HVAC Coil Cleaning for Improved Energy Savings Performance

White Paper
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Tri-State Light & Energy brings forty years of design/build expertise delivering comprehensive, strategic, energy efficient upgrades including utility incentive programs and engineering services. DPMC classified.

ABSTRACT

HVAC is typically the largest energy consumer for most homes and buildings and is a major driver of global energy consumption and carbon emissions. With this in mind, it is extremely important in the HVAC industry to maintain equipment at peak performance levels. Proper maintenance improves energy efficiency and space conditioning for the areas served.

HVAC Coil Cleaning

Coil Cleaning is a highly overlooked energy conservation measure (ECM), typically not implemented due to lack of knowledge about its effectiveness, or fear that traditional methods can be somewhat destructive to equipment.

New Technology for Coil Cleaning

This paper studies a pilot application performed by ELX Technologies using Blue Box Air coil treatment technology, a novel approach to cleaning heat transfer coils, which utilizes an advanced chemical-free enzyme formulation.

- Ultimate Comfort Control Corp, a TAB certified firm, supported the testing and balancing.
- The project site was St. Clare's Denville Hospital, in Denville NJ.
- Tejas Desai PE, General Manager at Tri State Light & Energy, performed witness testing.

The results were immediately apparent. The Blue Box Air coil treatment technology clearly demonstrated there were significant energy savings available. The evaluation method utilized in this study can be used to assess this measure's effectiveness in future applications.

For this case, Chilled Water Coil in AHU-3 was selected for testing. The result shows significant energy savings if the AHU were operating at Design Condition.

Types of Savings

There are two main components of savings in this example.

- The first savings component is realized from a reduced pressure drop across the coil, which indicates improved coil performance. The airflow in AHU-3 was increased from 8,407 CFM to 13,839 CFM. As the existing Variable Frequency Drive (VFD) on this unit was inoperative, the team took readings with different airflow conditions. The result was normalized to a design CFM of 10,000 CFM.
- The second savings component was due to improved cooling performance of the coil by reducing the fouling factor and improving overall heat transfer.
- Overall energy savings were divided into components, fan energy saving of 75,347 kWh and cooling energy savings of 3,977 kWh. The total savings was 79,324 kWh, which is about $9,518 in Energy Cost Saving at $0.12/kWh average rates.

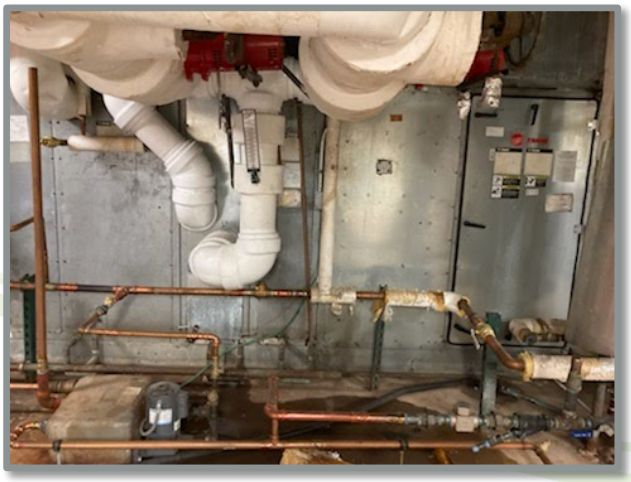
Introduction

St. Clare's Hospital in Denville, NJ was interested in coil cleaning.

ELX Technologies, Blue Box Air, and Ultimate Comfort Control worked closely with the facility staff to select a unit that would serve as a good representation of the units at the Hospital. Tri-State Light & Energy, Inc. (an NJ firm prequalified for DPMC Professional Engineering) witnessed the testing.

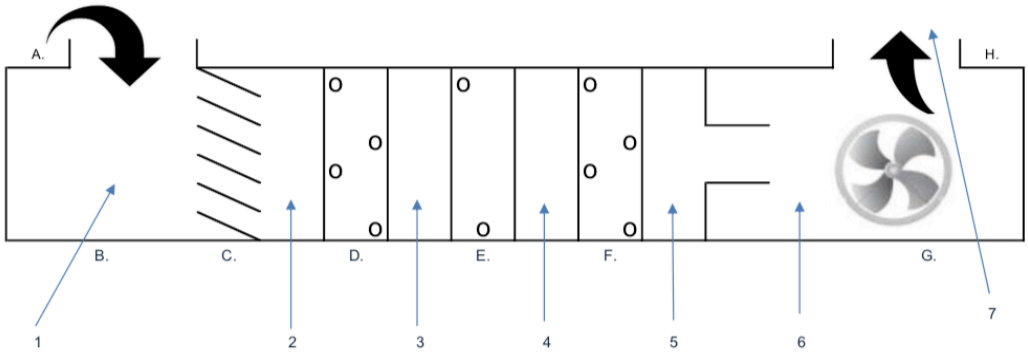
The Hospital staff selected AHU-3 unit as their best candidate for evaluating coil cleaning. This unit provides 100 percent outside air, services critical areas in the hospital, and was identified as significantly underperforming its design capacities.

Picture 1 and 2. Existing AHU



Picture 3. A packaged Air Handling Unit with the following sections:

1. Mixing Plenum
2. Filter Bank
3. Steam Pre-Heat Coil
4. Steam Heating Coil
5. Chilled Water Coil
6. Supply Fan Section
7. Discharge Section



Air Handling Unit Design Parameters

This Air Handling Unit (AHU-3) was installed in 2001 and designed with the following characteristics.

- Manufacturer: Trane
- Model Number: MCCA035GAYOAP
- Serial Number: K01B16664B
- Total Supply CFM: 10,000 CFM
- 100% Outside Air Unit
- Total Design Airside: delta T - 40 F
- Supply Fan Size: 40 HP
- Rated Supply Fan Current: 30 AMPS
- Electrical: 460 Volts/3PH/ 60Hz
- Coil Capacity: 432MBH
- The coil receives chilled water from a water-cooled chiller plant, which has an approximately efficiency of 0.6 kW/Ton

This unit is equipped with a Variable Frequency Drive. The Drive was not operational and the unit was operating in bypass mode for both pre-coil cleaning and post-coil cleaning.

Pre-Coil Cleaning TAB Results, Normalize and Baseline Energy Consumption

On May 10th, 2022, ELX Technologies, Blue Box Air, and Ultimate Comfort Control were onsite. Tejas Desai, PE was also onsite to observe pre-cleaning coil conditions.

Ultimate Comfort Control took the following readings as described in their report in appendix A.

NO.	DESCRIPTION
A.	OUTSIDE AIR INLET
B.	MIXING PLENUM
C.	FILTERS
D.	STEAM PRE HEAT COILS
E.	STEAM HEATING COILS
F.	CHILLED WATER COILS
G.	SUPPLY AIR FAN
H.	SUPPLY AIR OUTLET

- Pressure at various components within AHU-3
- Pressure Readings were taken from points A through H
- Temperature Readings were taken from points A through H
- The air flow reading was taken by measuring air velocities at various points
- Cross section of ductwork was measured
- Amp readings of the fan motor were taken

This information was utilized to calculate the following parameters.

Fan BHP = CFM X inch of WC pressure drop/(6356 X overall efficiency for Fan) = 8.95 HP (8,407 CFM, 4.4 inch of WC)

The Fan BHP was normalized for 10,000 CFM design condition. The pressure drop value was based on pressure drop at 10,000 CFM using affinity law.
Actual BHP Design CFM= 6.23 inch of WC

Coil COP = Th/(Th-Tc) = 3.08

Coil Capacity Q = 240,608.34 BTU/hr

ELX technologies utilized Blue Box Air to clean AHU-3's coils. This cleaning process is more effective than traditional methods because it allows the cleaning agent (enzyme formulation) to penetrate the full depth of the coil, resulting in a more comprehensive cleaning of all coil surfaces.

Post-Coil Cleaning TAB Results, Normalized and Proposed Energy Consumption

On May 12th, 2022, ELX Technologies, Blue Box Air, and Ultimate Comfort Control returned to the site. Tejas Desai, PE was also onsite to observe post-cleaning coil conditions.

Ultimate Comfort Control took the following readings as described in their report in appendix A.

- Pressure at various components within AHU-3
- Pressure Readings were taken from points A through H
- Temperature Readings were taken from points A through H
- The air flow reading was taken by measuring air velocities at various points
- Cross section of ductwork was measured
- Amp readings of the fan motor were taken

These data points were again utilized to calculate the following parameters.

Fan BHP = CFM X inch of WC pressure drop/(6356 X overall efficiency for Fan) = 9.38 HP

The Fan BHP was normalized for 10,000 CFM design condition. The pressure drop value was calculated for a pressure drop at 10,000 CFM using affinity law.

Actual, BHPdesignCFM= 1.46 inch of WC

Coil COP = Th/(Th-Tc) = 3.08

Coil Capacity Q = 240,608.34 BTU/hr

Energy Saving Calculations and Assumptions

It was critical to extrapolate all the readings to the design CFM levels.

The VFD was on bypass setting and inoperable, which restricted ELX Technologies and Ultimate Comfort Control from performing testing at the available condition. This required the measure to be evaluated at design condition, which requires the unit to operate at conditions that meet code and standards.

AHU-3 services critical spaces and operation 24x7 year around. As a result, this fan operates 8760 hours per year.

Fan Energy Saving = (6.23 BHP -1.46BHP) X 0.746 kW/BHP X 8760 Hours = 75,347.13 kWh

Cooling Energy Saving = (10,000CFMX 1.08 X 25 (Delt T) X COP (3.08) X0.6 kW/Ton X 1424 (EFLH))- (10,000CFMX 1.08 X 25 (Delt T) X COP (3.76) X0.6 kW/Ton X 1424 (EFLH))
= 3,977.21 kWh

Total Energy Saving = 79,324 kWh

Additional Considerations

Efficiency improvements from coil cleaning depend on the type of cooling system. Reductions in energy consumption can be provided by

- Fan savings by reducing air pressure drop across the cleaned coils
- Compressor savings from improved heat transfer through the walls of the cleaned coils
- Water pump and tower savings in VFD systems from reduced delta-T and smaller loads.

Conclusion

As an independent engineering consultant, Tri State Light & Energy, Inc. witnessed the coil cleaning process, and the performance readings that were taken pre and post coil cleaning.

This method of testing can be used to evaluate any coil cleaning whether it is chilled water, steam, HW or HW reheat coil. Ideally, all readings need to be taken at the same airflow for both the baseline case and proposed case so the resulting pressure and temperature variables can be evaluated. This method of evaluation can be adopted as a standard in evaluating this energy conservation measure.

Finally, there appear to be potential for significant fan energy savings as well as improved heat transfer savings.

References

- HVAC Reference Manual
- NJ Tech Resource Manual 2020
- Fan Laws Affinity law
- Ultimate Comfort Control pre and post testing and balancing report (*see attached*)
- Research Paper Coil Cleaning: UV Fundamental Sizing and Energy Savings by Normand Brais P.Eng., M.A.Sc., Ph.D. Vice President, SANUVOX TECHNOLOGIES Inc.

ULTIMATE COMFORT CONTROL

HVAC SYSTEM
PERFORMANCE ANALYSIS

PROJECT

Saint Clare's Denville Hospital

Pre and Post Coil Treatment

25 Pocono Road Denville, New Jersey 07834

OWNER

Saint Clare's Health

ARCHITECT

Saint Clare's Health

ENGINEER

Saint Clare's Health

CLIENT

ELX Technologies

DATE

May 12, 2022

TESTING, ADJUSTING AND BALANCING BUREAU

ULTIMATE COMFORT CONTROL

CERTIFICATION

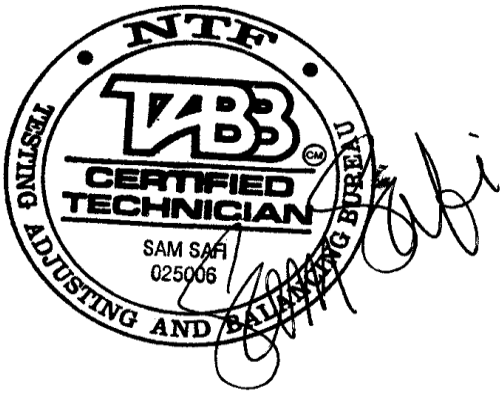
PROJECT

Saint Clare's Denville Hospital

Pre and Post Coil Treatment

25 Pocono Road Denville, New Jersey 07834

PERFORMED AND CERTIFIED BY:



TESTING, ADJUSTING AND BALANCING BUREAU

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TESTING, ADJUSTING AND BALANCING BUREAU

OBSERVATION SHEET

PROJECT NAME:	Saint Clare's Denville Hospital	PROJECT NUMBER:	1-1906
SYSTEM:	AHU 3	LOCATION:	LL B WING MER
TEST DATE	May 12, 2022	READINGS BY:	BW / SS

The following were observations noted during our site visits on May 10th and May 12th of 2022.

1. On initial site visit the AHU was noisy, appearing to be looking for airflow. The unit is 100% Outside Air unit and the VFD is switched to the Bypass mode only allowing the fan to run at 100% capacity.
2. While taking the pressure and temperature profile on the AHU it was noticed the rise in temperature on the steam pre heat valve was aproximatly 12 degrees. It was verified that the valve was commanded 100% closed.
3. It was also noted the pressures on the AHU were higher than average.
4. The AHU could not be shut down at this time. The steam heat piping appears to be shut off at this time.
5. The steam heat piping to the primary coil appears to be shut off at this time.
6. Post coil treatment apllication demonstrated a significant drop in pressures. Also the unit is running at a much more stable position.
7. The motor amperage increased from 19.7 amps to 24.2 amps. Nameplate maximum allowed is 30 amps. The motor amperage has increased but still below its maximum and safe to run at this time.
8. The airflow has increased from 8,407 CFM to 13,839 CFM. Please note the much higher than average velocity on the traverses indicating much more friction and noiser system affect in the ductwork.
9. We have a call into TRANE and discovered the unit was built in 2001 but unfortunitly are awaiting any more design information from TRANE to furnish goals to set back to original performance.
10. We recommend if TRANE is unable to furnish more information on this AHU we research for any drawings or information on the AHU or the area it feeds. We can assist in surveying the downstream conditions and provide suggestions on airflows to better get system under control.
11. We strongly recommend a review and repair of the VFD to at a minimum put the system back to pre conditions.
12. We also recommend a review and repair of the pre heat steam valve to remove the additional load onto the cooling coil and helping the remainder of the chilled eater system.
13. Once any or all of the repairs have been complete we can return and document conditions once returned back to as found conditions to realize total savings on this project.
14. Any questions please feel free to contact us at anytime.

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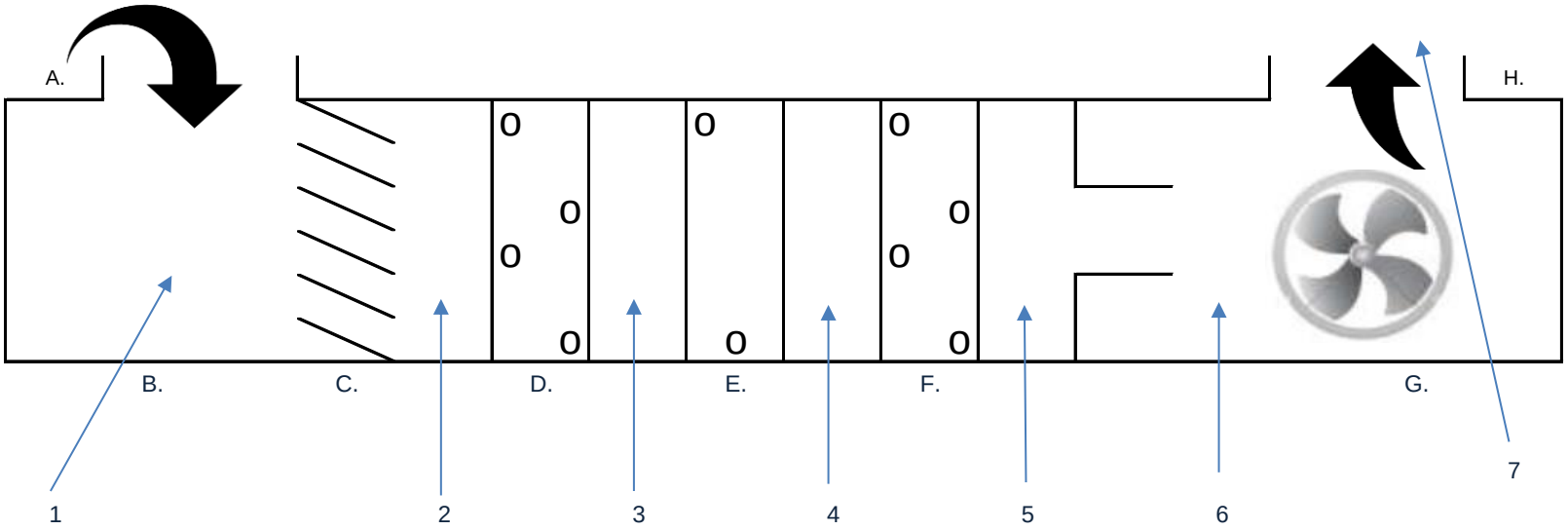
SYSTEM DIAGRAM

TESTING, ADJUSTING AND BALANCING BUREAU

PROJECT NAME:	Saint Clare's Denville Hospital	PROJECT NO.:	1-1906
DATE:	May 10, 2022	LOCATION:	LL B WING MER
SYSTEM:	AHU 3	READINGS BY:	BW / SS



NO.	DESCRIPTION
A.	OUTSIDE AIR INLET
B.	MIXING PLENUM
C.	FILTERS
D.	STEAM PRE HEAT COILS
E.	STEAM HEATING COILS
F.	CHILLED WATER COILS
G.	SUPPLY AIR FAN
H.	SUPPLY AIR OUTLET

NO.	DESCRIPTION	PRESSURE	TEMPERATURE
1	BEFORE FILTERS	- 2.67" WC	69.6 °F
2	AFTER FILTERS / BEFORE PRE HEAT	- 2.70" WC	69.6 °F
3	AFTER PRE HEAT / BEFORE HEAT	- 2.75" WC	81.5 °F
4	AFTER HEAT / BEFORE COOLING COIL	- 2.75" WC	76.9 °F
5	AFTER COOLING COIL / FAN SUCTION	- 3.00" WC	55.0 °F
6	FAN DISCHARGE	+ 1.40" WC	55.4 °F
7	SUPPLY DISCHARGE DUCT	+ 1.00" WC	55.6 °F
8	SUPPLY DUCT DOWNSTREAM	+ 0.62" WC	55.8 °F

COMMENTS:

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TESTING, ADJUSTING AND BALANCING BUREAU

AIR HANDLING UNIT TEST SHEET

PROJECT NAME:	Saint Clare's Denville Hospital	PROJECT NUMBER:	1-1906
SYSTEM:	AHU 3	LOCATION:	LL B WING MER
TEST DATE	May 10, 2022	READINGS BY:	BW / SS

UNIT DATA	
AHU MFG	TRANE
AHU MODEL NUMBER	MCCA035GAYOAP
AHU SERIAL NUMBER	KO1B16664B
PULLEY MFG / DIA. X BORE	NAC
NO. BELTS / MFG / SIZE	NAC

MOTOR DATA	DESIGN	ACTUAL
MFG / FRAME / SF	BALDOR / 284T / 1.15	
MOTOR RPM	1770	NAC
HP / PHASE / HERTZ	25.0 / 3 / 60	
MOTOR AMPERAGE T1 T2 T3	30.0	19.7
MOTOR VOLTAGE T1 T2 T3	460	464
SHEAVE MFG / DIA. / BORE	NAC	
SHEAVE TO PULLEY CENTERLINE	NAC	
AVAILABLE SLED ADJUSTMENT	NAC	

PERFORMANCE DATA	DESIGN	ACTUAL
FAN RPM	NAV	NAC
TOTAL CFM	NAV	8,407
RETURN AIR CFM	NAV	0
OUTSIDE AIR CFM	NAV	8,407
FAN TOTAL STATIC PRESSURE	NAV	4.40" WC
FAN SUCTION STATIC PRESSURE	NAV	- 3.30" WC
FAN DISCHARGE STATIC PRESSURE	NAV	+ 1.40" WC
FAN SPEED VORTEX POSITION	NAV	FIXED ON BYPASS

COMMENTS: NAC is Not Accessible due to not turning unit off. NAV is Not Available at this site visit.

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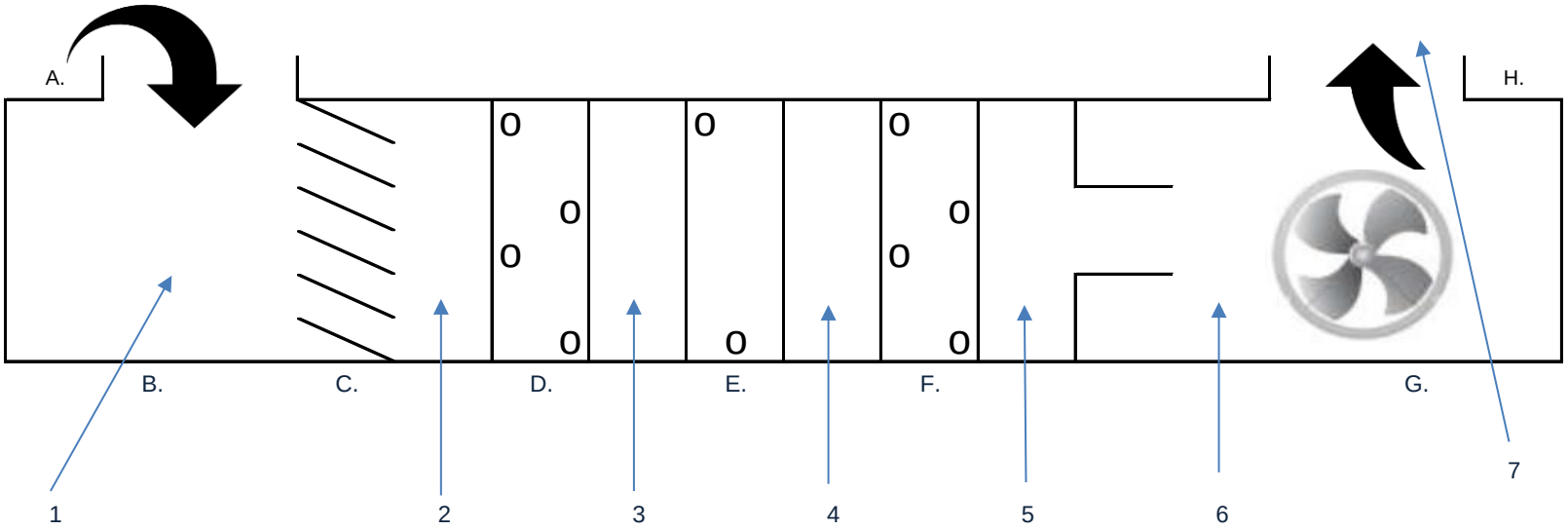
SYSTEM DIAGRAM

TESTING, ADJUSTING AND BALANCING BUREAU

PROJECT NAME:	Saint Clare's Denville Hospital	PROJECT NO.:	1-1906
DATE:	May 12, 2022	LOCATION:	LL B WING MER
SYSTEM:	AHU 3	READINGS BY:	BW / SS



NO.	DESCRIPTION
A.	OUTSIDE AIR INLET
B.	MIXING PLENUM
C.	FILTERS
D.	STEAM PRE HEAT COILS
E.	STEAM HEATING COILS
F.	CHILLED WATER COILS
G.	SUPPLY AIR FAN
H.	SUPPLY AIR OUTLET

NO.	DESCRIPTION	PRESSURE	TEMPERATURE
1	BEFORE FILTERS	- 1.80" WC	65.5 °F
2	AFTER FILTERS / BEFORE PRE HEAT	- 1.80" WC	65.5 °F
3	AFTER PRE HEAT / BEFORE HEAT	- 1.80" WC	75.1 °F
4	AFTER HEAT / BEFORE COOLING COIL	- 1.80" WC	74.4 °F
5	AFTER COOLING COIL / FAN SUCTION	- 1.90" WC	55.1 °F
6	FAN DISCHARGE	+ 1.00" WC	55.2 °F
7	SUPPLY DISCHARGE DUCT	+ 0.81" WC	55.2 °F
8	SUPPLY DUCT DOWNSTREAM	+ 0.48" WC	55.3 °F

COMMENTS:

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TESTING, ADJUSTING AND BALANCING BUREAU

AIR HANDLING UNIT TEST SHEET

PROJECT NAME:	Saint Clare's Denville Hospital	PROJECT NUMBER:	1-1906
SYSTEM:	AHU 3	LOCATION:	LL B WING MER
TEST DATE	May 12, 2022	READINGS BY:	BW / SS

UNIT DATA	
AHU MFG	TRANE
AHU MODEL NUMBER	MCCA035GAYOAP
AHU SERIAL NUMBER	KO1B16664B
PULLEY MFG / DIA. X BORE	NAC
NO. BELTS / MFG / SIZE	NAC

MOTOR DATA	DESIGN	ACTUAL
MFG / FRAME / SF	BALDOR / 284T / 1.15	
MOTOR RPM	1770	NAC
HP / PHASE / HERTZ	25.0 / 3 / 60	
MOTOR AMPERAGE T1 T2 T3	30.0	24.2
MOTOR VOLTAGE T1 T2 T3	460	464
SHEAVE MFG / DIA. / BORE	NAC	
SHEAVE TO PULLEY CENTERLINE	NAC	
AVAILABLE SLED ADJUSTMENT	NAC	

PERFORMANCE DATA	DESIGN	ACTUAL
FAN RPM	NAV	NAC
TOTAL CFM	NAV	13,839
RETURN AIR CFM	NAV	0
OUTSIDE AIR CFM	NAV	13,839
FAN TOTAL STATIC PRESSURE	NAV	2.90" WC
FAN SUCTION STATIC PRESSURE	NAV	- 1.90" WC
FAN DISCHARGE STATIC PRESSURE	NAV	+ 1.00" WC
FAN SPEED VORTEX POSITION	NAV	FIXED ON BYPASS

COMMENTS: NAC is Not Accessible due to not turning unit off. NAV is Not Available at this site visit.

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TESTING, ADJUSTING AND BALANCING BUREAU

TRAVERSE TEST SHEET

PROJECT NAME:	Saint Clare's Denville Hospital	PROJECT NUMBER:	1-1906
SYSTEM:	AHU 3	LOCATION:	LL B WING MER
TEST DATE	May 12, 2022	READINGS BY:	BW/SS

TS-1 TOTAL SUPPLY 5/10/2022			DESIGN			ACTUAL		
DUCT SIZE / AREA			42 X 24			7.00	SQ FT	
AIRFLOW			NAV	CFM		8407	CFM	
VELOCITY			NAV	FPM		1201	FPM	
STATIC PRESSURE			NAV	" WG		+ 0.62	" WG	
TRAVERSE LOCATION			B WING MER					
758	780	793	943	1366	1386	1407	1607	
457	721	916	1162	1264	1315	1638	1727	
694	869	1062	1318	1533	1581	1681	1515	
707	915	1040	1118	1253	1281	1409	1649	
783	833	1001	1262	1433	1550	1596	1699	

TS-1 TOTAL SUPPLY 5/12/2022			DESIGN			ACTUAL		
DUCT SIZE / AREA			42 X 24			7.00	SQ FT	
AIRFLOW			NAV	CFM		13839	CFM	
VELOCITY			NAV	FPM		1977	FPM	
STATIC PRESSURE			NAV	" WG		+ 0.62	" WG	
TRAVERSE LOCATION			B WING MER					
2714	2530	2262	2175	2009	1694	1321	1483	
2733	2650	2432	2133	1829	1701	1244	732	
2402	2420	2508	2316	2105	1438	1036	606	
2486	2498	2460	2319	2069	1585	842	908	
2740	2717	2695	2545	2299	1547	1207	1703	

COMMENTS: NAV is Not Available at this site visit.