UNISON COMFORT TECHNOLOGIES

- *Innovent® Air Handling Equipment*
- *Precision Coils*
- *Valent® Air Management Systems*

Unison™ Technical Support and Service Field Service Report

Job Information

CRM Case #	69-38376	Job Name:	Casper College
Sales Order #	210261	Serial # or Tags:	AHU-1
Ship Date:	2/28/2011	Rep Office:	LONG

Site Information

Innovent Representative	Todd Frykman
Service Contact(s)	Sean Brittenham, Daikin Applied
Site Contact(s)	Tom Popilek (Casper College), Rob (Casper College), Phil Nutter (ELogic)
Site Address:	125 College Dr, Casper, WY - Casper College, Gateway Building
Date of Trip:	3/21/17 – 3/22/17

Objective

To determine why the building is vibrating below the Innovent unit and to do a complete review of the unit condition and operation.

Scope of Work

After a couple of conversation with Tom Popilek at Casper College regarding the issues that they are seeing at the Innovent unit, which was installed in 2011, Innovent agreed to visit the site to perform an assessment. Daikin Applied accompanied Innovent as service support.

Innovent reviewed the initial operation and conditions of the building and unit upon arrival. Taking notes and pictures of what was found. It was found that the original Carel controls had been removed and replaced with Automated Logic, which limited what could be reviewed on Day 1. Based on the initial observations a plan of action with tests and measurements was created for Day 2.

On Day 2, Phil with ELogic was present to assist Innovent in commanding the unit, understanding the current control operation, and finding sensor locations. Based on the observations from Day 1 the unit was commanded into modes and adjusted to test different scenarios with the objective of determining what is causing the building vibration.

The below Complete Observations and Operational Tests provides details and data on Day 2. Based on these observations and test results a conclusion is made, and recommendations are provided.

Observations

1. Split Connections
    a. Separation Panels NOT silicone sealed (P2.1)
    b. Roof flashing at splits NOT fastened (P2.5)
    c. Curb supports at unit splits not supported to slab nor does it have spring isolation.
        i. Split support is bowing down. (P2.2)
    d. Internal split connections do not line up from section to section.
2. Air Leakage
    a. Air is coming out of base weep holes & at base split connections.
        i. Occurs more when the unit is in economizer mode.
    b. Curb is pressurized and when flex was opened air blows out.
        i. Occurs more when the unit is in economizer mode.
3. Carel Controls removed, and Automated Logic installed. (P1.4)
    a. Stated was done 2-3 years ago.
4. Internal Components
    a. Right recirculation damper was closed. Found that the actuator linkage had fallen off.
        i. A new c-clip was installed, and linkage reattached.
    b. Exhaust fan #3 is not operating.
        i. Found VFD for EF #3 & #4 had a much lower amperage.
        ii. Electrician stated that about a year ago they were getting alarms at the VFD and they determine there was an issue in this exhaust fans motor. The power to the motor was removed.
            1. The motor was never repaired, and power never reconnected.
    c. Supply Fan #3
        i. Isolators are locked. There is no movement of the blower.
        ii. Blower mounting rails appear to have been repositioned, and now the blower is not square to block-off wall (P4.1). There is about 1/8" gap of inlet flex on the right side (P4.3), but on the left side there is no gap, and the blower connection is touching the block-off connection (P4.2).
        iii. It appears that there was some repair done to SF# & SF#4 blower framing. It was stated that this had cracked and the welded an angle to repair. (P4.4)
    d. Outside air filters were dirty, and some were starting to fall out of the rack.
    e. DX Cooling Coil
        i. Visually dirty
            1. The static pressures across these coils was not high.
        ii. In the lower right corner of the right coil (air hitting back of head) there appears to be a potential refrigerant leak. (P2.7)
    f. Supply Air Discharge Compartment
        i. Section A wall (separates SA with EA) has some gaps between wall sections and at corner. (P3.1, 3.2 & 3.3)
        ii. Attached SA ducting is immediately reduced (unit SA discharge duct is 41" W x 275" L).
            1. Reduced 31" at both ends of duct near sides of the unit (total reduction of 62").
            2. Reduced 20" from width of duct. (P3.4)
            3. New opening: 21"W x 213" = 31 FT2 → 3,219 FPM
            4. Ducting takes an immediate 90° turn toward condensing section with turning vanes and sound attenuation. (P3.5 & 3.6)
                a. Also found that shortly after discharge of the unit there is another 90° turn down and the duct splits into three separate ducts.
    g. Return Air Inlet Compartment
        i. Attached RA ducting is immediately reduced (unit RA discharge duct is 41" W x 275" L).
            1. Reduced 31" at both ends of duct near sides of unit (total reduction of 62").
            2. Reduced 20" from width of duct.
            3. New opening: 21"W x 213" = 31 FT2 → 3,219 FPM

5. Building
    - Room Pressure Set Point = +0.03"
    - Supply Duct Static Pressure Set Point Reset = +0.6" to +1.50"
    a. Room Pressure Differential
        i. Room reference is on 4th floor in ceiling near concourse
        ii. Outside reference is next to unit on building wall within unit enclosure
            1. This reference could provide invalid readings to outside air pressures as the units building enclosure constantly has additional air provided by the exhaust air outlet.
    b. Supply Duct Static Pressure Sensor
        i. Located on the 2nd floor in room 224. Unit is located on the 4th floor.
        ii. This reference location is on the opposite side of the building from the unit.
    c. Supply Ducting
        i. Ducting immediately splits to 3 different trunks to serve the four floors. (F1.1 & F1.2)
        ii. No common ducting trunk before separation.
        iii. There are more than 100 VAVs that the AHU-1 is serving
    d. Return Ducting
        i. Utilizing dropped ceiling as a return.
            1. Some areas do not have return grate in ceiling panels.
            2. There are wall separations with no return path for air from areas of building opposite of the unit.
        ii. 3rd Floor office below the unit and at the return duct had ceiling panels removed. The door from the main concourse to this office became a wind tunnel. (P1.1)
            1. Damper on return duct was rattling excessively.
                a. Is this a fire/smoke or return damper?

Operational Tests

[Test results can fan curves can be viewed in Appendix A]

From the initial observations and understanding of how the building was being maintained and controlled a couple of tests were performed. These tests were to look at how the unit operated and the building vibration compared to different modes. Each of these tests were to be performed with ALL building VAVs at their maximum airflow set point.

The first test was with the unit at its minimum outside air mode. In this mode the minimum outside air damper position is at 70%, economizer outside air dampers are closed, recirculation dampers are at 100%, and the exhaust air heat exchanger bypass dampers are closed. With the building VAVs locked at maximum airflow and unit operating at minimum outside air mode (0% economizer), the supply fan was commanded to its minimum speed. The exhaust fan was allowed to modulate to maintain the space pressure. The supply fan speed was commanded to its minimum speed and increased by 15%. At each supply fan speed, the 3rd-floor office was observed for evidence of vibration, the unit's internal pressures were measured, and the control pressures (supply air discharge & space differential pressure) were recorded.

During this minimum outside air mode, the vibration within the building was either none existent or only slightly noticeable. The vibration was slightly noticeable only at 90% supply fan speed and above. When the supply fan was operating at 100% speed, the measured pressures were very close to the originally designed pressures. The total static pressure across the supply fan was measured at 6.1". Designed operating total static pressure was 6.34". ELogic calculated all of the VAVs measured airflows at this conditioned and found the total airflow to be 87,040 CFM (12,960 CFM less than design).

Once the first test was completed, the unit was shut off and all overrides were removed. Do to the overrides of the unit control the building spaces went above their desired conditions. When the unit was restarted it went to 100% economizer with mechanical cooling. The supply static pressure set point was at it maximum position (1.50") and the unit was attempting to meet this set point and running the supply fan at 100%. The 3rd floor offices below the unit were experiencing heavy vibration. The VAVs were not all at their maximum airflow positions as some spaces had been satisfied. With the unit operating in these conditions, the unit pressures were measured for Test 2.

With the unit operating in the Test 2 conditions, the total static pressure measured across the supply fan was 6.5". The unit's supply air discharge pressure was measured at 3.80", but the controls supply duct static pressure reference was 1.35". This is a pressure difference of 2.45" from the unit discharge to the 2nd floor reference.

Conclusions

After completing our tests and reviewing the measured pressures, as well as understanding the building ducting and control the vibration is originating at the unit.

This unit is moving a large amount of airflow, and due to moving components, there will be some vibration that occurs which is normal to occur. This unit is mounted on an isolation curb, but the curb does not support the unit at all spots necessary, specifically at the unit splits. Due to the lack of center support the unit had a bow in the middle that resulted in the perimeter isolation to not be level. The springs appeared to be at their maximum compression. The return ducting rigid connection was compressed onto each other without any flex separation to the unit. This rigidity would allow any resonance unit vibration to reach the building without dampening.

This resonance vibration is only a minimal amount as determined in Test 1. What Test 1 has shown, as well as the observation of building ducting, is that the supply ducting has a higher static pressure drop than designed. The return ducting also appeared to have a higher static pressure drop than designed, which the supply fan will pull 70% of its air from in minimum outside air mode. Due to this additional static pressure drop, the supply fan has to overcome the increased total static pressure. This brings the supply fan to its designed total static pressure operating point when ALL VAVs are at their maximum airflow set points. Once the VAVs are allowed to operate, based on their respective space temperature and adjusting airflow setpoint, the amount of static pressure for the supply fan to overcome increases putting the supply fan into surge. Comparing the designed supply fan curve with the measured conditions (Appendix A) the supply fan is in surge in many mode conditions. When a fan is in surge it is receiving insufficient air and doesn't completely fill the space between the blades. It the air will need to fill before it is released. The constant filling and releasing causes the air to pulse. This pulsation creates a vibration of the unit which is then transmitted through the supporting structure and into the occupied space below the air handler.

The supply fans are creating the building vibration, but its vibration is due to it operating out of its designed conditions. When the increase of static pressure pushes the fan out of its designed conditions, a surge scenario is created and causes a noticeable vibration.

Based on some of the air handling component operations it is evident that more maintenance needs to be performed on this unit. With damper closing unexpectedly, fans not operating, fans relocation impinging on rigid connections, fans without isolation there is a reduction in the life of the unit optimal operation. These lack of maintenance will cause the unit to operate out of its normal scenarios and could result in a catastrophic issue.

The installation of the unit is an additional concern. Due to the lack of center support of this large unit the effectiveness of the isolation curb is significantly reduced. The rigid to rigid connection will cause excess resonance into the building.

Recommendations

To correct the issues that were observed there are steps that need to be completed. Based on the tests and review of building design and control here are recommendations to correct.

Unit Vibration

1. Correct the supply and return ducting to reduce the static pressure.
    a. Determine return ducting design.
2. Rebalance the VAVs to operate at airflows that keep the supply fan in an operable condition.
    a. Apply higher minimums and maximums airflow set points.
    b. Create a total VAVs' airflow to coordinate directly with the speed of the supply fan.
3. Correct the isolation curbs missing center split support of the unit base.
4. Determine if they are correct and/or need there needs to be maintenance to the isolation curb's springs.
5. Correct supply fan #3's orientation to allow space for inlet flex connection to have a separation gap.
6. Correct supply fan #3's lack of isolation dampening.

Unit Operation

7. Repair exhaust fan #3 motor.
8. Replace dirty filters on a regular basis.
9. Routinely check correct damper & actuator operation, annually.
10. Routinely check blower & motor operation, annually.
11. Routinely check the refrigeration system operation, annually.

*Work with Daikin Applied to determine an Annual Maintenance could be set up.

Control Suggestions

12. Relocate supply duct static pressure sensor.
    a. Measure from unit supply air discharge compartment.
    b. Install additional supply duct static pressure sensor references for each floor.
        i. Determine necessary pressures for each floor trunk to provide the correct airflow and keep supply fan's total static pressure below surge point.
13. In economizer do not completely close the heat exchanger face damper.
    a. This will increase the temperature at the mixed condition but will reduce the pressure differential across the bypass dampers and reduce the total static pressure at the supply fan.

Appendix A: Operation Tests for Vibration & Pressures

Test 1: Minimum Outside Air

With the outside air damper at its minimum (normal, 70%) position and recirculation at its maximum position (100%) we adjusted the supply fan speed from minimum to 100%. We also made sure the VAVs were all at their "Maximum Cooling Set Points" and allowed the exhaust fan to control to maintaint he space pressure.

						Controls								*Controls*	
Test	SF @	EF @	RA Duct	EF In	HXEA PD	*Room Diff*	HX OA	HX SA	HXSA PD	SF In	SF Out	SF TSP	SA Disch	*SADSP*	VIBRATION
A	30%	25%	-0.25	-0.35	0.10	*0.00*	-0.10	-0.25	0.15	-0.26	0.24	0.50	0.20	*0.01-0.02*	None
B	45%	25%	-0.32	-0.37	0.05	*0.02*	-0.15	-0.46	0.31	-0.41	0.70	1.11	0.59	*-0.05 - 0.04*	None
C	60%	40%	-0.60	-0.75	0.15	*0.03*	-0.28	-0.81	0.53	-0.75	1.25	2.00	1.04	*0.06*	None
D	75%	53%	-1.07	-1.70	0.63	*0.03*	-0.42	-1.35	0.93	-1.27	1.85	3.12	1.63	*0.07-0.16*	None
E	90%	63%	-1.47	-2.00	0.53	*0.02*	-0.60	-1.83	1.23	-1.73	2.85	4.58	2.65	*0.19*	Slight
F	100%	71%	-1.83	-2.65	0.82	*0.02*	-0.75	-2.20	1.45	-2.20	3.90	6.10	3.40	*0.48-0.50*	Slight

Supply Fan			Exhaust Fan			
Speed	Freq	Current	Speed	Freq	Current	Current*
30%	18.6	45	25%	15.18	39.6	20.2
45%	27.9	46.9	25%	15.18	39.6	20.2
60%	37.1	52.2	40%	23.9	39.6	20.1
75%	46.3	61.9	53%	30.4	40.9	21.1
90%	55.6	76	63%	35.3	43	22.3
100%	61.3	87.2	71%	42.8	49	25

*EF3 was not operating. Power was disconnected 1 year ago due to alarms, but never repaired.

Test 2: 100% Economizer

With the VAVs controlling in auto the unit was in 100% economizer (min OAD at 70% & econ OAD at 100%, OAHX face closed & OAHX Bypass open 100%, recirc closed, EA bypass damper at 100%) and the supply fan operating at 100% & exhaust fan at 90%.

														Controls	
Test	SF @	EF @	RA Duct	EF In	HXEA PD	Room Diff	HX OA	HX SA	HXSA PD	SF In	SF Out	SF TSP	SA Disch	SADSP	VIBRATION
A	100%	90%	-1.30	-2.40	1.10	0.02	-0.36	-2.20	1.84	-2.30	4.20	6.50	3.80	1.35	YES

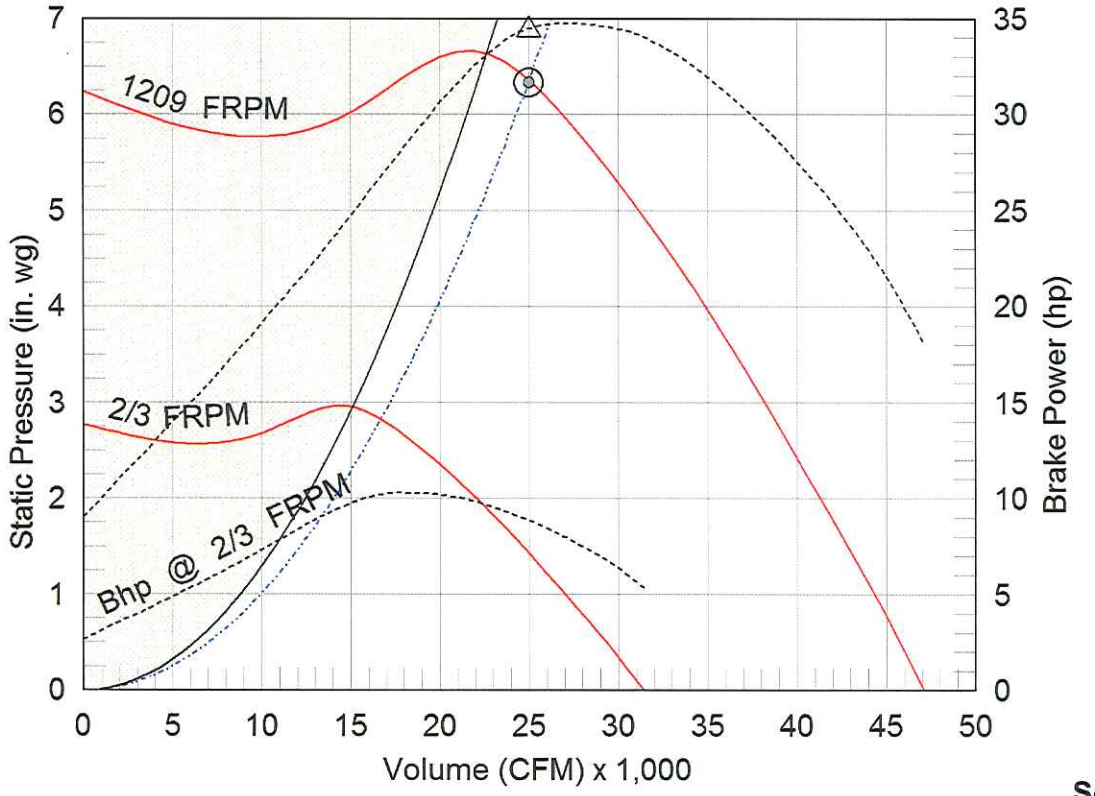
Supply Fan			Exhaust Fan			
Speed	Freq	Current	Speed	Freq	Current	Current*
100%	60.9	91	90%	53.7	65	32

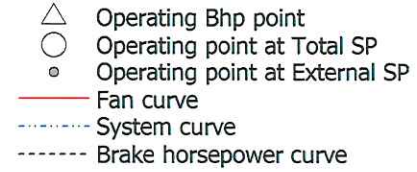
*EF3 was not operating. Power was disconnected 1 year ago due to alarms, but never repaired.

40-APH-4-95-II-400

Chart Type: 1/3 Reduction

Requested Volume (CFM)	25,000	Actual Volume (CFM)	25,000	Fan RPM	1209
External SP (in. wg)	6.34	Total SP (in. wg)	6.34	Operating Power (hp)	34.41
Elevation (ft)	5,289	Airstream Temp. (F)	70	Static Efficiency (%)	72





Sound Power by Octave Band

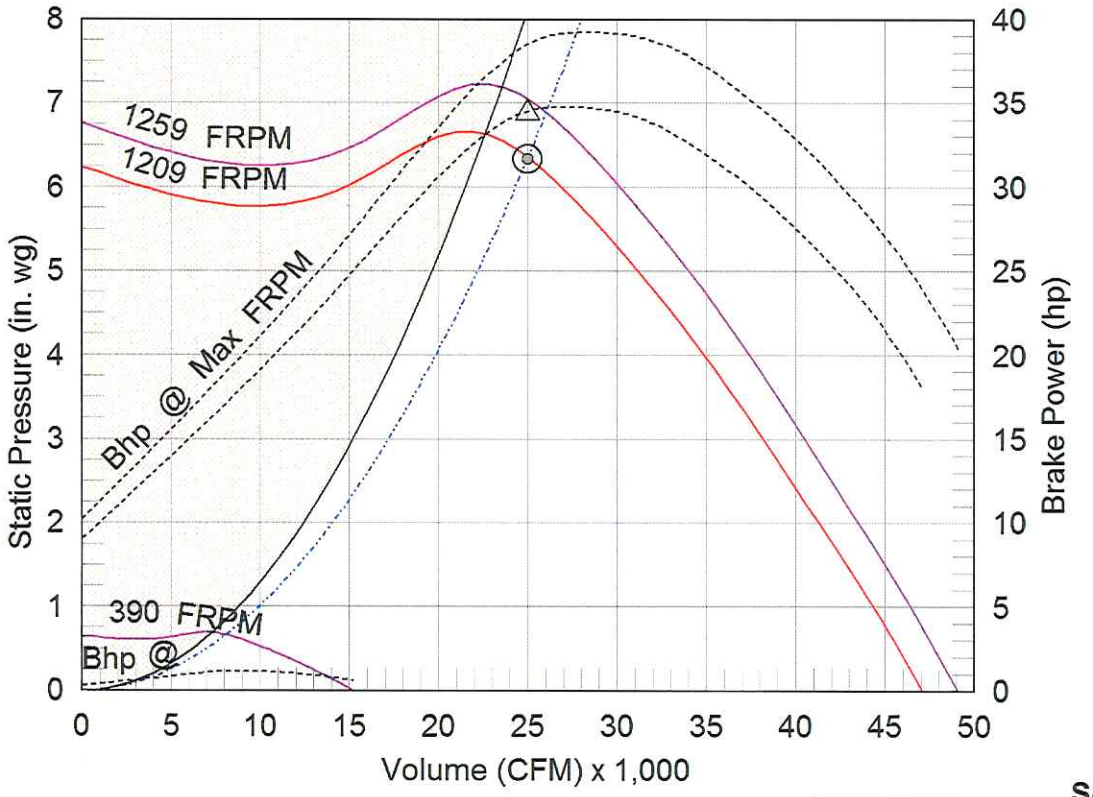
Sound Data	62.5	125	250	500	1000	2000	4000	8000	LwA	dBA
Inlet	88	93	101	88	84	78	77	76	94	83
Outlet	95	99	103	96	92	86	83	78	99	87

LwA - A weighted sound power level, based on ANSI S1.4
dBA - A weighted sound pressure level, based on 11.5 dB attenuation per Octave band at 5 ft. dBA levels are not licensed by AMCA International

40-APH-4-95-II-400

Chart Type: Min/Max Speed

Requested Volume (CFM)	25,000	Actual Volume (CFM)	25,000	Fan RPM	1209
External SP (in. wg)	6.34	Total SP (in. wg)	6.34	Operating Power (hp)	34.41
Elevation (ft)	5,289	Airstream Temp. (F)	70	Static Efficiency (%)	72



- Operating Bhp point
- Operating point at Total SP
- Operating point at External SP
- Construction/System Limit
- Fan curve
- VFD 20 HZ Limit
- System curve
- Brake horsepower curve

Sound Power by Octave Band

Sound Data	62.5	125	250	500	1000	2000	4000	8000	LwA	dBA
Inlet	88	93	101	88	84	78	77	76	94	83
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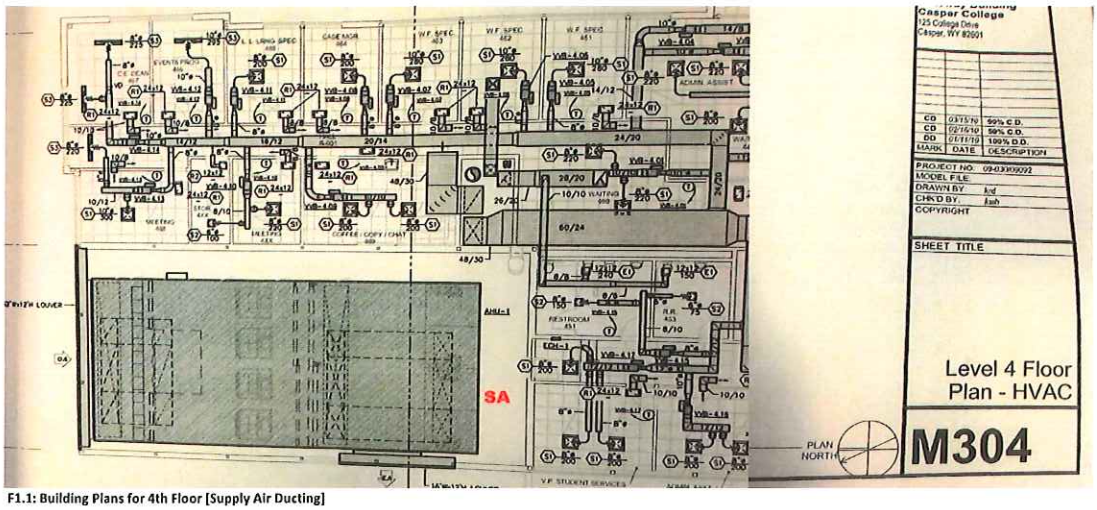
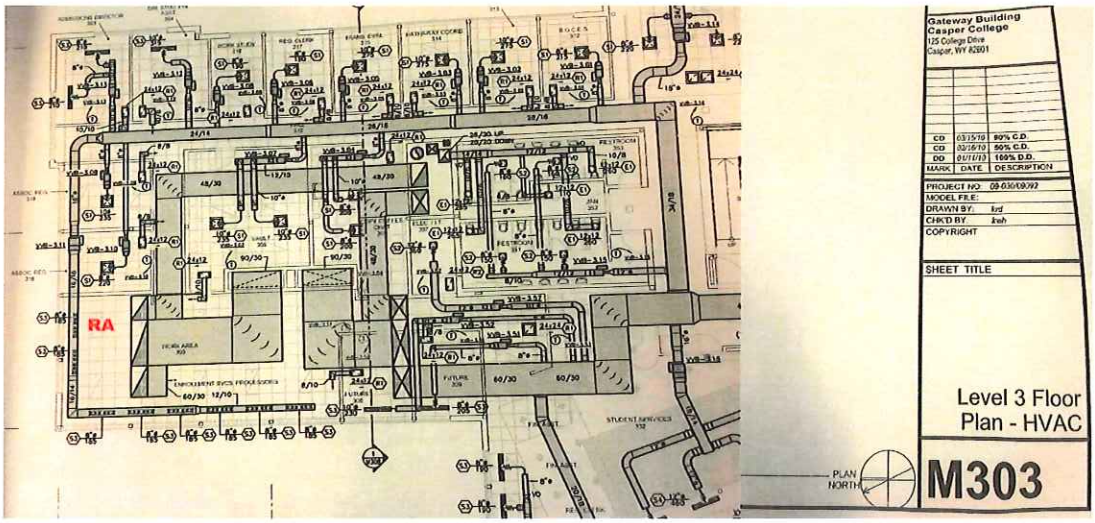
LwA - A weighted sound power level, based on ANSI S1.4
dBA - A weighted sound pressure level, based on 11.5 dB attenuation per Octave band at 5 ft. dBA levels are not licensed by AMCA International

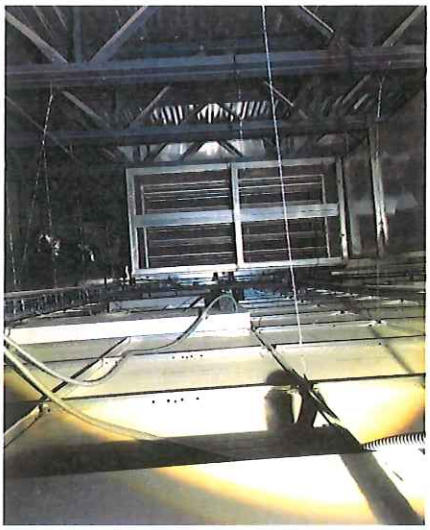
APPENDIX B: SITE PHOTOS



F1.1: Building Plans for 4th Floor [Supply Air Ducting]

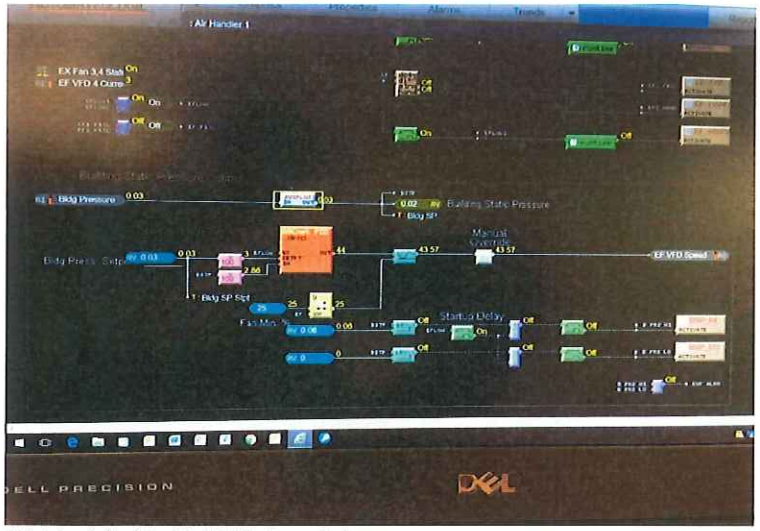


F1.2: Building Plans for 3rd Floor [Return & Supply Ducting]

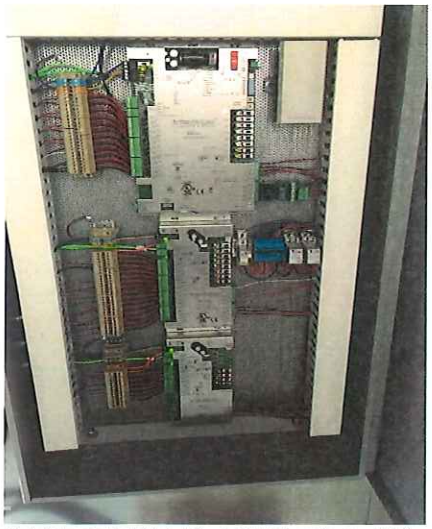


P1.1: Return Duct from 3rd Floor Ceiling [Just below unit]

P1.2: Automated Logic Front End - Unit Display



P1.3: Automated Logic Front End - Building Pressure Logic



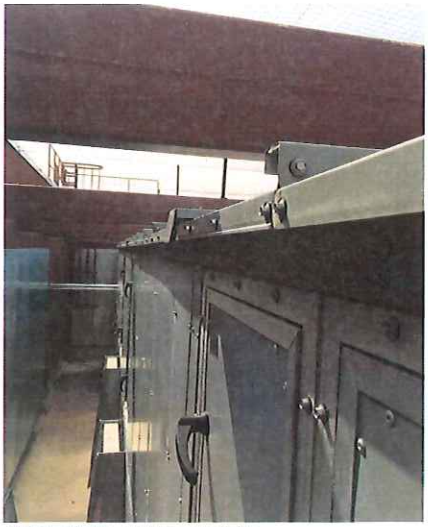
P1.4: Automated Logic Control Panel within Exhaust Section of Unit

P2.1: Base Split Connection at Section C & D

P2.2: Section Splits Under Unit Section C & D within Curb [No Spring or Curb Support to Slab]

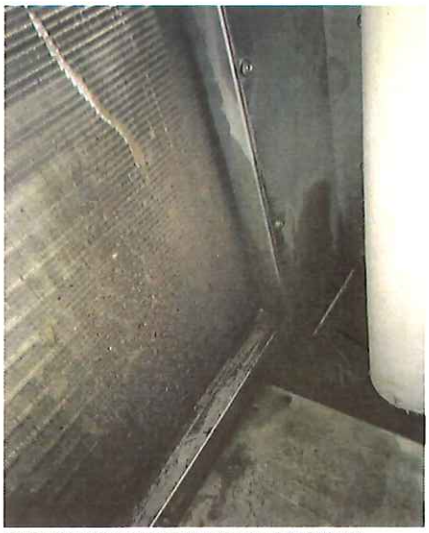
P2.3: Isolation Curb Springs and Mount Not Level

P2.4: Isolation Curb Springs at Section C

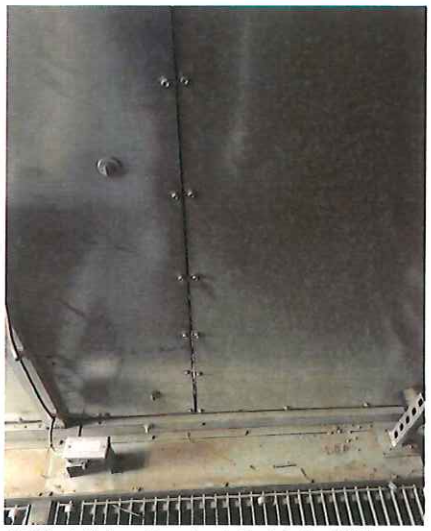


P2.5: Roof Flashing Not Fastened at Splits

P2.6: HWC Piping Run Through Unit Flooring, Not into Pipe Chase



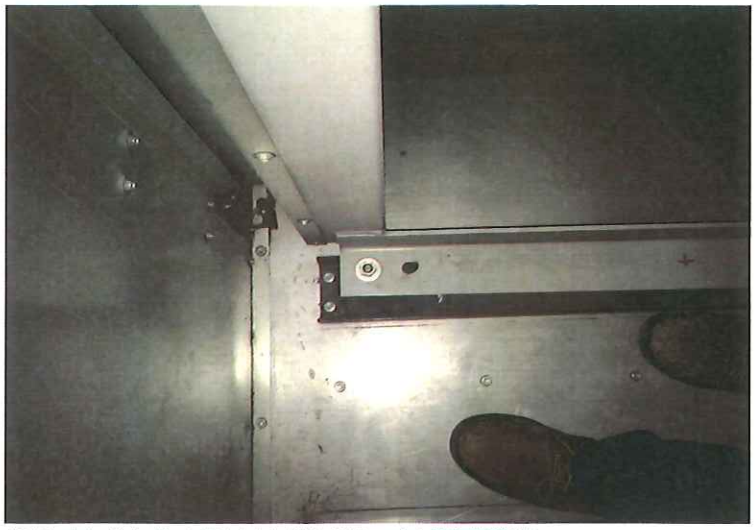
P2.7: Lower Right Corner of DX Cooling Coil - Potential Leak



P3.1: Supply Discharge Compartment - Gap in Section A Wall

P3.2 & 3.3: Supply Discharge Compartment - Gap in Corner of Section A Wall

P3.4, 3.5, & 3.6: Supply Air Discharge Ducting Transition - Reduced Open Area, Turning Vanes, & Sound Attenuation



P4.1: Supply Fan #3 - Isolator Rail Reinstalled with Fan Off Square to Inlet Block-Off Wall

P4.2: Supply Fan #3 Inlet Flex Connection - Left - Impinged

P4.3: Supply Fan #3 Inlet Flex Connection - Right - 1/8" Gap

P4.4: Supply Fan #3 Blower Rail Repair - Welded on Steel Angle