WORCESTER TRIAL COURT
HVAC SYSTEM EVALUATION SUMMARY

Visited September 18, 2020. Inspected the air handling units and toured the occupied portions of the building to determine if the spaces generally matched usage noted on the architectural plans. The Worcester Trial Court was constructed in 2007 and is approximately 427,000 square feet in size. The building is served by four Haakon, variable air volume, and custom air handling units located in the penthouse mechanical room. Each unit provides 105,000CFM of 100% outside air to the building. The air handlers each contain a 4", MERV 8 prefilter and a 12", MERV 14 final filter. Each unit also contains a steam humidifier. The air handling units are clean, appear to be in excellent condition, and all outside air and return/exhaust air dampers and actuators appear to be in good or excellent condition.

1.0 Airflow Rate Per Person (Reduced Occupancy)

Courtroom	*Total People (reduced occupancy)*	*Total Air*		*Outdoor Air*	
		Supply Airflow (CFM)	*Airflow Rate (CFM/Person)*	*Outside Airflow (CFM)*	*Airflow Rate (CFM/Person)*
Jury Pool Room	55	4,575	83	4,575	83
Juvenile Court 2-1	17	1,950	115	1,950	115
Probate and Family Courtroom 2-2	16	1,800	113	1,800	113
Juvenile Court 2-3	16	1,800	113	1,800	113
Probate and Family Courtroom 2-4	14	1,800	129	1,800	129
Juvenile Court 2-5	16	1,800	113	1.800	113
Probate and Family Courtroom 2-6	12	1,800	150	1,800	150
Housing Court 2-7	24	3,000	125	3,000	125
Probate and Family Courtroom 2-8	24	3,000	125	3,000	125
Housing Court 2-9	16	1,800	113	1,800	113
Probate and Family Courtroom 3-1	18	2,475	138	2,475	138
Probate and Family Courtroom 3-2	25	3,000	120	3,000	120
District Courtroom 3-3	18	1,950	108	1,950	108
Superior Courtroom 3-4	35	3,000	86	3,000	86
District Courtroom 3-5	23	3,000	130	3,000	107
Superior Arraignment Court 3-6	28	3,000	107	3,000	107
District Arraignment Court 3-7	23	3,000	130	3,000	130
Superior Courtroom 3-8	26	3,000	115	3,000	115
District Courtroom 3-9	29	3,000	103	3,000	103
District Courtroom 4-11	18	1,950	108	1,950	108

Superior Courtroom 4-12	36	3,000	83	3,000	83
District Courtroom 4-13	31	3,000	97	3,000	107
Superior Courtroom 4-14	28	3,000	107	3,000	107
District Court 4-15	29	3,000	103	3,000	103
Superior Courtroom 4-16	26	3,000	115	3,000	115
District Courtroom 4-17	29	3,000	103	3,000	13

2.0 Recommendations

Section	Recommendation/Finding	Action
2.1	**Filtration Efficiency**	
	No actionable items identified	MERV-14 in use
2.2	**Testing and Balancing**	
	No actionable items identified	N/A
2.3	**Equipment Maintenance and Upgrades**	
	No actionable items identified	N/A
2.4	**Control System**	
RC-1	Implement a pre and post-occupancy flush sequence	Complete
RC-6	Monitor Relative Humidity	Complete
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.*	In-progress
2.6	**Humidity Control**	
	No actionable items listed – continuous monitoring for seasonal changes	On-going
2.7	**Other Recommendations**	
2.7.1	Quantity of outdoor air	Deferred – included in 5 year Capital Plan

Worcester Trial Court
Worcester , MA

HVAC SYSTEM EVALUATION COVID-19

Office of Court Management

December 7, 2020

Tighe&Bond

100% Recyclable

Section 1
Existing Conditions & Site Observations

Tighe & Bond visited the Worcester Trial Court on September 18, 2020. While on site we inspected the air handling equipment located in the mechanical rooms and toured the facility to determine if the spaces generally matched usages noted on the architectural plans.

Site Visit Attendees:

- *Office of Court Management:*
  - Michael Norman, Manager of Court Facilities – Region 2
  - Courthouse Facilities Staff
- Tighe & Bond
  - Jason Urso, PE, Senior Mechanical Engineer
  - Timothy Bill, Staff Mechanical Engineer

1.1 Existing Ventilation System

The Worcester Trial Court was constructed in 2007 and is approximately 427,000 square feet in size. The building is served by four Haakon, variable air volume, custom air handling units located in the penthouse mechanical room. Each unit provides 105,000 CFM of 100% outside air to the building. All return air from the building passes through a heat recovery wheel inside each unit before being exhausted to the outdoors. The wheel tempers the outside air before being further heated or cooled by steam heating and chilled water coils. The air handlers each contain a 4", MERV 8 prefilter and a 12", MERV 14 final filter. Each unit also contains a steam humidifier. Supply air is distributed throughout the building via variable air and constant volume boxes.

The air handling units are clean, appear to be in excellent condition, and all outside air and return/exhaust air dampers and actuators appear to be in good or excellent condition. The steam coils appear to be slightly dirty, while the cooling coils looked relatively clean. Each unit contains a freeze stat at the chilled water coil. We did observe peeling paint in the fan section, which was most likely caused by running the humidifiers. We also noticed some of the seals around the heat wheels needed repair or replacement.

Two 850 ton, water cooled chillers provide chilled water to the air handling units and four 8,000 MBH, gas fired steam boilers generate steam for the building.

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

TABLE 1
Existing Air Handling Units

Unit	Design Airflow (CFM)	Design Min. O.A. (CFM)	Pre/Final Filters	Condition
AHU-1	105,000	105,000	4" MERV 8/ 12" MERV 14	Excellent
AHU-2	105,000	105,000	4" MERV 8/ 12" MERV 14	Excellent
AHU-3	105,000	105,000	4" MERV 8/ 12" MERV 14	Excellent
AHU-4	105,000	105,000	4" MERV 8/ 12" MERV 14	Excellent

Photo 1 – Representative Air Handler

1.2 Existing Control System

The Worcester Trial Courthouse appears to have a full Automated Logic building management control system (BMS) that controls HVAC equipment in the building.

Section 2
Recommendations

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

2.1 Filtration Efficiency Recommendations

We do not recommend any filtration upgrades for the air handling units. The units currently contain MERV 14 final filters, which ASHRAE is recommending be installed during the COVID-19 pandemic.

2.2 Testing & Balancing Recommendations

The air handling units are approximately 13 years old and it is unknown to Tighe & Bond when the last time the units were tested and balanced. We do not recommend any testing and balancing. All air handlers provide 100% outdoor air to the building, which results in ventilation levels well above the code required minimum.

The average airflow rate per person is shown below in Table 2. These values are based on the original design supply airflow rate which is equal to the supplied outdoor air flow rate. 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 2
Average Airflow Rate per Person

	All spaces	***Courtrooms***	***Non-Courtroom Spaces***
Total Occupancy (People)	4,201	2,490	1,712
Total Supply Air (CFM/Person)	95	27	195
Outdoor Air (CFM/Person)	95	27	195

The airflow rate per person for each Courtroom and the Jury Pool Room is shown below in Table 3. These values are based on full occupancy without taking diversity into account, and the original design supply airflow rate which is equal to the outdoor airflow rate. 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 3
Airflow Rate per Person - Courtrooms

		Total Air		Outdoor Air	
Courtroom	***Total People***	***Supply Airflow (CFM)***	***Airflow Rate (CFM/Person)***	***Outside Airflow (CFM)***	***Airflow Rate (CFM/Person)***
Jury Pool Room	141	4,575	32	4,575	32
Juvenile Court 2-1	114	1,950	16	1,950	16
Probate and Family Courtroom 2-2	114	1,800	16	1,800	16
Juvenile Court 2-3	111	1,800	17	1,800	17
Probate and Family Courtroom 2-4	111	1,800	16	1,800	16
Juvenile Court 2-5	111	1,800	16	1,800	16
Probate and Family Courtroom 2-6	111	1,800	16	1,800	16
Housing Court 2-7	140	3,000	18	3,000	18
Probate and Family Courtroom 2-8	142	3,000	21	3,000	21
Housing Court 2-9	102	1,800	18	1,800	18
Probate and Family Courtroom 3-1	99	2,475	25	2,475	25
Probate and Family Courtroom 3-2	144	3,000	21	3,000	21
District Courtroom 3-3	113	1,950	17	1,950	17
Superior Courtroom 3-4	166	3,000	18	3,000	18
District Courtroom 3-5	164	3,000	18	3,000	18
Superior Arraignment Court 3-6	144	3,000	21	3,000	21
District Arraignment Court 3-7	164	3,000	18	3,000	18
Superior Courtroom 3-8	166	3,000	18	3,000	18
District Courtroom 3-9	143	3,000	21	3,000	21
Superior Courtroom 4-10	143	3,000	21	3,000	21
District Courtroom 4-11	110	1,950	18	1,950	18
Superior Courtroom 4-12	165	3,000	18	3,000	18
District Courtroom 4-13	164	3,000	18	3,000	18
Superior Courtroom 4-14	164	3,000	18	3,000	18
District Court 4-15	164	3,000	18	3,000	18
Superior Courtroom 4-16	143	3,000	21	3,000	21

District Courtroom 4-17	144	3,000	21	3,000	21

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 schedule determined by the Office of Court Management, is shown below in Table 3a. 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 3a
Airflow Rate per Person (Reduced Occupancy)

		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	55	4,575	83	4,575	83
Juvenile Court 2-1	17	1,950	115	1,950	115
Probate and Family Courtroom 2-2	16	1,800	113	1,800	113
Juvenile Court 2-3	16	1,800	113	1,800	113
Probate and Family Courtroom 2-4	14	1,800	129	1,800	129
Juvenile Court 2-5	16	1,800	113	1,800	113
Probate and Family Courtroom 2-6	12	1,800	150	1,800	150
Housing Court 2-7	24	3,000	125	3,000	125
Probate and Family Courtroom 2-8	24	3,000	125	3,000	125
Housing Court 2-9	16	1,800	113	1,800	113
Probate and Family Courtroom 3-1	18	2,475	138	2,475	138
Probate and Family Courtroom 3-2	25	3,000	120	3,000	120
District Courtroom 3-3	18	1,950	108	1,950	108
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District Arraignment Court 3-7	23	3,000	130	3,000	130
Superior Courtroom 3-8	26	3,000	115	3,000	115
District Courtroom 3-9	29	3,000	103	3,000	103
Superior Courtroom 4-10	27	3,000	111	3,000	111

District Courtroom 4-11	18	1,950	108	1,950	108
Superior Courtroom 4-12	36	3,000	83	3,000	83
District Courtroom 4-13	31	3,000	97	3,000	97
Superior Courtroom 4-14	28	3,000	107	3,000	107
District Court 4-15	29	3,000	103	3,000	103
Superior Courtroom 4-16	26	3,000	115	3,000	115
District Courtroom 4-17	29	3,000	103	3,000	103

2.3 Equipment Maintenance & Upgrades

We recommend the repair or replacement of the heat recovery wheel seals. Without seals, air can bypass (leak) from one air stream to the other. According to the design airflow rates in the air handler schedule and the air handling unit detail drawings, the supply section of the air handlers draws more air than the exhaust fan and the fans are setup in a draw through configuration. This arrangement may be causing some unfiltered building exhaust air to leak into the supply air stream.

We do not recommend any other equipment maintenance or upgrades. The air handling units are only 13 years old and appear to be very well maintained. Facilities staff did not mention any issues they are having with the units.

2.4 Control System

We recommend the following control system modifications:

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

Considering the building is supplied with 100% outside air, less time is required to flush the building. We recommend enabling the air handlers two hours before occupancy and extending occupied mode two hours after typical occupancy. If the units currently run longer in occupied mode, we recommend maintaining the current schedule.

RC-6: Monitor Relative Humidity

Trend space humidity levels via the existing BMS. Maintaining ASHRAE's recommended humidity levels in the building using the existing humidifiers in the air handling units.

2.5 Additional Filtration and Air Cleaning

We recommend the installation of the following air cleaning devices:

RFC-1: *Install portable HEPA filters.*

Despite the large amount of outside air that is supplied to the building, adding portable HEPA filters would provide an additional measure of filtering air. If the Courthouse is to operate at a high capacity (i.e. 50%-75% 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

We recommend the continued use of the humidifiers in the air handlers during the winter if they are working properly to prevent compromising indoor air quality or creating mold issues. Studies have shown maintaining a space relative humidity between 40% and 60%, especially during colder months, decreases the risk of airborne infectious particles and decreases the infection rate of many viruses in the air.

Outside air during the winter months is typically dry air. Considering all supply air is outside air, maintaining the proper relative humidity is difficult without the use of humidifiers. "Total energy recovery wheels" is a type of wheel that captures both sensible and latent (humidity) energy and transfers it to the supply air. This type of wheel would provide some level of additional humidity to the supply air during the winter. According to the design drawings, these units were provided with a heat recovery wheel, not a total energy recovery wheel. Heat wheels only recover sensible heat and do not recover latent (humidity) energy.

2.7 Other Recommendations

2.7.1 Quantity of Outdoor Air

The air handling units for this building were designed to provide a maximum airflow rate of 400,000 CFM of 100% outdoor air with no recirculated air. While a 100% outdoor air system provides better indoor air quality than a recirculating system using only minimum outdoor air, this system most likely uses more energy, despite the use of a heat recovery wheel. According to our calculations, this building only requires approximately 41,000 CFM of outside air. We recommend performing an energy study to determine how much energy savings could be realized if this building was served by a recirculating air system with minimum outside air. A follow up engineering exercise to determine if the existing system can be converted to this system type and the cost to install would be warranted.

Section 3
Testing & Balancing Results

On November 5, 2020 Wing's Testing & Balancing Co., Inc. visited the Worcester Trial Court 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 Wings in the balancing process. A summary of the tested airflow rates versus the design airflow rates are shown below in Tables 4 and 5. Their full testing and balancing report is attached.

TABLE 4
Air Handler Testing & Balancing Results

	Design		Actual	
Unit	Supply Fan Airflow (CFM)	Return Fan Airflow (CFM)	Supply Fan Airflow (CFM)	Return Fan Airflow (CFM)
AHU-1	111,630	110,250	113,679	106,694
AHU-2	111,630	110,250	102,167	53,720[1]
AHU-3	111,630	110,250	112,460	124,629
AHU-4	111,630	110,250	112,462	125,631

(1) Unable to ramp fan up to full speed during testing

TABLE 5
Exhaust Fan Testing & Balancing Results

Unit	Serving	Design Exhaust Fan Airflow	Actual Exhaust Fan Airflow
EF-14	Holding Cells	6,300	6,495

Please note the air handler design supply and return airflow rates noted in Table 4 include the additional air for purging. The actual air supplied to and returned from the space is 105,000 CFM and 103,620 CFM, respectively.

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

1. AHU-1 is performing within acceptable range for both fans.
2. AHU-2 supply fan is performing within acceptable range, however the return fan is significantly underperforming. The return fan is returning approximately 56,000 CFM less air than specified, creating a large positive pressure in the spaces this air handler serves. We recommend the operation of the return fan be further investigated by the ATC contractor and corrected to provide a return

airflow rate of 110,250 CFM. The testing and balancing (TAB) Contractor noted that a setting in the return fan VFD or in the controls sequence may be limiting the fan airflow setpoint and may need to be adjusted.

3. AHU-3 and AHU-4 supply fans are performing within acceptable range, however the return fans are returning more air than specified. This may be causing a slight negative pressure in the spaces these two air handlers serve. We recommend balancing the return fans down to their specified airflow rate of 110,250 CFM.
4. Exhaust fan EF-14 serving the detainee area is performing within acceptable range.

The TAB contractor also noted the following findings in their report:

1. The airflow rates of several VAV boxes that the BMS was reporting did not match the maximum setpoints.

   For example, AHU-1 VAV box serving Seating Area G010 reported an airflow rate of 947 CFM, however the maximum setpoint is 1,800 CFM. During the airflow testing, the ATC Contractor commanded all VAV boxes to their maximum setpoint, therefore this VAV box should have reported an airflow rate closer to 1,800 CFM instead of 947 CFM.

   We recommend further evaluation of the VAV box readings provided in the TAB report to identify which VAV boxes are underperforming. An inspection and/or individual airflow testing of each problematic VAV box may be required to determine the cause of airflow discrepancy. The VAV box dampers may not be operating correctly or the airflow sensor within the VAV box may be malfunctioning.

2. The ATC Contractor was unable to calibrate the airflow station or understand how they function. We recommend the ATC Contractor properly calibrate the airflow stations.

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.

WING'S TESTING & BALANCING CO., INC.

Worcester Trial Court
HVAC/Ventilation Survey

* * * *

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

November 5, 2020

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WING'S TESTING & BALANCING CO., INC.

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

November 5, 2020

Re: Worcester Trial Court- HVAC/ Ventilation Survey

Dear Jason,

The survey of the above referenced location has been completed. While onsite, we worked with Fred and Tom Falcone, the in-house technicians. Following is the workflow we performed, as well as pertinent findings.

Workflow

- We had the control contactor drive all VAV boxes on a system to full cooling flow
  - Control tech documented CFM setpoints on boxes and what the BMS showed.
- We tested the total supply at each AHU
- We tested the total exhaust at the AHU's exhaust side
- We took static pressure profiles of each system
- We documented system and motor performance (supply and exhaust)
  - Amperage, RPM, sheave, belt and filter sizes, etc.
  - Document static pressure control points on supply and exhaust
    - Check with controls to see if setpoint is being met
  - Note any unusual conditions
    - Dirty filters, dirty coils, wear and tear, etc.
- We noted that the heat was steam and the CHW was drained for the season.
- We documented airflow measuring station setpoints
  - The control contractor noted that he could not calibrate flow stations.
- We measured flow and performance of EF-14

Findings

- The exhaust side of AHU-2 was unable to be sped up to full flow.
  - Note that AHU-2 has many fewer boxes than other systems.
  - It could be that the EF was limited on the drive, or not allowed in controls to go above a certain setting.
  - We recommend that the control vendor verify the sequence for this fan.

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Worcester Trial Court
November 5, 2020

Findings continued

- Included in this report are spreadsheets and BMS screen printouts showing the CFM set points and what the BMS thought the boxes were doing.
    - Note that many boxes show almost no flow
        - These boxes should be investigated to determine if they are open or if there are control issues.
- The control contractor was unable to calibrate any of the flow stations or determine how their setpoints were calculated.
    - It is unclear if the setpoints are a sum of the VAV boxes minus an offset, or if they are controlling to a different point.
    - We recommend that the sequence of operation for these flow stations be investigated and to have the control vendor verify their operation.
- It should be noted that the systems were tested under 'max cooling' command. It is unclear how the system will react when it is operating in automatic.
    - We recommend that the design team consider increasing the minimum flow rates on the zones to ensure adequate ventilation is always provided.

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 do not 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: Worchester Courthouse	**DATE:** 10/29/20
AREA SERVED: AHU-1	**TECH:** BS

FAN DATA

FAN NUMBER	AHU-1		AHU-1RF			
LOCATION	Penthouse		Penthouse			
AREA SERVED	All Floors		AHU-1			
MANUFACTURER	Haakon Industries		Haakon Industries			
MODEL OR SIZE	Air Pack/105,000 CFM		111,626 CFM			
	DESIGN	**ACTUAL**	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**
TOTAL CFM	111,630	113,679	110,250	106,694		
RETURN AIR	0	0	---	---		
OUTSIDE AIR	100%	100%	---	---		
DISCH. STATIC	---	+2.11"	---	+.68"	---	
SUCTION STATIC	---	-3.40"	---	-3.19"	---	
TOTAL STATIC	8.75"	5.51"	N/L	4.87"		
FAN RPM	1312	1157	854	774		
PULLEY O.D.	11.0"		21.5"			
ESP	2.53"		2.63"			
VFD SPEED	60 Hz		55 Hz			

MOTOR DATA

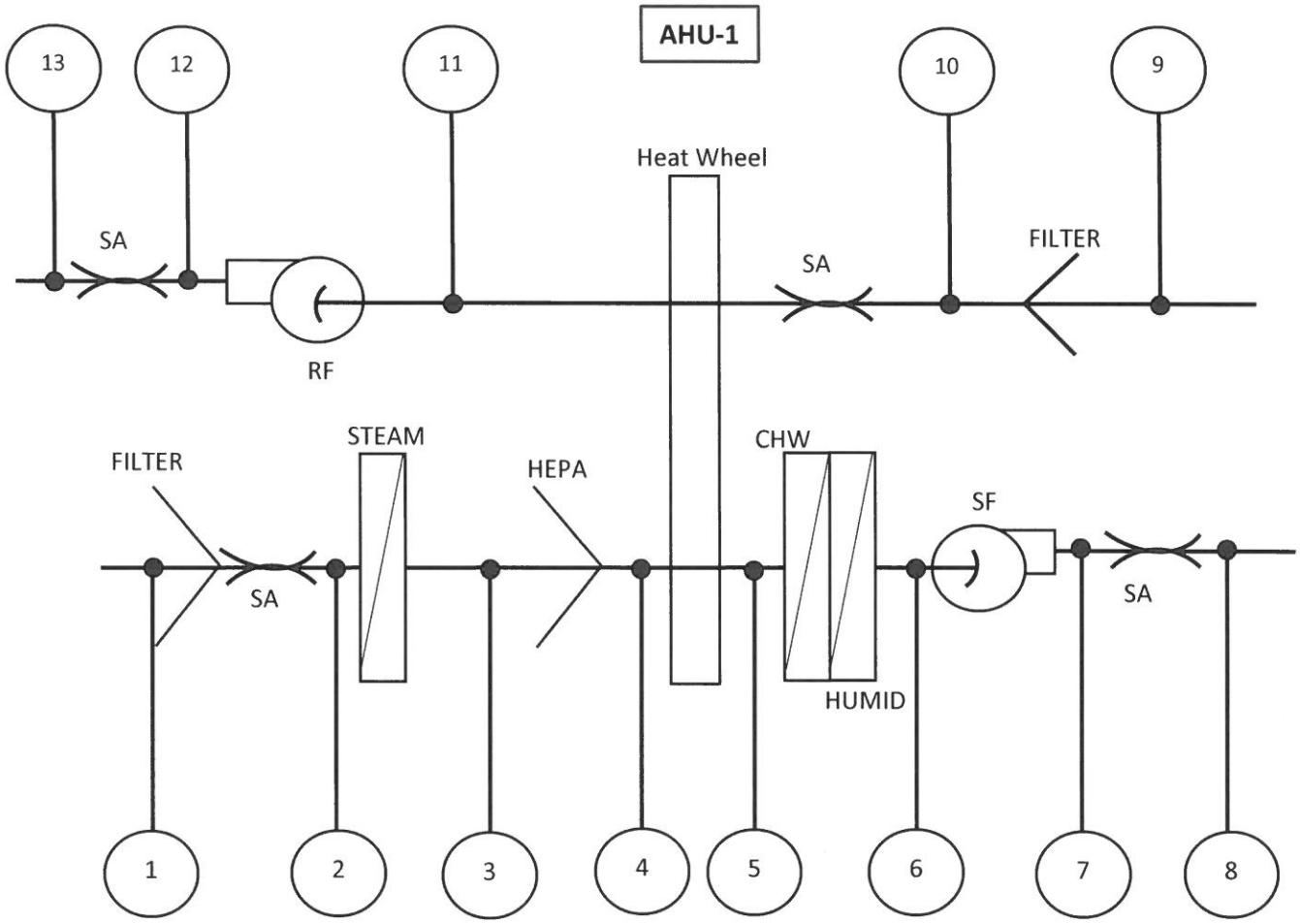
MANUFACTURER	Baldor (x2)		Baldor (x2)			
MODEL OR FR.	444T		405T			
HORSEPOWER	125	125	100	100		
MOTOR RPM	1780	1780	1780	1780		
VOLTAGE / PH.	460/3	460/3	460/3	460/3		
AMPS LEG 1	139	100.9	109	67.3		
AMPS LEG 2	---	106.3	---	66.5	---	
AMPS LEG 3	---	104.8	---	67.1	---	
SHEAVE O.D.	15.0"		10.5"			
BELTS - QTY / SIZE	5/5Vx900		5/5Vx1700			
SHEAVE POSITION	Fixed		Fixed			
BHP	93.5		61.4			

REMARKS

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

SYSTEM STATIC PRESSURE PROFILE

PROJECT: Worchester Courthouse	**DATE:** 10/29/20
SYSTEM/AREA SERV: AHU's	**TECH:** BS



STATIC PRESSURE READINGS "wc

POS. (+) / NEG.(-)	1	2	3	4	5	6	7	8
AHU-1	-0.45"	-0.68"	-0.87"	-1.82"	-2.75"	-3.40"	+2.11"	+2.08"
	9	**10**	**11**	**12**	**13**			
	-2.26"	-2.49"	-3.19"	+0.68"	+0.37"			

REMARKS

SA = Sound Attenuator

SUPPLY FAN REPORT

PROJECT: Worchester Courthouse	**DATE:** 10/29/20
AREA SERVED: AHU-2	**TECH:** BS

FAN DATA

FAN NUMBER	AHU-2		AHU-2RF			
LOCATION	Penthouse		Penthouse			
AREA SERVED	All Floors		AHU-2			
MANUFACTURER	Haakon Industries		Haakon Industries			
MODEL OR SIZE	Air Pack/105,000 CFM		111,626 CFM			
	DESIGN	**ACTUAL**	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**
TOTAL CFM	111,630	102,167	110,250	53,720 (1)		
RETURN AIR	0	0	---	---		
OUTSIDE AIR	100%	100%	---	---		
DISCH. STATIC	---	+2.63"	---	+.10"	---	
SUCTION STATIC	---	-2.74"	---	-2.53"	---	
TOTAL STATIC	8.75"	5.37"	N/L	2.63"		
FAN RPM	1312	962	854	539		
PULLEY O.D.	11.0"		21.5"			
ESP	2.99"		2.22"			
VFD SPEED	48.3 Hz		38 Hz			

MOTOR DATA

MANUFACTURER	Baldor (x2)		Baldor (x2)			
MODEL OR FR.	444T		405T			
HORSEPOWER	125	125	100	100		
MOTOR RPM	1780	1780	1780	1780		
VOLTAGE / PH.	460/3	460/3	460/3	460/3		
AMPS LEG 1	139	95.2	109	41.4		
AMPS LEG 2	---	93.3	---	41.9	---	
AMPS LEG 3	---	91.7	---	40.5	---	
SHEAVE O.D.	15.0"		10.5"			
BELTS - QTY / SIZE	5/5Vx900		5/5Vx1700			
SHEAVE POSITION	Fixed		Fixed			
BHP	84.0		37.9			

REMARKS

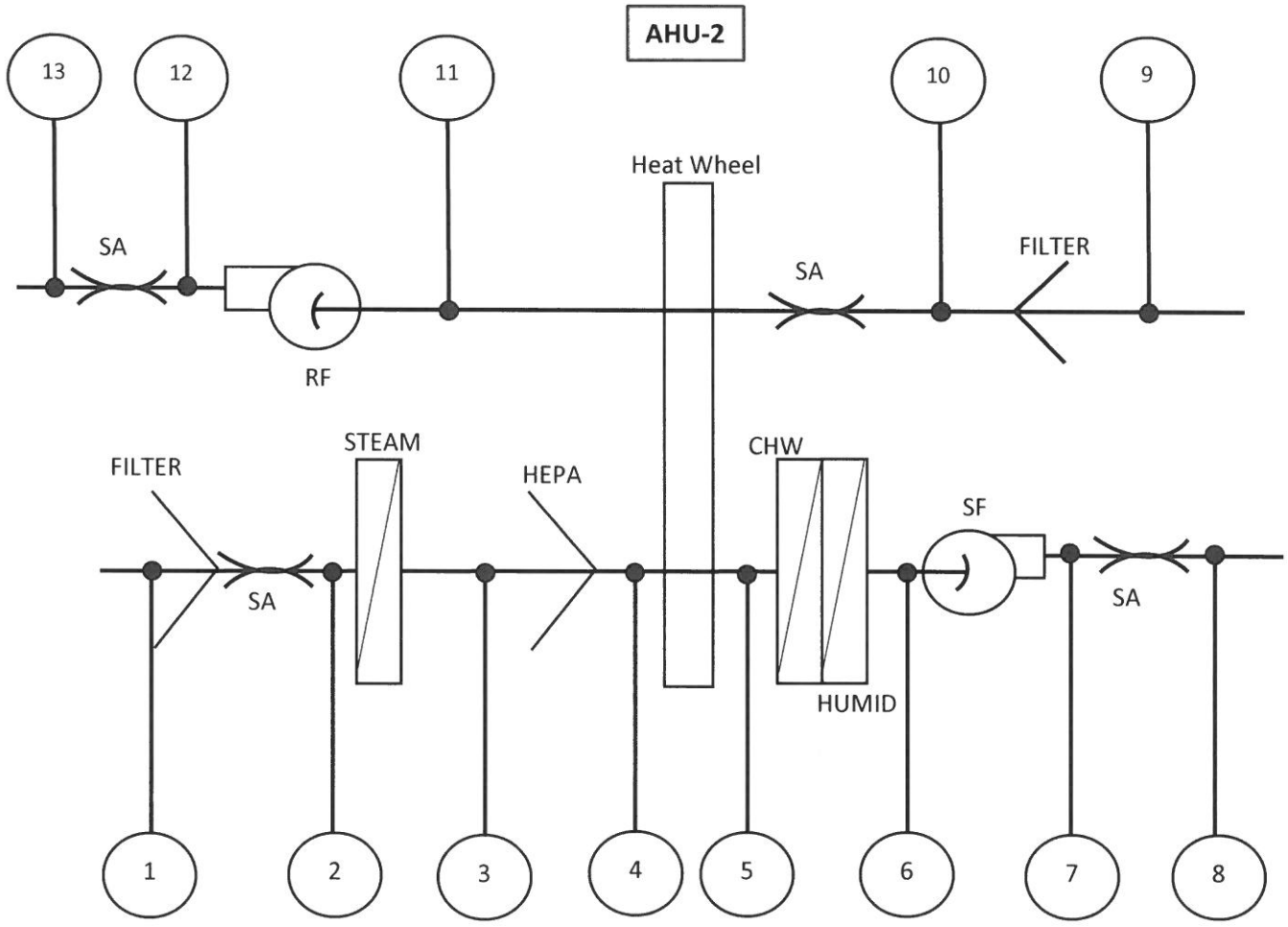
(1) Controls contractor was not able to get this fan fully ramped up during testing.

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

SYSTEM STATIC PRESSURE PROFILE

PROJECT: Worchester Courthouse | **DATE:** 10/29/20

SYSTEM/AREA SERV: AHU's | **TECH:** BS



STATIC PRESSURE READINGS "wc

POS. (+) / NEG.(-)	1	2	3	4	5	6	7	8
AHU-2	-0.41"	-0.57"	-0.69"	-1.48"	-2.28"	-2.74"	+2.63"	+2.58"
	9	**10**	**11**	**12**	**13**			
	-2.15"	-2.26"	-2.53"	+0.10"	+0.07"			

REMARKS

SA = Sound Attenuator

SUPPLY FAN REPORT

PROJECT: Worchester Courthouse	**DATE:** 10/29/20
AREA SERVED: AHU-3	**TECH:** BS

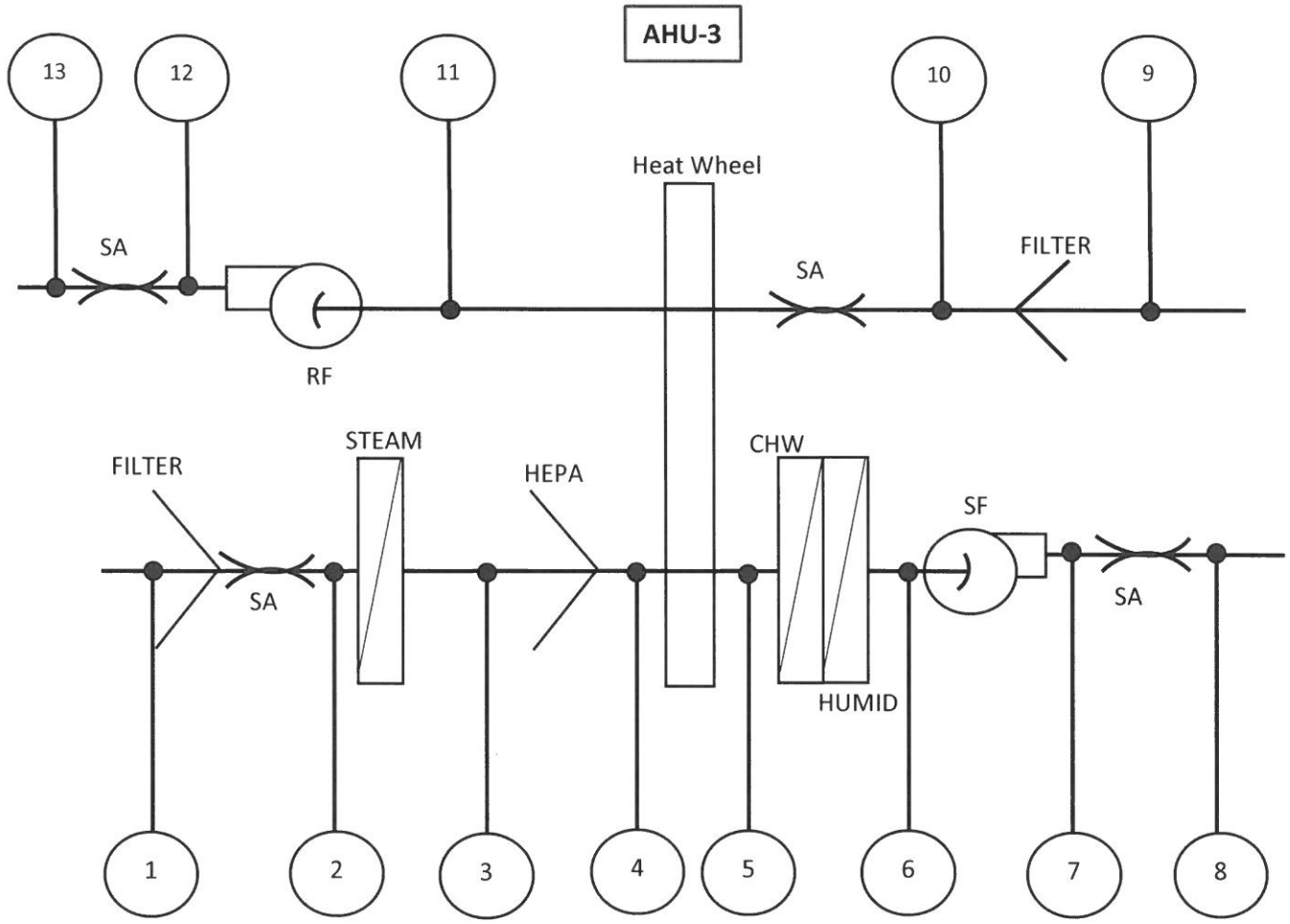
FAN DATA						
FAN NUMBER	AHU-3		AHU-3RF			
LOCATION	Penthouse		Penthouse			
AREA SERVED	All Floors		AHU-3			
MANUFACTURER	Haakon Industries		Haakon Industries			
MODEL OR SIZE	Air Pack/105,000 CFM		111,626 CFM			
	DESIGN	**ACTUAL**	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**
TOTAL CFM	111,630	112,460	110,250	124,629		
RETURN AIR	0	0	---	---		
OUTSIDE AIR	100%	100%	---	---		
DISCH. STATIC	---	+2.70"	---	+.88"	---	
SUCTION STATIC	---	-3.13"	---	-3.75"	---	
TOTAL STATIC	8.75"	5.83"		4.63"		
FAN RPM	1312	1146	854	858		
PULLEY O.D.	11.0"		21.5"			
ESP	3.14"		3.53"			
VFD SPEED	60 Hz		60 Hz			
MOTOR DATA						
MANUFACTURER	Baldor (x2)		Baldor (x2)			
MODEL OR FR.	444T		405T			
HORSEPOWER	125	125	100	100		
MOTOR RPM	1780	1780	1780	1780		
VOLTAGE / PH.	460/3	460/3	460/3	460/3		
AMPS LEG 1	139	108	109	81.2		
AMPS LEG 2	---	106	---	78.6	---	
AMPS LEG 3	---	103	---	77.9	---	
SHEAVE O.D.	15.0"		10.5"			
BELTS - QTY / SIZE	5/5Vx900		5/5Vx1700			
SHEAVE POSITION	Fixed		Fixed			
BHP	95.0		72.7			

REMARKS

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

SYSTEM STATIC PRESSURE PROFILE

PROJECT: Worchester Courthouse	**DATE:** 10/29/20
SYSTEM/AREA SERV: AHU's	**TECH:** BS



STATIC PRESSURE READINGS "wc

POS. (+) / NEG.(-)	1	2	3	4	5	6	7	8
AHU-3	-0.53"	-0.68"	-0.87"	-1.58"	-2.60"	-3.13"	+2.70"	+2.61"
	9	**10**	**11**	**12**	**13**			
AHU-3 RF	-2.77"	-2.98"	-3.75"	+0.88"	+0.76"			

REMARKS

SA = Sound Attenuator

SUPPLY FAN REPORT

PROJECT: Worchester Courthouse	**DATE:** 10/29/20
AREA SERVED: AHU-4	**TECH:** BS

FAN DATA						
FAN NUMBER	AHU-4		AHU-4RF			
LOCATION	Penthouse		Penthouse			
AREA SERVED	All Floors		AHU-4			
MANUFACTURER	Haakon Industries		Haakon Industries			
MODEL OR SIZE	Air Pack/105,000 CFM		111,626 CFM			
	DESIGN	**ACTUAL**	**DESIGN**	**ACTUAL**	**DESIGN**	**ACTUAL**
TOTAL CFM	111,630	112,462	110,250	125,631		
RETURN AIR	0	0	---	---		
OUTSIDE AIR	100%	100%	---	---		
DISCH. STATIC	---	+2.59"	---	+.80"	---	
SUCTION STATIC	---	-3.23"	---	-3.48"	---	
TOTAL STATIC	8.75"	5.82"	N/L	4.28"		
FAN RPM	1312	1148	854	847		
PULLEY O.D.	11.0"		21.5"			
ESP	3.02" wg		3.10"			
VFD SPEED	60 Hz		58 Hz			
MOTOR DATA						
MANUFACTURER	Baldor (x2)		Baldor (x2)			
MODEL OR FR.	444T		405T			
HORSEPOWER	125	125	100	100		
MOTOR RPM	1780	1780	1780	1780		
VOLTAGE / PH.	460/3	460/3	460/3	460/3		
AMPS LEG 1	139	105	109	77.4		
AMPS LEG 2	---	104	---	75.6	---	
AMPS LEG 3	---	101	---	77.8	---	
SHEAVE O.D.	15.0"		10.5"			
BELTS - QTY / SIZE	5/5Vx900		5/5Vx1700			
SHEAVE POSITION	Fixed		Fixed			
BHP	92.9		70.6			

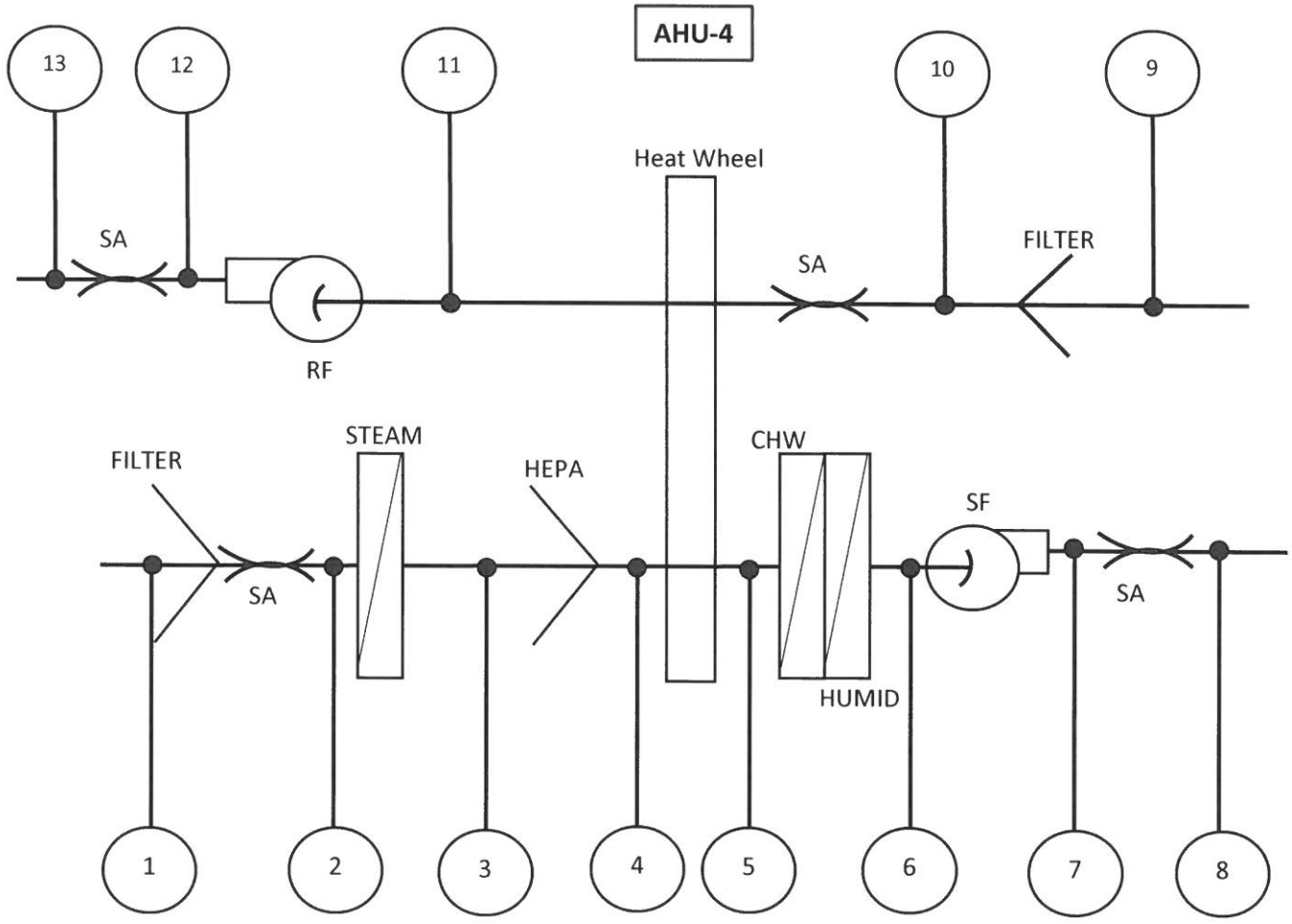
REMARKS

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

SYSTEM STATIC PRESSURE PROFILE

PROJECT: Worchester Courthouse | **DATE:** 10/29/20

SYSTEM/AREA SERV: AHU's | **TECH:** BS



STATIC PRESSURE READINGS "wc

POS. (+) / NEG.(-)	1	2	3	4	5	6	7	8
AHU-4	-0.50"	-0.69"	-0.86"	-1.65"	-2.66"	-3.23"	+2.59"	+2.52"
	9	**10**	**11**	**12**	**13**			
	-2.33"	-2.67"	-3.48"	+0.80"	+0.77"			

REMARKS

SA = Sound Attenuator

EXHAUST FAN REPORT

PROJECT: Worchester Courthouse					**DATE:** 10/29/20	
AREA SERVED:					**TECH:** BS	
FAN DATA						
FAN NUMBER		EF-14				
LOCATION		Penthouse				
AREA SERVED		Holding Cells				
MANUFACTURER		Greenheck				
MODEL OR SIZE		SWB-218-50				
TOTAL CFM	DESIGN	6300				
	ACTUAL	6495				
FAN RPM	DESIGN	2003				
	ACTUAL	2147				
PULLEY	O.D.	5.0"				
SERVICE		1.15				
MOTOR DATA						
MANUFACTURER		Reliance Electric				
MODEL NUMBER		184T				
MOTOR HP	DESIGN	5				
	ACTUAL	5				
MOTOR RPM		1745				
VOLTAGE/PHASE		460/3				
MOTOR AMPS	DESIGN	6.6				
	ACT. LEG 1	6.3				
	ACT. LEG 2	6.0				
	ACT. LEG 3	6.0				
SHEAVE		6.5"				
BELTS-QTY/SIZE		1/BX42				
SHEAVE POSITION		Fully Closed				
BHP		4.6				
REMARKS						

VELOCITY PRESSURE READINGS

PROJECT: Worchester Courthouse | **DATE:** 10/29/20

AREA SERVED: | **TECH:** BS

TRAVERSE LOCATIONS	DUCT SIZE "	AREA SQ.FT.	DESIGN		CENTERLINE STATIC PRES."	TEST		NOTES
			FPM	CFM		FPM	CFM	
AHU-1 Supply	99" x 332"	221.38	504	111630	w/velgrid	514	113679	
AHU-1 R	42" x 286"	83.42	1322	110250	w/velgrid	1279	106694	
AHU-2 Supply	99" x 332"	221.38	504	111630	w/velgrid	461	102167	
AHU-2 RF	42" x 286"	83.42	1322	110250	w/velgrid	644	53720	
AHU-3 Supply	99" x 332"	221.38	504	111630	w/velgrid	508	112460	
AHU-3 RF	42" x 286"	83.42	1322	110250	w/velgrid	1494	124629	
AHU-4 Supply	99" x 332"	221.38	504	111630	w/velgrid	508	112462	
AHU-4 RF	42" x 286"	83.42	1322	110250	w/velgrid	1506	125631	
EF-14	18"Ø	1.77	3559	6300	-2.57	3677	6495	

REMARKS