mechanicalservicecorporation
41 South Jefferson Road
Whippany, New Jersey 07981
Tel > 973.884.5000
Fax > 973.884.5060

Fiber Draw Tower Investigation

Project Number: [redacted]

Overview

The fiber draw tower in question is a four-story room that is served by a [redacted] roof-mounted dehumidification unit with a desiccant wheel for moisture removal as well as conventional heating and cooling. The unit appears to have been installed during initial building construction from the gathered documentation, however the room specification and fit out was separate from the general building. The building construction is steel frame on a concrete slab with additional floors being poured concrete on corrugated decking. The two exterior walls in the room are block walls with large glass window arrays, and the two interior walls are conventional sheetrock walls that run from the floor to the bottom of the roof deck.

The [redacted] unit utilizes a precool coil, desiccant wheel and post-cooling coil to provide dehumidification (when necessary) and space heating via gas-fired furnace. The unit operates heating or cooling as required to satisfy the required space sensible temperature.

Properly-installed HVAC systems are a balance of not only controlled temperatures but also air flows. Buildings and rooms operate in three types of pressure ranges: positive to the outside, neutral to the outside, and negative to the outside. It is desired to operate at a slight positive to the outside or, in some cases, positive to the adjacent room. In order to achieve a positive pressure in the fiber tower, the rate at which outdoor air is supplied to the space needs to exceed the rate at which air is exhausted, either mechanically or passively through openings. The primary reason to operate rooms and buildings in a positive is to control the space temperature and humidity as well as cleanliness. When rooms and buildings go into a negative relative to the outside or to adjacent rooms (as the fiber draw tower currently runs), they begin to drag air in to meet the needs of the exhaust. Usually that air being dragged into the space is unconditioned and unfiltered, and with the HVAC equipment already playing catch-up to supply air to the space, it has no extra capacity to meet the new unconditioned load placed on the equipment. Operating in a positive pressure relative to surrounding spaces and/or outdoors enables the space to maintain the correct temperature, humidity and cleanliness required.

Our Assignment

The reported problem with the fiber draw tower is that during the summer and on “rainy” days, the humidity in the fiber draw tower rises above the maximum permitted limit of 30% RH. It was also reported that the room is negative to the outdoors and surrounding spaces and is drawing unconditioned and unfiltered air into the space. Our assignment was to confirm these problems as well as investigate the reasons why these conditions may exist and formulate or recommend steps to take for corrective actions(s).

Investigative Work

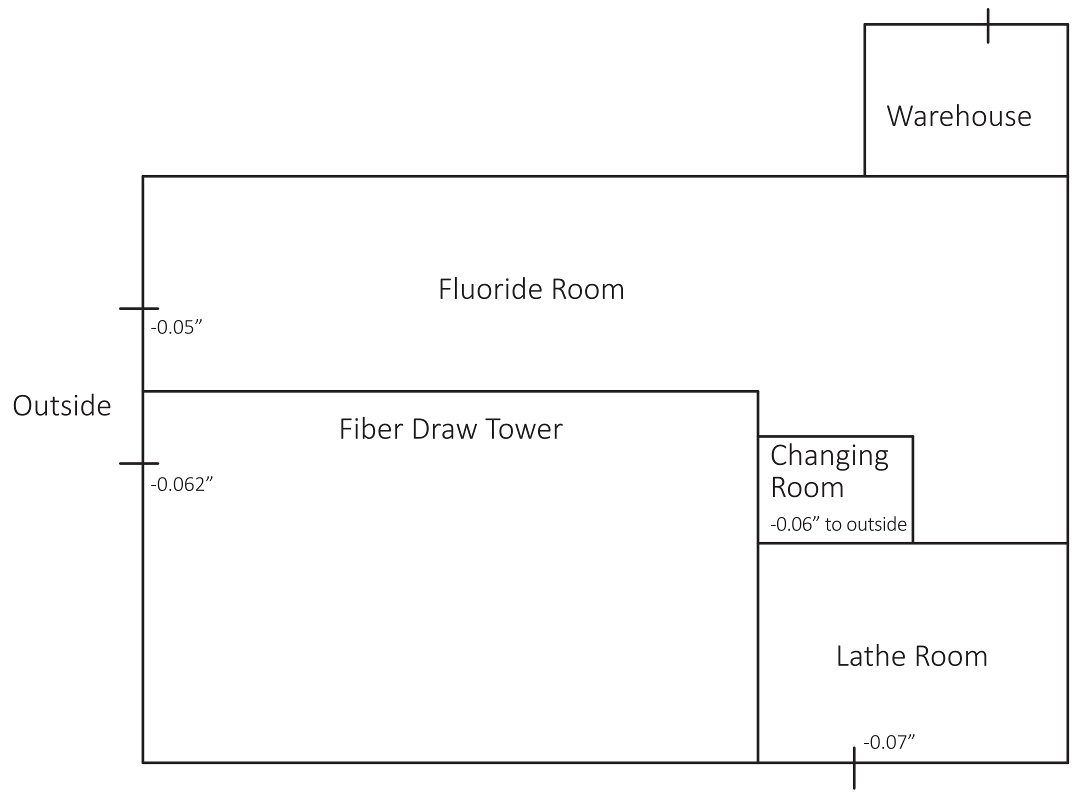
1. Investigate why the fiber draw tower room runs out of spec and fails to achieve the desired temperature and relative humidity.
2. Investigate if and why the fiber draw tower is in a negative and drawing air from the outside into the room.
3. Provide suggestions for corrective measures.

Observations and Technical Notes

[redacted] Unit:

1. Actual building equipment differs from what is found in the design drawings. Many of the installed fans are larger than initially specified and additional exhaust systems were added to the room.
2. The unit was found set to 72°F and 35% RH upon arrival.
3. A balance report was not available for the fiber tower and lathe room. Air flow readings were not taken during this assignment.
4. Unit specs: [redacted] rooftop air handler with desiccant wheel, pre- and post-cool coils, 8:1 turndown ration between two indirect fired gas burners and a 20 HP supply fan. Supply fan is fixed speed and not on a VFD.
5. The [redacted] rooftop desiccant air handler is a constant volume system with one VAV terminal serving the lathe room with returns in both spaces.
6. [redacted]'s design criteria calls for a supply of 10,000 CFM at 52.2°F DB and 32.2 grains/lb. humidity ratio. Barring any internal moisture gains, this will result in a space RH of 30% at 72°F.
7. Designed equipment entering air condition (combination of outside and return air) is specified in the submittal as 78°F DB and 65.2°F WB.
8. Calculations indicate that the design appears to have been based around ASHRAE 2% conditions for July dehumidification wet bulb and mean coincidental dry bulb (77.9°F/89.2°F respectively) with an approximate outdoor air percentage of 40% (4,000 CFM). Design drawings indicate that the unit was intended to supply 3,400 CFM of outdoor and return 6,200 CFM of return air.
9. The [redacted] unit is currently operating with damper positions of 40% outside air and 60% return air.
10. A field pressurization test was performed with all space exhausts operating, the return damper fully closed, and the outside air damper fully open. During this test the space pressure went from -0.062" WC to +0.12" WC.
11. Assuming the supply fan is delivering the specified 10,000 CFM and the total exhaust to the fiber tower is 4,730 CFM, the space is capable of a positive pressure overcoming mechanical exhaust to the fiber draw tower and possible exfiltration to the lathe room. The [redacted] unit, however, does not have adequate dehumidification capacity to handle supplying the 10,000 CFM of 100% outdoor air.

12. The illustration below shows the pressure differentials measured during our testing with the reference outside of the building. The readings were taken with the space operating as found. All readings are in inches of water column ("WC).



13. The [redacted] pressure sensor was not calibrated and was giving false readings. Mike zeroed it out and tested it against our calibrated instrument.
14. The OA and RA actuator signals are limited by a setting (adjustable) in the unit controller preventing the dampers from fully opening or closing fully.
15. [redacted] notes that there is a programming issue where there is an open loop in the code that disables building pressure control when the desiccant system is not operating. Current weather conditions lock out the desiccant system and it was observed that building pressure control is disabled.
16. When operating at 100% outside air, the lathe room exhausts and fume hood exhausts were being draw into the OA intake due to the discharges being located within 10' of intake. The discharges of these fans should be extended and directed away from the unit.
17. When the unit was put into regen override, the regen side of the unit operated as it should. When pressure control was forced on, and the voltage signals for OA and RA changed to factory settings (2-10) the RA damper went to 9V and the OA went to 1V. Building pressure then read 0" WC on a digital mag. Took unit out of overrides and OA went to 100%/10V and RA went to 0%/0V. unit was returned to prior set points due to room being in process.

Fiber Draw Tower:

1. The wall mounted [redacted] humidity and temperature sensor adjacent to the control panel is not wired to the [redacted]. All signal wiring goes to the [redacted] humidity and temperature transducer. The humidity and temperature readings being provided to the unit are not a calibrated reading as they do not match our instruments and there are no correction factors inputted into the controller to correct the readings.
2. The "Emergency VAV Cooling" switch on the control panel enables two VAV boxes supplied by RTU-3. One is on the first floor in the fluoride room and the other is on the second floor in a closet. The thermostats are on the wall adjacent to the panel.
3. The supply and return ducts from the two VAV boxes enter the tower room but have been foil taped over.
4. Exposed joints and cracks in the building construction is a source of air and moisture infiltration. Locations include where ductwork penetrates sheetrock walls (in some locations you can see the adjacent room through the penetration). The area where the sheetrock interior walls meet the corrugated metal decking for the floor above have large gaps. It is also unknown if the walls at the roof deck is fully sealed. The bottom of the sheetrock walls lack wall base where the sheetrock meets the concrete and in some locations the gaps are ½"-1".
5. The expansion joints in the slab of the tower room also have ½"+ gaps between the joint board and the adjacent slab which can act as a conduit for moisture and air to travel.
6. Doorways into and out of the tower room and lathe room are conventional steel doors with no sweeps under the door to provide a seal. The lack of sweeps under the doors allow airflow to occur under the door.
7. Emergency exit door in the tower room to the outside is not sealed along its edges and a draft is evident. Daylight can be seen under the door and water entered the space during a recent light rain.

Supply and Exhausts:

1. Initial designs called for the [redacted] unit to provide 3,400 CFM of outside air for make-up and returning 6,600 CFM from the space yielding a total supply of 10,000 CFM.
2. The lathe room was originally to be supplied by RTU-3 but was included in the fiber draw tower design. The original duct penetrations to the lathe room for the RTU-3 supply and returns currently exist. The return is currently capped in the space and the location on the 14" x 22" filtered transfer duct is where the supply was to enter.

   <u>Fiber Tower</u>**:**

   a) The fiber tower has a design supply volume of 10,000 CFM less what is being supplied to the lathe room at any one time (1,800 CFM – 180 CFM). We will assume that when the VAV terminal in the lathe room throttles down that the excess air is then distributed through the constant volume supply system in the tower room.

Throttling of the VAV terminal in the lathe room does alter the pressure differential between the rooms.

b) The design exhaust for the fiber draw tower was 3,360 CFM being done by two similar exhaust fans on the roof operating in unison (EF-4 and EF-5 on drawings).
c) The two fans' suctions are ducted together on the roof and travel down through the space along the wall. These fans serve as general exhaust for the space on the first and second floor of the catwalk.
d) On the control panel just inside the fiber room there is an exhaust fan switch that operates either EF-1 or EF-2 with percentage dials that vary the speed of the selected fan with the corresponding VFDs mounted to the panel next to the panel. These devices labeled EF-1 and EF-2 control the EF-4 and EF-5 fans on the roof shown in the plans. The wiring was traced out to confirm.
e) It appears that either EF-4 or EF-5 are intended to operate individually with the other provided for redundancy. The model number and nameplate data indicate that each fan is designed to exhaust around 3,360 CFM.
f) There is a hood in the tower room that has a nameplate exhaust of 810 CFM with the fan on the roof.
g) There is a HEPA fan powered box in the changing room that draws air from the tower room. It was designed for 600 CFM and it is unsure how much was expected to return to the tower.
h) The two bottle rooms off the changing room each have a designed 50 CFM exhaust provided by the hood exhaust fan for the lathe room. There are 6"x 6" transfer grills that go between the changing room and bottle rooms. They appear to have only been designed with transfer grills connecting them to the lathe room (those 6"x 6" are also installed).
i) The push-pull system for the tower is an independent system in the room, however it draws 100 CFM from the space.
j) Total mechanical exhaust for the fiber draw tower is 4,370 CFM, 3,360 CFM in general exhaust, 810 CFM for the hood, 100 CFM for the bottle rooms and 100 CFM for the push-pull system.

<u>Lathe Room</u>**:**

a) The lathe room has a variable volume supply ranging from 1,800 CFM at full cooling to 180 CFM at minimum cooling which is served by the [redacted] unit. The design for heating calls for 900 CFM to be delivered to the room.
b) The design exhaust for the lathe room was 2,020 CFM being done by four exhaust fans mounted in the space.
c) The exhaust from this space is presently provided by two fans (EF-FT-2, EF-FT-3) located on the roof. The specified name plate volumes of these two fans are 2,400 CFM and 2,000 CFM respectively.

d) EF-FT-2 is equipped with a VFD that was operating at 100% at the time of the readings. EF-FT-2 serves as the exhaust for the lathe hood. An airflow report for this fan indicates it is exhausting 2,112 CFM.
e) EF-FT-3 is a constant volume fan exhausting 2,000 CFM which serves all of the bottle rooms and two hoods in the lathe room.
f) The lathe room has three transfer ducts to the fluoride room. The three transfers to the fluoride room are as follows: two unfiltered 14"x 14" passages and one 14"x 22" passage with a pleated filter.
g) There are 6"x 6" transfer duct that connect the lathe room to the two bottle rooms off of the changing room. There are also transfer ducts into the bottle room located in the lathe room.
h) Total mechanical exhaust for the lathe room is 4,112 CFM.

The following is the designed Exhaust Fan Schedule section from the fiber draw tower drawing dated 1/30/12 (the most up-to-date drawing available). EF-FT-1 and EF-FT-4,5 are the only fans that were to serve the tower room. Currently EF-FT-6 & 7 below were added on to EF-FT-3 and serve the bottle rooms with a larger fan installed.

EXHAUST FAN SCHEDULE									
SYMBOL	SERVICE	MFR.	MODEL #	CFM	S.P	RPM	MOTOR		
							HP	V	Ø
EF-FT-1	AIR LOCK			600	-	-	1/5	120	1
EF-FT-2	LATHE EXHAUST			170	1.0	1393	¼	120	1
EF-FT-3	HOOD			1500	1.0	950	¾	460	3
EF-FT-4,5	TOWER EXHAUST			3360	1.5	1187	2.0	460	3
EF-FT-6	CONTROL ROOM			100	1.0	-	74W	120	1
EF-FT-7	CONTROL ROOM			250	1.0	-	157W	120	1

Tabulated exhaust totals compared to the supply CFMs for that area:

Equipment	Location	Exhaust (CFM)	Supply (CFM)
EF-FT-4,5	Fiber Tower	3,360	
Lab Hood	Fiber Tower	810	
Changing Room HEPA	Fiber Tower	100	
Push Pull	Fiber Tower	100	
FIBER TOWER TOTAL		4,370	9,820-8,200
Lathe Hood	Lathe Room	2,112	
Hood & Bottle Rooms	Lathe Room	2,000	
LATHE ROOM TOTAL		4,112	180-1,800
TOTAL		**8,482**	**10,000**

Investigation Summary

Temperature and Humidity Control

It is apparent from [redacted]'s design criteria for the unit that it is not fully capable of conditioning 100% outside air and was initially designed to use only about 40%. Once the outside air temperature reaches and exceeds 78°F and 50% RH, the unit will begin to use a mixture of outside and return air in order to control the discharge air temperature, thus losing the ability to control space pressure.

Not only does the unit not have enough cooling capacity for outside air during warm and humid periods, it may also be lacking sufficient heating capacity during cold weather. When the unit was tested for 100% outside air function, and the outside air temperature was 15°F, the discharge air temperature started to fall rapidly and the unit's settings were returned to avoid negatively affecting the space.

Space Pressure

The fiber tower room does run in a negative to adjacent rooms and the outside with the only exception being the lathe room that, when all exhausts are on, is the most negative room. The progress goes as follows: the warehouse is negative to the outside, the fluoride room is negative to the warehouse, the fiber tower is negative to the fluoride room and the lathe room is negative to the fiber tower. All of the rooms mentioned are negative to the outside and, due to this condition, are pulling in unconditioned and unfiltered air from the outside. The negative state that the rooms operate in are due to a greater rate of exhaust than supply.

In addition to the high exhaust rates, the construction of the building facilitates infiltration through cracks and penetrations, which if left unsealed will allow exfiltration from the space and make it more difficult to pressurize. There are also numerous transfer ducts between rooms that allow air to pass through, making it more difficult to create pressure gradients between rooms.

[redacted] Desiccant Air Handler

As noted previously, the settings and configurations in the controller have been changed by others from the initial factory settings. After consulting with the factory, they made light of the fact that the program also is missing a part of code that allows the unit to operate in building pressure mode when the desiccant wheel is not in operation. Since the current outdoor air conditions do not require the desiccant system to operate, building pressure control is disabled and the tower room operates in a -0.06" WC to -0.03" WC depending on what exhausts are taking place.

It is not known how the system operates during the warmer months and if the building pressure control turns off when the unit runs at or past its dehumidification capacity. It is also apparent that the space sensors are not calibrated as the temperature was 1°F off and the humidity was 5% off and no offsets were added to correct for the difference.

The unit serves both the tower room and lathe room but there is no documentation as to why the VAV box was added to serve the lathe room in the tower fit out. Previous design drawings of the building indicate that the lathe room was to be supplied by RTU-3. Since the lathe room operates in such a negative, it essentially is being supplied by both the unit and air from the fluoride room.

Going Further

The next recommended steps to take would be to fully seal the tower room, have [redacted] provide a new updated control sequence, take airflow readings to determine where the room is actually operating, and decide what conditions are needed in each location for that corner of the building.

The room should have all penetrations, cracks and openings sealed from the floor up to the roof deck to reduce and eliminate the possibility of infiltration and exfiltration once the room is running in a positive. The emergency VAV supplies and returns should be fully capped or completely removed as they are of no benefit; they would only supply general house air and the returns may be drawing air out of the tower. The transfer ducts to the lathe room from the fluoride room should be removed and sealed.

A new control sequence should be downloaded to the unit's controller to fix the open loop that disables building pressure mode when the desiccant system is off. It would also be beneficial to return the unit to the factory settings and restart the unit.

Traverses should be taken on all supply and exhausts of the tower room and the lathe room to determine where the rooms are actually operating and how much make-up air is needed in order to bring the rooms to a positive pressure. It appears that the desiccant wheel is at capacity when operating normally and additional equipment will need to be added in order to fully condition the room based on how much make-up air is needed.

Installation of another larger dehumidification unit is an option however further room analysis should be done on what airflow totals actually exist. One possible solution is to provide conventionally conditioned outside air (72°F and 45% RH) in front of the fume hoods in the fiber tower and lathe rooms in order to reduce the amount of make-up air the [redacted] unit must do. There are a few other alternatives, however the most pressing issues are sealing the room as best as possible and finding actual airflows in the supply and exhaust streams.

Abbreviations

VAV	Variable air volume, a type of air supply system that varies the amount of air delivered based on space requirements
VFD	Variable frequency drive, a method to vary speed of electric motors
DB	Dry bulb temperature
WB	Wet bulb temperature
RH	Relative humidity
CFM	Cubic feet per minute (flow of air per minute)
OA	Outside air
RA	Return air
" WC	Inches of water column, a unit of measure for measuring low pressures

mechanicalservicecorporation

Andrew Heilmann, PE
Engineer, General Manager
Direct: 973-929-6146
aheilmann@mscnj.com

41 South Jefferson Rd.
Whippany, NJ 07981
973-884-5000