

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-A
Exhaust

TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)		" DIAMETER		Sq Ft =	0.00
DUCT SIZE (RECT.)	21 1/2	" WIDTH x	21 1/2 " DEPTH	Sq Ft =	3.21

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	6600
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	6837
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**6841**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	2240	2330	1744				
B	1928	2334	2194				
C	2032	2057	2310				
D							
E							
F							
G							
H							
I							

NO. OF READINGS = 9 AVERAGE FPM = 2130

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

FAN DATA SHEET

	FAN NO.	HRV-B	FAN NO.	Exhaust
Serves / Location:	Supply	Roof	Exhaust	Roof
Manufacturer:	GREENHECK			
Model Number:	ERV-581H-30-B-ES			
Size:	NL			
Serial Number:	10958058			
MOTOR	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Manufacturer:	NL	RELIANCE	NL	RELIANCE
Frame Number:	NL	184T	NL	184T
Horsepower:	5	5	7.5	5
Brake Horsepower:	NL	NA	NL	NA
Safety Factor:	NL	1.15	NL	1.15
Volts/Phase:	208/3	208/3	208/3	208/3
Motor Amperage:	14.6	7.8	14.6	6.3
Motor RPM:	1745	1751	1745	1749
Speeds:	NL	1	NL	1
Heater Size:	NL	CB	NL	CB
Heater Amps.:	NL	CB	NL	CB
FAN	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Supply Air CFM:	6600	7158		
Return Air CFM:				
Exhaust Air CFM:			6600	6886
Outside Air CFM:				
Suction Pressure:	NL	-1	NL	-0.94
Discharge Pressure:	NL	0.21	NL	0.17
Fan Static Pressure:	NL	NA	NL	NA
External Pressure:	1.2	1.21	1.2	1.11
RPM	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Fan RPM:	NL	NA	NL	NA
Motor Drive:	NL	VP56	NL	VP56
Motor Size/Bore:	NL	1 1/8	NL	1 1/8
Fan Drive:	NL	BK77	NL	BK80S
Fan Size/Bore:	NL	1"	NL	1"
Belt Size / Number:	NL	BX54x1	NL	BX60x1
Shafts C-C:	NL	19"	NL	21 1/2
Turns Open:	NL	2.5	NL	2.5

Comments:

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-B
Supply

TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)		" DIAMETER			Sq Ft =	0.00
DUCT SIZE (RECT.)	55	" WIDTH x	31	" DEPTH	Sq Ft =	11.84

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	6600
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	7158
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**7162**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	561	418	598	445			
B	877	929	702	483			
C	416	778	609	439			
D							
E							
F							
G							
H							
I							

NO. OF READINGS = 12 AVERAGE FPM = 605

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-B
Exhaust

TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)		" DIAMETER			Sq Ft =	0.00
DUCT SIZE (RECT.)	21 1/2	" WIDTH x	21 1/2	" DEPTH	Sq Ft =	3.21

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	6600
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	6886
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**6890**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	1717	1739	2290				
B	2483	2153	2306				
C	2291	2112	2215				
D							
E							
F							
G							
H							
I							

NO. OF READINGS = 9 AVERAGE FPM = 2145

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse

Address: 200 Tradecenter Dr., Woburn, MA

Date: 11/12/2020 **Project No.** 20-550

FAN DATA SHEET

	FAN NO.	HRV-C	FAN NO.	Exhaust
Serves / Location:	Supply	Roof	Exhaust	Roof
Manufacturer:	GREENHECK			
Model Number:	ERV-581H-30-B-ES			
Size:	NL			
Serial Number:	10958059			
MOTOR	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Manufacturer:	NL	RELIANCE	NL	RELIANCE
Frame Number:	NL	184T	NL	184T
Horsepower:	5	5	7.5	5
Brake Horsepower:	NL	NA	NL	NA
Safety Factor:	NL	1.15	NL	1.15
Volts/Phase:	208/3	208/3	208/3	208/3
Motor Amperage:	14.6	7.7	14.6	6.3
Motor RPM:	1745	1754	1745	1755
Speeds:	NL	1	NL	1
Heater Size:	NL	CB	NL	CB
Heater Amps.:	NL	CB	NL	CB
FAN	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Supply Air CFM:	6600	6059		
Return Air CFM:				
Exhaust Air CFM:			6600	6481
Outside Air CFM:				
Suction Pressure:	NL	-1.1	NL	-0.94
Discharge Pressure:	NL	0.17	NL	0.09
Fan Static Pressure:	NL	NA	NL	NA
External Pressure:	1.2	1.27	1.2	1.03
RPM	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Fan RPM:	NL	NA	NL	NA
Motor Drive:	NL	VP56	NL	VP56
Motor Size/Bore:	NL	1 1/8	NL	1 1/8
Fan Drive:	NL	BK77	NL	BK80S
Fan Size/Bore:	NL	1"	NL	1"
Belt Size / Number:	NL	BX54x1	NL	BX60x1
Shafts C-C:	NL	19"	NL	21 1/2
Turns Open:	NL	2.5	NL	2.5

Comments:

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-C
Supply

TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)		" DIAMETER			Sq Ft =	0.00
DUCT SIZE (RECT.)	55	" WIDTH x	31	" DEPTH	Sq Ft =	11.84

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	6600
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	6059
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**6063**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	553	489	540	451			
B	531	501	459	514			
C	604	512	460	527			
D							
E							
F							
G							
H							
I							

NO. OF READINGS = 12 AVERAGE FPM = 512

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-C
Exhaust

TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)		" DIAMETER			Sq Ft =	0.00
DUCT SIZE (RECT.)	21 1/2	" WIDTH x	21 1/2	" DEPTH	Sq Ft =	3.21

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	6600
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	6481
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**6484**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	1504	2232	2195				
B	2118	2080	1894				
C	2099	1718	2330				
D							
E							
F							
G							
H							
I							

NO. OF READINGS = 9 AVERAGE FPM = 2019

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse

Address: 200 Tradecenter Dr., Woburn, MA

Date: 11/12/2020 **Project No.** 20-550

FAN DATA SHEET

	FAN NO.	HRV-D	FAN NO.	Exhaust
Serves / Location:	Supply	Roof	Exhaust	Roof
Manufacturer:	GREENHECK			
Model Number:	ERV-581H-30-B-ES			
Size:	NL			
Serial Number:	10958060			
MOTOR	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Manufacturer:	NL	RELIANCE	NL	RELIANCE
Frame Number:	NL	184T	NL	184T
Horsepower:	5	5	7.5	5
Brake Horsepower:	NL	NA	NL	NA
Safety Factor:	NL	1.15	NL	1.15
Volts/Phase:	208/3	208/3	208/3	208/3
Motor Amperage:	14.6	7.7	14.6	6
Motor RPM:	1745	1758	1745	1755
Speeds:	NL	1	NL	1
Heater Size:	NL	CB	NL	CB
Heater Amps.:	NL	CB	NL	CB
FAN	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Supply Air CFM:	6600	6143		
Return Air CFM:				
Exhaust Air CFM:			6600	5542
Outside Air CFM:				
Suction Pressure:	NL	-0.93	NL	-1.1
Discharge Pressure:	NL	0.11	NL	0.17
Fan Static Pressure:	NL	NA	NL	NA
External Pressure:	1.2	1.04	1.2	1.27
RPM	**DESIGN**	**TESTED**	**DESIGN**	**TESTED**
Fan RPM:	NL	NA	NL	NA
Motor Drive:	NL	VP56	NL	VP56
Motor Size/Bore:	NL	1 1/8	NL	1 1/8
Fan Drive:	NL	BK77	NL	BK80S
Fan Size/Bore:	NL	1"	NL	1"
Belt Size / Number:	NL	BX54x1	NL	BX60x1
Shafts C-C:	NL	19"	NL	21 1/2
Turns Open:	NL	2.5	NL	2.5

Comments:

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-D
Supply

TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)		" DIAMETER			Sq Ft =	0.00
DUCT SIZE (RECT.)	55	" WIDTH x	31	" DEPTH	Sq Ft =	11.84

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	6600
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	6143
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**6147**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	363	597	525	573			
B	421	613	561	517			
C	433	555	578	490			
D							
E							
F							
G							
H							
I							

NO. OF READINGS = 12 AVERAGE FPM = 519

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns

Project: Middlesex Superior Courthouse
Address: 200 Tradecenter Dr., Woburn, MA
Date: 11/12/2020 **Project No.** 20-550

VELGRID TRAVERSE DATA

SYSTEM: HRV-D
Exhaust

TRAVERSE NUMBER : T1
TRAVERSE LOCATION: Roof

DUCT SIZE (ROUND)		" DIAMETER			Sq Ft =	0.00
DUCT SIZE (RECT.)	21 1/2	" WIDTH x	21 1/2	" DEPTH	Sq Ft =	3.21

AIR DENSITY DATA

STATIC PRESS @ CL:	NA	InWg.	DESIGN CFM =	6600
DUCT AIR TEMP :	70	Deg F	ACTUAL CFM =	5542
BAROMETRIC PRESS :	29.92	In Hg.	SCFM=	**5545**

AIR DENSITY RATIO CORRECTION = 1.00
SCFM CORRECTION FACTOR 1.00
ACTUAL DENSITY 0.075

TEST HOLE	1	2	3	4	5	6	7
A	1881	1770	1601				
B	1727	1468	1637				
C	2081	1894	1478				
D							
E							
F							
G							
H							
I							

NO. OF READINGS = 9 AVERAGE FPM = 1726

J							
K							
L							
M							
N							
O							
P							
Q							
R							

TECHNICIAN: David Burns