Civil

Structural

Mechanical

Electrical

Technology

Lighting Design

Commissioning

Special Services

Study for Outside Air Quantity
25 Sigourney Street
Hartford, Connecticut

Final Report

August 21, 2006

State of Connecticut
Department of Public Works
Project Number BI-2B-033 J

BVH Project Number 21-06-056

BVH integrated services

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Table of Contents

1. INTRODUCTION

BVH Integrated Services, Inc. was commissioned to investigate various aspects of the HVAC systems at 25 Sigourney Street in Hartford, Connecticut. The building is a 20 year old, 420,000 square foot high-rise office building that has been the subject of various indoor air quality investigations in the past. A report by Turner Building Science, LLC from December 2005 noted that the building HVAC systems were bringing in more outside air than necessary thus causing high humidity in the occupied space and ductwork during high humidity days. The purpose of this report is to determine if it is possible to reduce the amount of outside air delivered to the building while maintaining positive pressurization. A previous project corrected outside air infiltration and stack effect.

This study encompasses many aspects of the building's HVAC systems. The scope of the project is:

- Review existing outside air quantities delivered to building spaces and compare to outside air required based on current occupancy and assumed maximum capacity.
- Determine if it is possible to reduce outside air quantities in order to reduce moisture within ductwork and spaces while maintaining building pressurization.
- Provide scope and cost estimate for a dehumidification system for outside air if available outside air reduction is insufficient to reduce humidity levels.
- Assess condition of drain pans in existing air handling units throughout the building.
- Provide schematic cost estimate for replacement of existing air handling units, fiberglass ductwork, and VAV boxes including all costs such as ceiling removal and replacement.
- Provide a budget estimate for all recommended work.

The building is a 20 story mixed use office building. The building's mechanical systems are typical of speculative office buildings built in the same era. Each typical office floor is approximately 30,000 square feet with a north and south mechanical room on each typical floor. Each mechanical room has a variable volume air handling unit with hot and chilled water coils. Air is distributed to the floors to terminal VAV boxes with pneumatic controls. The air handling units and all head-end systems are controlled by direct digital controls (DDC).

Outside air is delivered to two shafts by two separate outside air fans at the penthouse level and distributed to each mechanical room. Outside air is mixed with return air within the mechanical room, which acts as a mixed air plenum. Each floor is equipped with an airflow station on the outside air duct which modulates a damper to maintain the specified outside air quantity on each floor. The airflow stations and dampers on the outside air deliver even ventilation throughout the building and equally pressurize each floor. A relief air shaft allows excess air on each floor (when more outside air is introduced on a floor than exhausted) to relieve, through gravity, to the roof level.

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2. Review of Outside Air Quantity

The December 2005 report by Turner Building Science, LLC noted that existing outside air quantities exceed ASHRAE recommendations for minimum outside air by "2-3 times". Current building code and the building code at the time of the controls upgrade project dictates the amount of outside air required per occupant and dictates the number of occupants that must be used for the design.

Per code, design occupancy for each 30,000 (approximate) square foot floor plate of office is seven occupants per 1,000 square feet, which equates to 210 occupants per typical floor. The code outside air requirement is 20 cfm per person. This equates to 4,200 cfm per floor, or 2,100 cfm per air handling unit. The current outside air setting on each typical air handling unit is 2,200 cfm. To calculate outside air for the entire building, 420,000 square feet equates to an occupancy of 2,940 people. At 20 cfm/person, 58,800 cfm is required for minimum ventilation in the building.

The two existing outside air fans were designed to deliver 49,000 cfm each for a total of 98,000 cfm. The original design included provisions for air-side economizer operation; the minimum outside air delivery was 61,300 cfm total for both fans and controls allowed the fans to increase in speed to deliver 98,000 cfm in economizer. According to recent testing by Wing's Testing and Balancing (July 15 2004), the outside air fans deliver 60,713 cfm at minimum outside air and 81,480 cfm at economizer operation (maximum air delivery).

The existing ventilation meets current code requirements. Each floor receives about 20 percent outside air at peak design conditions which is typical of office buildings and exceeds minimum requirements by 3.3 percent, which is within standard balancing tolerances.

According to operations staff, the actual peak occupancy is not expected to exceed 1,500 people. Using this occupancy as a basis for design, outside air could, theoretically, be reduced to 30,000 cfm for the entire building. Any reduction in outside air quantities should be reviewed with the authority having jurisdiction; adequate proof of occupancy rates well below code requirements will be required in order to reduce outside air quantities to this level.

In addition to providing ventilation for building occupants, the outside air also pressurizes each floor to prevent potential moisture infiltration through the building envelope. Pressurization controls on each floor modulate the relief air damper on the floor in order to maintain the pressurization setpoint. Any reduction in outside air will require a reduction in the pressurization setpoint.

The current exhaust air from the building is approximately 26,300 cfm, compared to an outside air delivery of approximately 60,713 cfm. The excess air for pressurization is 34,413 cfm. Theoretically, the outside air quantity could be reduced to 30,000 cfm without producing a negative pressure and still provide enough ventilation for the assumed peak occupancy of 1,500 people. Due to the height of the building, however, equalizing the outside air and the exhaust air would likely produce a positive pressure on upper floors and a negative pressure on lower floors. Each typical floor has about 4,400 cfm of outside air at minimum conditions and 1,200 cfm exhaust. The positive pressurization for each floor is about 3,200 cfm (note, this is a general statement and varies from floor to floor), which is removed through the relief air shaft.

The existing pressurization controls are set to maintain 0.20 inches of water differential pressure between the interior space and atmospheric pressure. The controls modulate the relief dampers on each floor to maintain the setpoint on each floor. Observations of the existing controls showed that the measured floor pressurization varied from floor to floor but, on average, was sufficiently positive. The floor static setpoint is high and can be reduced to 0.10 inches, a number that is used for healthcare and clean room pressurization applications. Reducing this number may help to reduce the pressure on the floors that are pressurized above setpoint and increase the pressure on floors where pressure is below the setpoint.

A motorized damper at the top of the relief shaft controls the total building pressurization. The control system is set up to utilize an average of all of the floor pressures. The total building static pressure setpoint at the controls was set at 0.05 inches and was observed to be measuring between 0.03 and 0.10 inches. The setpoint for this control should match the setpoint for the individual floor controls. It was observed that the relief damper modulated rapidly and appeared to need some fine tuning.

Utilizing the current relationship of pressure and flow rate differential, it may be possible to reduce outside air flow and maintain 0.10 inches positive pressure on each floor. Based on current relationships, the total outside air quantity could be reduced by about 30 percent. This would reduce the differential cfm between outside air and exhaust air from 34,413 cfm to 24,100 cfm, reducing total outside air at minimum conditions to 50,400 cfm. We would not recommend reducing airflow any lower than this number. This reduction in airflow should be done proportionally at each floor and should be performed by a commissioning agent, a certified testing and balancing agency, and a control technician. The reduction should be done by trial and error to assure that positive pressurization is maintained. If pressurization cannot be maintained at the minimum airflow prescribed in this report, then the airflow should be increased until the pressurization is maintained. The building Owner should approach the authority having jurisdiction with population data to assure that a reduction in outside air below code requirements is acceptable.

3. OUTSIDE AIR MOISTURE

The Turner Building Science Report noted that the existing HVAC system brings in "large quantities of raw, unconditioned outside air," which may be responsible for mold growth in the air handling units and in the distribution ductwork. As discussed in the previous section, the amount of outside air is typical of an office building and meets current code requirements. The physical amount of outside air delivered to the building does not create any abnormal moisture issues above and beyond typical HVAC systems for this building type. The delivery method could create moisture infiltration through the outside air shaft walls and, potentially, higher than normal moisture levels in the mechanical room. If the systems are operating as designed, the mechanical room will be under a negative pressure which will prevent any moisture infiltration to the occupied space and if the outside air shafts are properly sealed, there is no route for moisture to pass between the shaft and the occupied space. The outside air shafts are reported to be in good condition.

The outside air is mixed with return air in the mechanical room (which acts as a mixing plenum) and drawn into the air handling unit. Each air handling unit is equipped with a chilled water cooling coil which provides moisture removal from the mixed air stream.

As described in the previous section, the air systems have a limited economizer which allows additional outside air into the mechanical room plenum. The economizer controls are based on enthalpy, which takes into account both moisture and temperature. The controls will not allow the system, for example, to go into economizer operation on a very humid day with a moderate outside air temperature in the economizer temperature range.

The 0.4 percent design dehumidification day in Hartford, per ASHRAE climatic data, is 81 deg. F dry bulb/75 deg. F wet bulb (approximately 76% RH). This condition would be the basis of design for a dehumidification system; it's considered worst case for moisture (on average, only 0.4% of the year would have more moisture in the outside air than this). During these conditions, the outside air fans would be delivering minimum outside air.

To take, for example, the mechanical room with the highest amount of minimum outside air after balancing was performed on July 15, 2004 by Wing's Testing and Balancing, was in mechanical room 14N. The minimum outside air to this unit was balanced at 2,333 cfm. The design airflow for this unit is 14,500 cfm. It is reasonable to assume that the zone load would not be at full load under these conditions – taking an 80 percent diversity factor, the total supply air would be 11,600 cfm. The outside air percentage is around 20 percent at this condition. Assuming a return air condition of 78 deg. F, 50% RH, the mixed air condition would be 79 deg. F dry bulb/67.5 deg. F wet bulb, which has slightly more moisture than the original coil design entering air condition of 79/66. The cooling coil would still remove moisture from the air in this condition, but the relative humidity may creep up slowly in the space if the coil was unable to remove all the moisture in the air. Relative humidity sensors could be installed on different floors to monitor humidity with the existing system operation to see if this is the case.

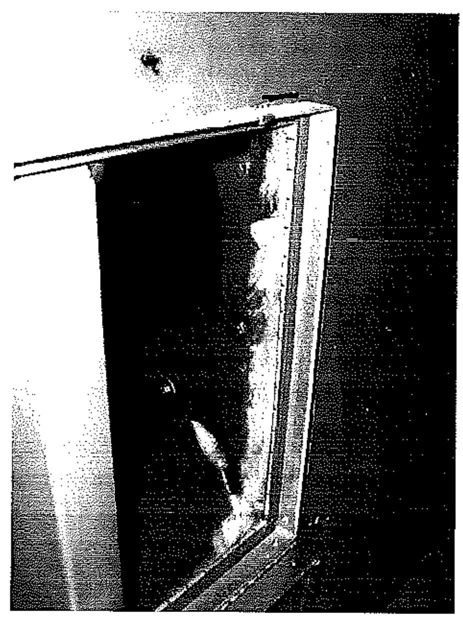

Figure 1 - Air handling unit with failing insulation

The TBS report also noted that moisture levels in the building would promote mold growth if the outside air had a high relative humidity and the cooling coils were not in operation. Due to the low amounts of outside air, there are no conditions where the humidity ratio of the outside air is greater than the humidity ratio of the inside air where the cooling coil wouldn't be active. It is also unlikely that the surface temperature inside the air handling unit would fall below the dewpoint of the discharge air and cause condensation on the inside surfaces of the unit, as long as the outside air is off during unoccupied periods (which is the current control scheme). This may have been a problem in the past before the recent controls upgrade. Condensation could occur regularly during the summer on the outside of the casing due to warm mixed air in the mechanical room in areas where the casing insulation within the air handling unit had worn away or fallen off. The existing internal insulation on all units is being replaced and should be complete at the time of the issue of this report.

A likely cause of moisture penetration on the former internal casing of the air handling unit and on fiberglass liner in the ductwork just downstream of the fan is moisture carryover due to a high velocity at the cooling coil. As the moisture condenses on the cooling coil, it drips down the coil and collects in the drain pan. As the velocity increases at the coil, the likelihood that the drops of condensation will be pulled into the airstream increases. Standard design typically limits the face velocity at the coil to 500-550 feet per minute. According to the most recent test report (July 14. 2005 – Wing's Testing and Balancing), the velocity at design conditions was 760 feet per minute on the typical floors. This velocity is not unusual with limited mechanical space, which is the case with this building.

Moisture carryover can be reduced with larger air handling units (or larger cooling coil face area), by installing moisture eliminators downstream of the cooling coil, or dehumidifying the outside air. The first two options require new air handling equipment in limited mechanical space. The dehumidification unit would have to be sized for economizer operation at 100,000 cfm (to match the original design and maximize the energy-saving capabilities of the system, which is limited by the existing outside air shaft sizes). A dehumidification unit would also reduce the possibility of moisture migration through the walls of the outside air shafts.

The existing mechanical rooms that house the outside air fans do not have enough space to accommodate a dehumidification unit, so a single unit would have to be placed on the roof of the penthouse and ducted over to the two existing shafts. A new pair of chilled and hot water risers originating from the service entrance of the thermal utilities in the basement would be required to serve the dehumidification unit. Significant structural modifications would likely be required in order support the unit on the roof; the scope of this work is unknown at this time.

Placement of the dehumidification unit would be crucial due to the proximity of the cooling tower discharge, which would be at the same elevation as the new intake location on the roof of the penthouse. If this option were to be pursued, a wind study using tracer gases should be commissioned to assure that the cooling tower plume will not be entrained into the outside air intake. It should be noted that the current outside air intake locations are sufficiently separated from the cooling tower plume and are located below the cooling tower discharge.

As an option, a heat recovery wheel could be added to the system to recapture heat from the toilet exhaust, as suggested in the TBS report. This would require a new toilet exhaust fan and additional ductwork from the fan to the dehumidification unit. Pricing for dehumidification options can be found in Section 6.

Another way to minimize moisture in the space is to have an unoccupied set-up temperature setpoint that will allow the individual air handling units to cycle on without any outside air to cool the space so that space temperatures and humidity levels don't become excessive over long periods of unoccupied periods. A standard set-up setpoint is 85 degrees. Control can also be set on relative humidity levels; the existing control system is not equipped with relative humidity sensors on each floor.

4. AIR HANDLING UNIT CONDENSATE DRAINAGE

The existing air handling units utilize the floor of the fan section to drain condensate. With the exception of the 19th floor unit (in the penthouse mechanical room), each unit was only drained from one side. The opposite sides of the units were inaccessible and the drain connection was capped. It was not possible to see if all of the bases were sloped to one side, but the floors of the units were not uniformly flat due to their age; the surfaces lent themselves to condensate ponding.

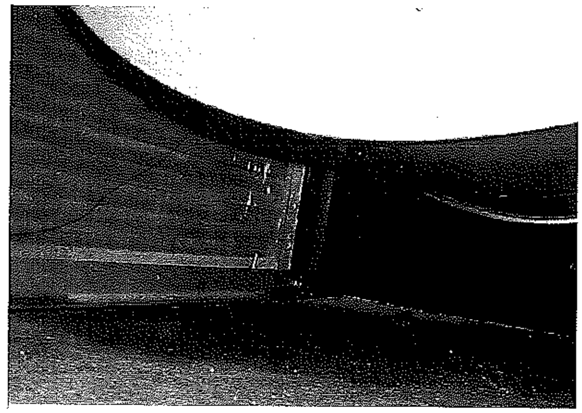

Figure 2 - Existing drain pan before refurbishment

During the time of our survey, the units were in the process of being cleaned and re-insulated and the drain section was being coated with an anti-microbial coating. This process will be complete for all air handling units by the time the final report is submitted. Finished units were clean and in better condition than units that had not been serviced. Internal fiberglass insulation was loose on the unfinished units and the floors of the units in the fan section were corroded and in poor condition in most cases.

Figure 3 - Condensate drain piping pitched away from drain

According to the manufacturer of the existing units (Trane), the casing is structural and there is no way to cut a new drain pan in under the existing cooling coil. It may be possible to fabricate a stainless steel drain pan and slide it under the existing coil (there is about 2 inches of clearance between the bottom of the coil and the floor of the unit), but access is limited and proper attachment would be difficult. In addition, there is not enough vertical clearance to properly pitch the drain pan to one side of the unit.

Figure 4 - Refurbished air handling unit floor

The condensate traps appeared to be properly sized throughout. Condensate discharge piping on many units needed to be adequately secured to the floor to maintain pitch.

The new coating appears to have improved the condition of the floor, but proper pitch inside the unit cannot be verified or corrected because of the drainage arrangement. Since the unit is equipped with two drain connections and only one is connected on most units, it is possible that the floor is not draining properly in all cases. As part of preventative maintenance, pitch of discharge piping should be examined periodically and corrected, if necessary. Additionally, the fan section bases should be examined periodically during high humidity days to assure proper drainage. The units are nearing the end of their expected useful life and should be considered for replacement with units equipped with stainless steel IAQ drain pans.

5. Air Systems Replacement Scope of Work

The scope of work described by operations staff for replacement of existing HVAC systems includes the replacement of existing air handling units, replacement of existing VAV boxes, and replacement of existing secondary ductwork (fiberglass duct downstream of VAV boxes). The scope for these improvements will be broken into three components so that work can be prioritized.

5.1. Air Handling Unit Replacement

Scope of work (typical for each mechanical room):

- Remove existing air handling unit, supply ductwork within the mechanical room, existing cooling and heating coil connections, supports, electrical connections, controls, and all associated accessories.
- Provide a new air handling unit sized for approximately 500 feet per minute at design airflow with chilled water cooling coil and hot water heating coil.
- Unit shall be equipped with a stainless steel IAQ drain pan with single or double-sided connections depending on accessibility.
- Supply fan motor shall be premium efficient and meet or exceed the more stringent of code requirements or Northeast Utilities' Energy Conscious Construction program.
- Unit shall be equipped with 85% efficient filters with 30% pre-filters.
- Reuse existing control valves and sensing devices.
- Provide new supply ductwork within mechanical room with acoustic lining that meets UL and ASTM standards for erosion, moisture, fungi and bacteria resistance.
- Reuse existing variable frequency drives.
- Provide new condensate drain piping and properly-sized trap to existing floor drain.

5.2. *Replacement of VAV Boxes*

Typical scope of work:

- Remove existing VAV boxes and associated hangers and supports.
- Remove existing hot water piping to boxes with hot water reheat coils – cap piping and save for reuse.
- Remove existing pneumatic controls back to source.
- Provide new supply ductwork within mechanical room with acoustic lining that meets UL and ASTM standards for erosion, moisture, fungi and bacteria resistance.
- Reconnect hot water to boxes with hot water coils; provide new DDC control valve and all new trim.
- Replace existing zone thermostat with new DDC temperature sensor.
- Provide box with DDC controls tied into existing building management system.
- Provide new power to fan-powered VAV boxes.

5.3. *New Secondary Ductwork*

Typical scope of work:

- Remove all existing secondary ductwork between VAV boxes and diffusers.
- Provide all new galvanized steel ductwork between VAV boxes and diffusers.
- Provide all new flexible ductwork for runouts to diffusers in accessible ceiling areas (maximum flexible duct run of 6 feet).
- Provide new volume dampers at all duct takeoffs.
- Line first 10 feet of ductwork downstream of VAV boxes with acoustic lining that meets UL and ASTM standards for erosion, moisture, fungi and bacteria resistance.
- Insulate all supply ductwork with 1.5 inches fiberglass insulation with vapor barrier.
- Remove existing ceilings and install new ceilings.
- Remove existing light fixtures and ceiling devices and save for reuse.

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6. Cost Estimates

The following is an assessment of the estimated costs associated with the recommendations made in the previous sections. Note that costs do not include any provisions for escalation and are conceptual level cost estimates for budgetary purposes only. All construction work is assumed to be on premium time. Estimates include (where noted) 35 percent for soft costs and do not include costs associated with the impact on operations or costs for cleaning upon completion.

6.1. Rebalancing of Outside Air Quantity, Commissioning, and ATC Programming Adjustments

Item	*Estimated Cost*
Commissioning, Testing, and Balancing	$24,000
Control Technician	$ 4,000
Total	**$28,000**

6.2. Dehumidification Unit

Base Unit (No Heat Recovery):

Item	*Estimated Cost*
Dehumidification Unit	$250,000
Rigging and Installation	$180,000
New Chilled and Hot Water Risers (assuming straight path up through building)	$125,000
Roof-Mounted Ductwork (insulated)	$ 50,000
Demolition	$ 25,000
Controls	$ 20,000
Testing and Balancing	$ 4,000
Electrical	$ 20,000
Structural Modifications	$125,000
General Conditions, Contractor OH&P	$160,000
Soft Costs	$336,000
Total	**$1,295,000**

Alternate Unit (With Heat Recovery):

Item	*Estimated Cost*
Base Cost	$1,295,000
Heat Recovery Section	$ 250,000
Additional Ductwork, Exhaust Fan	$ 35,000
Additional Balancing	$ 1,500
Additional Controls	$ 15,000
Additional Electrical	$ 8,000
Additional General Conditions, Contractor OH&P	$ 62,000
Additional Soft Costs	$ 130,000
Total	**$1,796,500**

6.3. Air Handling Unit Replacement

Item	*Estimated Cost (Each Unit, Floors 6S, 7-19)*	*Estimated Cost (Each Unit, Lobby and 6N)*	*Estimated Cost (Floor 20)*
Air Handling Unit	$ 25,000	$ 19,000	$ 12,000
Installation and Rigging	$ 15,000	$ 15,000	$ 20,000
Piping and Insulation	$ 7,000	$ 7,000	$ 7,000
Ductwork and Insulation	$ 10,000	$ 9,000	$ 7,500
Controls	$ 8,000	$ 8,000	$ 8,000
Demolition	$ 9,000	$ 9,000	$ 9,000
Testing and Balancing	$ 2,000	$ 2,000	$ 2,000
Electrical Power	$ 6,000	$ 6,000	$ 6,000
Fire Alarm Modifications	$ 6,000	$ 6,000	$ 6,000
General Conditions, Contractor OH&P	$ 18,000	$ 16,000	$ 15,500
Soft Costs	$ 37,000	$ 34,000	$ 32,500
Total (each unit)	**$143,000**	**$131,000**	**$125,500**
Total (all 29 units)	**$3,831,500**		

6.4. VAV Box Replacement

Item	*Estimated Cost (Each Floor, Floors 7-19)*	*Estimated Cost (Lobby and 6th Floor)*	*Estimated Cost (Floor 20)*
VAV Boxes (assuming 800 SF/zone)	$110,000	$115,000	$ 20,000
Piping Reconnections and Insulation	$ 25,000	$ 27,000	$ 5,000
Ductwork Reconnections and Transitions	$ 25,000	$ 27,000	$ 5,000
Controls	$115,000	$120,000	$ 22,000
Testing and Balancing	$ 8,000	$ 9,000	$ 1,500
Demolition	$ 15,000	$ 16,000	$ 2,000
Electrical	$ 20,000	$ 25,000	$ 5,000
Ceiling Removal and Installation of New	$ 30,000	$ 40,000	$ 5,000
General Conditions, Contractor OH&P	$ 70,000	$ 76,000	$ 13,100
Soft Costs	$146,000	$159,000	$ 27,500
Total (per floor)	**$564,000**	**$614,000**	**$106,100**
Total (entire building)	**$7,488,000**		

6.5. Secondary Ductwork Replacement

Item	*Estimated Cost (Each Floor, Floors 7-19)*	*Estimated Cost (Lobby and 6th Floor)*	*Estimated Cost (Floor 20)*
Demolition	$ 35,000	$ 40,000	$ 8,000
New Sheet Metal Ductwork	$125,000	$135,000	$ 40,000
Duct Accessories	$ 45,000	$ 50,000	$ 8,000
Duct Insulation and Lining	$ 68,000	$ 74,000	$ 15,000
Testing and Balancing	$ 15,000	$ 18,000	$ 3,000
Electrical Associated with Ceiling Work	$ 75,000	$ 80,000	$ 15,000
Ceiling Removal and Installation of New	$180,000	$210,000	$ 30,000
Allowance for Conflicts with Existing Utilities and Systems	$ 15,000	$ 20,000	$ 5,000
General Conditions, Contractor OH&P	$112,000	$125,000	$ 25,000
Soft Costs	$235,000	$263,000	$ 52,000
Total (per floor)	**$905,000**	**$1,015,000**	**$201,000**
Total (entire building)	**$12,076,000**		

7. Conclusion and Recommendations

Based on the findings of this report, we recommend the following:

- Balance existing outside air quantity down to no lower than 50,400 cfm total for both outside air fans. This reduction in airflow should be done proportionally at each floor and should be performed by a commissioning agent, a certified testing and balancing agency, and a control technician. The building Owner should approach the authority having jurisdiction with population data to assure that a reduction in outside air below code requirements is acceptable. Once airflow is reduced, pressure readings should be taken to assure that all floors are positively pressurized. Where floors are not positively pressurized, minimum outside air should be increased until the floor is positive. Pressurization setpoints should be changed to 0.10 inches. Existing CO2 ventilation controls and economizer controls shall continue to operate under the current control scheme. As part of the scope of this work, the following additional items should be investigated and, if necessary, corrected:
  - ⇒ Confirm control sequences for pressurization and outside air match specified control sequences
  - ⇒ Pressurization control should be able to operate on high pressure, low pressure, or average pressure at the user interface
  - ⇒ Review existing control programming loop for building relief damper and tune to smooth operation and alleviate swings in building pressure
  - ⇒ Pneumatic relief dampers on each floor should be investigated to assure that they close tightly when controls command dampers closed
- Consider installation of new dehumidification unit for outside air delivery. Perform life cycle cost analysis to determine if heat recovery is a viable option. Perform modeling to assure that cooling tower plume is not drawn into new outside air intake location.
- Existing air handling units are approaching the end of their expected useful lives and should be replaced within 5 to 10 years. When units are replaced, they should be replaced with units that have a greater face area that will minimize the carryover of condensation from the cooling coil and are equipped with IAQ drain pans. If properly designed and installed, the new units will eliminate condensation issues that would otherwise be mitigated by the installation of a dehumidification unit. In lieu of installing the dehumidification unit on the roof, we recommend accelerating the replacement of the existing air handling units as this is a more cost effective way to deal with any moisture issues in the occupied space. The only part of the system that would be exposed to direct outside air would be the outside air intake shafts. The shafts are reported to be in good condition by building management. Ideally, units should be replaced on unoccupied floors to minimize cost and disruption. The existing duct system is a loop system that allows for one unit to feed a whole floor when the other is shut down. This arrangement provides about 50-60% of the total available capacity to the floor. This amount of capacity should be sufficient to provide adequate (though not perfect) conditioning during the winter and some of the shoulder seasons. Units should not be replaced on occupied floors

during the summer; one unit will not have enough capacity to keep the occupants comfortable on most summer days. Installation on an occupied floor would take about 2-3 weeks. If the floor was unoccupied, the work could be done in about 7-10 days since both units could be replaced at the same time.

- Initiate a preventative maintenance program to assure that all existing condensate drain piping is properly pitched and draining on existing units until new units are installed.
- Begin phased replacement of existing VAV boxes and secondary fiberglass ductwork. If feasible, VAV boxes and secondary ductwork should be replaced at the same time to minimize disruption and reduce overall cost. If not done at the same time, the VAV boxes should be replaced first, then secondary ductwork should be replaced. Ideally, the secondary ductwork should be replaced when floors are unoccupied to reduce cost and disruption. If work is done while floors are occupied, ceilings will have to be removed and reinstalled each night or weekend and much of the contractor's productive time will be spent on preparation before and reinstallation and cleaning after. Replacement of VAV boxes and secondary ductwork should be phased after the installation of new air handling units.

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Alternate Unit (With Heat Recovery):

Item	*Estimated Cost*
Base Cost	$1,295,000
Heat Recovery Section	$ 250,000
Additional Ductwork, Exhaust Fan	$ 35,000
Additional Balancing	$ 1,500
Additional Controls	$ 15,000
Additional Electrical	$ 8,000
Additional General Conditions, Contractor OH&P	$ 62,000
Additional Soft Costs	$ 130,000
Total	**$1,796,500**

6.3. *Air Handling Unit Replacement*

Item	*Estimated Cost (Each Unit, Floors 6S, 7-19)*	*Estimated Cost (Each Unit, Lobby and 6N)*	*Estimated Cost (Floor 20)*
Air Handling Unit	$ 25,000	$ 19,000	$ 12,000
Installation and Rigging	$ 15,000	$ 15,000	$ 20,000
Piping and Insulation	$ 7,000	$ 7,000	$ 7,000
Ductwork and Insulation	$ 10,000	$ 9,000	$ 7,500
Controls	$ 8,000	$ 8,000	$ 8,000
Demolition	$ 9,000	$ 9,000	$ 9,000
Testing and Balancing	$ 2,000	$ 2,000	$ 2,000
Electrical Power	$ 6,000	$ 6,000	$ 6,000
Fire Alarm Modifications	$ 6,000	$ 6,000	$ 6,000
General Conditions, Contractor OH&P	$ 18,000	$ 16,000	$ 15,500
Soft Costs	$ 37,000	$ 34,000	$ 32,500
Total (each unit)	**$143,000**	**$131,000**	**$125,500**
Total (all 29 units)	**$3,831,500**		

35% 8%

Backup # 4

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6.4. VAV Box Replacement

Item	*Estimated Cost (Each Floor, Floors 7-19)*	*Estimated Cost (Lobby and 6th Floor)*	*Estimated Cost (Floor 20)*
VAV Boxes (assuming 800 SF/zone)	$110,000	$115,000	$ 20,000
Piping Reconnections and Insulation	$ 25,000	$ 27,000	$ 5,000
Ductwork Reconnections and Transitions	$ 25,000	$ 27,000	$ 5,000
Controls	$115,000	$120,000	$ 22,000
Testing and Balancing	$ 8,000	$ 9,000	$ 1,500
Demolition	$ 15,000	$ 16,000	$ 2,000
Electrical	$ 20,000	$ 25,000	$ 5,000
Ceiling Removal and Installation of New	$ 30,000	$ 40,000	$ 5,000
General Conditions, Contractor OH&P	$ 70,000	$ 76,000	$ 13,100
Soft Costs	$146,000	$159,000	$ 27,500
Total (per floor)	**$564,000**	**$614,000**	**$106,100**
Total (entire building)	**$7,488,000**		

10.0

back up to #5

BVH integrated services

6.5. Secondary Ductwork Replacement

Item	*Estimated Cost (Each Floor, Floors 7-19)*	*Estimated Cost (Lobby and 6th Floor)*	*Estimated Cost (Floor 20)*
Demolition	$ 35,000	$ 40,000	$ 8,000
New Sheet Metal Ductwork	$125,000	$135,000	$ 40,000
Duct Accessories	$ 45,000	$ 50,000	$ 8,000
Duct Insulation and Lining	$ 68,000	$ 74,000	$ 15,000
Testing and Balancing	$ 15,000	$ 18,000	$ 3,000
Electrical Associated with Ceiling Work	$ 75,000	$ 80,000	$ 15,000
Ceiling Removal and Installation of New	$180,000	$210,000	$ 30,000
Allowance for Conflicts with Existing Utilities and Systems	$ 15,000	$ 20,000	$ 5,000
General Conditions, Contractor OH&P	$112,000	$125,000	$ 25,000
Soft Costs	$235,000	$263,000	$ 52,000
Total (per floor)	**$905,000**	**$1,015,000**	**$201,000**
Total (entire building)	**$12,076,000**		

Nakos, George

From: Moore, Doug
Sent: Monday, January 07, 2013 9:47 AM
To: Nakos, George
Subject: FW: Turner building sciences report long range recommendations & estimates with back up
Attachments: Turner report recommended long range building improvements.doc; back up for turners report recs.pdf

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From: Brown, Jacquelyn
Sent: Monday, January 07, 2013 9:39 AM
To: Moore, Doug
Subject: FW: Turner building sciences report long range recommendations & estimates with back up

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From: Brown, Jacquelyn
Sent: Friday, September 23, 2011 10:54 AM
To: Moore, Doug
Cc: Morrin, Laureen P.; Bantz, Marilyn
Subject: Turner building sciences report long range recommendations & estimates with back up

Turner report recommended long range building improvements
Note: Turner report noted that ALL recommendations eventually be addressed in order to provide a consistently healthy & comfortable & manageable indoor environment:

1. Turner report recommendation: to install dehumidification to help control humidity levels in the building: XH ✓
BVH consultant study identified it would be more effective to replace existing air handling unit equipment with newly designed system that could better control humidity because existing equipment was at the end of their useful life.
   - 2006 study estimate for AHU replacement on all floors: ~3.9 million adjusting for current costs, additional design and construction cost to handle working in an occupied space: ~5.0 million (see back up attached.).

2. Turner recommendations to evaluate/ install a drainage plane between exterior façade and interior for more consistent control water infiltration in the future:
   - Benassi architects study in 2006 provided options and estimates for drainage plane work estimated between 7.3 and 7.8 million in 2006 – estimated current cost including costs associated with construction limitations due to working in an occupied building (like barrier installation or providing swing space or afterhours work etc): 10.0 million (see back up attached)

3. Turner recommendation to remove/ redesign of exterior balconies:
   - Benassi study 2006 estimate for design/enclosure of balconies 2.5 million. Estimated current cost including costs associated with construction limitations due to working in an occupied building: 5.0 million (see back up attached)

4. Turner recommendation to replace existing variable air volume controls with digital controls:
   - 2006 BVH study estimate: 7.5 million. Current estimated costs including cost associated with construction limitations due to working in an occupied building: 10.0 million (see back up attached)

VX ✓

5. Turner recommendation to replace old duct board/fiberglass lined ductwork:
   - BVH 2006 study estimate to replace secondary ductwork 12.1 million. Current estimate including costs associated with construction limitations due to working in an occupied building: 15.0 million (see back up attached)

6. LOWER PRIORITY Turner recommendation to Install perimeter radiation and consider eliminating 2/3rds of exterior glazing (ie to better control temps along perimeter) :
   - Estimate: 3.0 million

7. LOWER PRIORITY Turner recommendation for 100 % exhaust of kitchenette area on each floor to improve indoor air quality (by eliminating odors)
   - Estimate in excess of 2.0 million

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Note: Turner report noted that ALL recommendations eventually be addressed in order to provide a consistently healthy & comfortable & manageable indoor environment:

1. Turner report recommendation: to install dehumidification to help control humidity levels in the building: AHU ✓
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VAV ✓

5. Turner recommendation to replace old duct board/fiberglass lined ductwork:
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   - Estimate in excess of 2.0 million

Back up for Rec. estimate # 2

Martin A. Benassi AIA		COST ESTIMATE - Appendix C				Design Phase
Architect		DPW #BI-2B-033-I				
Drainage Plane Study - 25 Sigourney Street		Date: July 21, 2006				Page 1 of 5
DIV.	PRINCIPAL TRADE ITEM AND ITEM DESCRIPTION	UNIT	QTY	UNIT PRICE	ITEM PRICE	SELECTED ITEM COST
	GENERAL					
	bonding, insurance, general administrative	unit	1	$150,000.00	$150,000.00	
	scaffolding, swing stagging rental and equip.	mo	4	$6,000.00	$24,000.00	
	site foreman, supervision	mo	4	$11,000.00	$44,000.00	
						$218,000.00
	OPTION A - add rainscreen system					
	add alum. rainscreen system with all related flashing	sf	107,100	$45.00	$4,819,500.00	
	additional rigid insulation 1 inch thick	sf	107,100	$0.80	$85,680.00	
						$4,905,180.00
	SUB-TOTAL					$5,123,180.00
	city cost index	0.094				$481,578.92
	soft costs include A/E, CA, & DPW, etc.	0.30**				$1,681,427.68
	TOTAL:					$7,286,186.60
*	terracotta rainscreen system, et. al = $65/SF		107,100	$65.00	$6,961,500.00	
	stone rainscreen system, et. al = $75/SF		107,100	$75.00	$8,032,500.00	
**	Based on total value of a larger project size.					

Some of the dollar figures used were calculated based on information obtained from the 2006 Building Construction Cost Data, published by Robert Snow Means Company, Inc. Kingston, Massachussetts. Additional figures were obtained from similar active projects with inflation and geographical percentages included and manufacturer's pricing. The final dollar amount shown is for guidance only and is a "ball park" figure. An assumption is made that all repair work will be performed under one contract and not spaced out over a period of time. The amount does not include any Architectural / Engineering fess or contingencies. Total dollar amount to be adjusted if work is to be performed during off hours or on weekends.

add'l back up to # 2

Martin A. Benassi AIA		COST ESTIMATE - Appendix C				Design Phase
Architect		DPW #BI-2B-033-I				
Drainage Plane Study - 25 Sigourney Street		Date: July 21, 2006				Page 4 of 5
DIV.	PRINCIPAL TRADE ITEM AND ITEM DESCRIPTION	UNIT	QTY	UNIT PRICE	ITEM PRICE	SELECTED ITEM COST
	GENERAL					
	bonding, insurance, general administrative	unit	1	$150,000.00	$150,000.00	
	scaffolding, swing stagging rental and equip.	mo	4	$6,000.00	$24,000.00	
	site foreman, supervision	mo	4	$11,000.00	$44,000.00	
						$218,000.00
	OPTION D - rem/replace brick & add barrier					
	~~remove and replace brick veneer~~	sf	107,100	$45.00	$4,819,500.00	
	remove & replace rigid insulation	sf	107,100	$1.25	$133,875.00	
	install barier on exterior of existing CMU	sf	107,100	$3.00	$321,300.00	
	sealant	u	1	$8,000.00	$8,000.00	
						$5,282,675.00
	SUB-TOTAL					$5,500,675.00
	city cost index	0.094				$517,063.45
	soft costs include A/E, CA, & DPW, etc.	0.30**				$1,805,321.54
	TOTAL:					$7,823,059.99
**	Based on total value of a larger project size.					

Some of the dollar figures used were calculated based on information obtained from the 2006 Building Construction Cost Data, published by Robert Snow Means Company, Inc. Kingston, Massachussetts. Additional figures were obtained from similar active projects with inflation and geographical percentages included and manufacturer's pricing. The final dollar amount shown is for guidance only and is a "ball park" figure. An assumption is made that all repair work will be performed under one contract and not spaced out over a period of time. The amount does not include any Architectural / Engineering fess or contingencies. Total dollar amount to be adjusted if work is to be performed during off hours or on weekends.

Back up for # 3

Martin A. Benassi AIA						
Architect		COST ESTIMATE - Appendix C				Design Phase
Drainage Plane Study - 25 Sigourney Street		DPW #BI-2B-033-I				
		Date: July 21, 2006				
DIV.	PRINCIPAL TRADE ITEM AND ITEM DESCRIPTION	UNIT	QTY	UNIT PRICE	ITEM PRICE	Page 5 of 5 SELECTED ITEM COST
	GENERAL					
	bonding, insurance, general administrative	unit	1	$98,000.00	$98,000.00	
	scaffolding, swing stagging rental and equip.	mo	4	$2,000.00	$8,000.00	
	site foreman, supervision	mo	4	$11,000.00	$44,000.00	
						$150,000.00
	ADDITIONAL ITEMS - enclose terraces					
	enclose terraces with greenhouse windows	sf	10,000	$110.00	$1,100,000.00	
	remove existing safety line tie back anchors	u	50	$250.00	$12,500.00	
	remove sliding doors and adjacent glazing (optional)	u	27	$4,500.00	$121,500.00	
	remove existing railings	lf	746	$35.00	$26,110.00	
	miscellaneous interior finishes and trim	u	27	$12,000.00	$324,000.00	
	revise mechanical system	u	1	$45,000.00	$45,000.00	
						$1,629,110.00
	SUB-TOTAL					$1,779,110.00
	city cost index	0.094				$167,236.34
	soft costs include A/E, CA, & DPW, etc.	0.30**				$583,903.90
	TOTAL:					$2,530,250.24
**	Based on total value of a smaller project size.					

Some of the dollar figures used were calculated based on information obtained from the 2006 Building Construction Cost Data, published by Robert Snow Means Company, Inc. Kingston, Massachussetts. Additional figures were obtained from similar active projects with inflation and geographical percentages included and manufacturer's pricing. The final dollar amount shown is for guidance only and is a "ball park" figure. An assumption is made that all repair work will be performed under one contract and not spaced out over a period of time. The amount does not include any Architectural / Engineering fees or contingencies. Total dollar amount to be adjusted if work is to be performed during off hours or on weekends.

WING'S TESTING & BALANCING CO., INC.
94 No. Branford Rd., Branford, CT 06405
203-481-4988 Fax 203-488-5634

25 Sigourney Street
Hartford, CT

* * * *

B.V.H. Integrated Services
Attn: Jeff Cichonski
50 Griffin Road South
Bloomfield, CT 06002

June 21, 2006

WING'S TESTING & BALANCING CO., INC.
94 No. Branford Rd., Branford, CT 06405
203-481-4988 Fax 203-488-5634

June 21, 2006

B.V.H. Integrated Services
Attn: Jeff Cichonski
50 Griffin Road South
Bloomfield, CT 06002

Re: 25 Sigourney Street, Hartford, CT

Dear Jeff:

Testing for the above referenced location has been completed. Fan totals for CEF-1 and 2, as well as Ref-1, could not be obtained by Velocity Pressure Traverse, and outlet summation would require further time and investigation. Total flows for the remainder of the fans requested are as listed on the following pages.

If you have any questions regarding the information provided, or if we can be of further assistance, please do not hesitate to call.

Very truly yours,
Wing's Testing & Balancing Co., Inc.

John Flanagan
Certified TABB Technician #BB040033
CT SM-2 License 771

TABB
Testing, Adjusting and Balancing Bureau
The Professional's Choice
Name: John Flanagan
Stamp #: BB040033
Issue Date: 09/20/2002

EXHAUST FAN REPORT

PROJECT:	25 SIGOURNEY STREET	**DATE:**	6/7/06
AREA SERVED:	HARTFORD, CT	**TECH:**	J. FLANAGAN

FAN DATA

FAN NUMBER		CEF-1	CEF-2	REF-1		
LOCATION		ROOF	ROOF	ROOF		
AREA SERVED		CAFETERIA	CAFETERIA	TOILETS		
MANUFACTURER		CENTRIMASTER	CENTRIMASTER	CENTRIMASTER		
MODEL OR SIZE		PUB256IU	PUB300IU	M#PN365N		
TOTAL	DESIGN	N.L.	N.L.	15600		
CFM	ACTUAL	(1)	(1)	(1)		
FAN	DESIGN	N.L.	N.L.	N.L.		
RPM	ACTUAL	814	739	761		
PULLEY	O.D.	5 1/2" X 1"	9" X 1"	13 1/8"X1 3/16"		
SUCTION SP.		-1.15" (3)	-1.34" (3)	-.627 (3)		

MOTOR DATA

MANUFACTURER		MAGNETEC	MAGNETEC	CENTURY		
MODEL NUMBER		FRS182T	FRS184T	FR:S184T		
MOTOR	DESIGN	N.L.	N.L.	N.L.		
HP	ACTUAL	3	5	5		
MOTOR RPM		1740	1786 (2)	1745		
VOLTAGE/PHASE		460/3	460/3	460/3		
MOTOR AMPS	DESIGN	4.3	7.2	7.2		
	ACT. LEG 1	2.3	4.5	7.4		
	ACT. LEG 2	2.5	4.7	7.6		
	ACT. LEG 3	2.1	4.1	7.5		
SHEAVE		3 1/4"X1 1/8"	4" X 1 1/8"	6 1/2"X1 1/8"		
BELTS-QTY/SIZE		2/AP26	2/AP41	1/AX62		
SHEAVE POSITION						

REMARKS

(1) NO SUITABLE LOCATION FOR READING.
(2) NAMEPLATE LISTING HAS BEEN SCRATCHED OFF.
(3) SUCTION S.P. IS MEASURED BEFORE THE MOTORIZED BACKDRAFT DAMPER.

WING'S TESTING BALANCING CO., INC., 94 NO. BRANFORD RD., BRANFORD, CT 06405

VELOCITY PRESSURE READINGS

PROJECT: 25 SIGOURNEY STREET **DATE:** 6/7/06

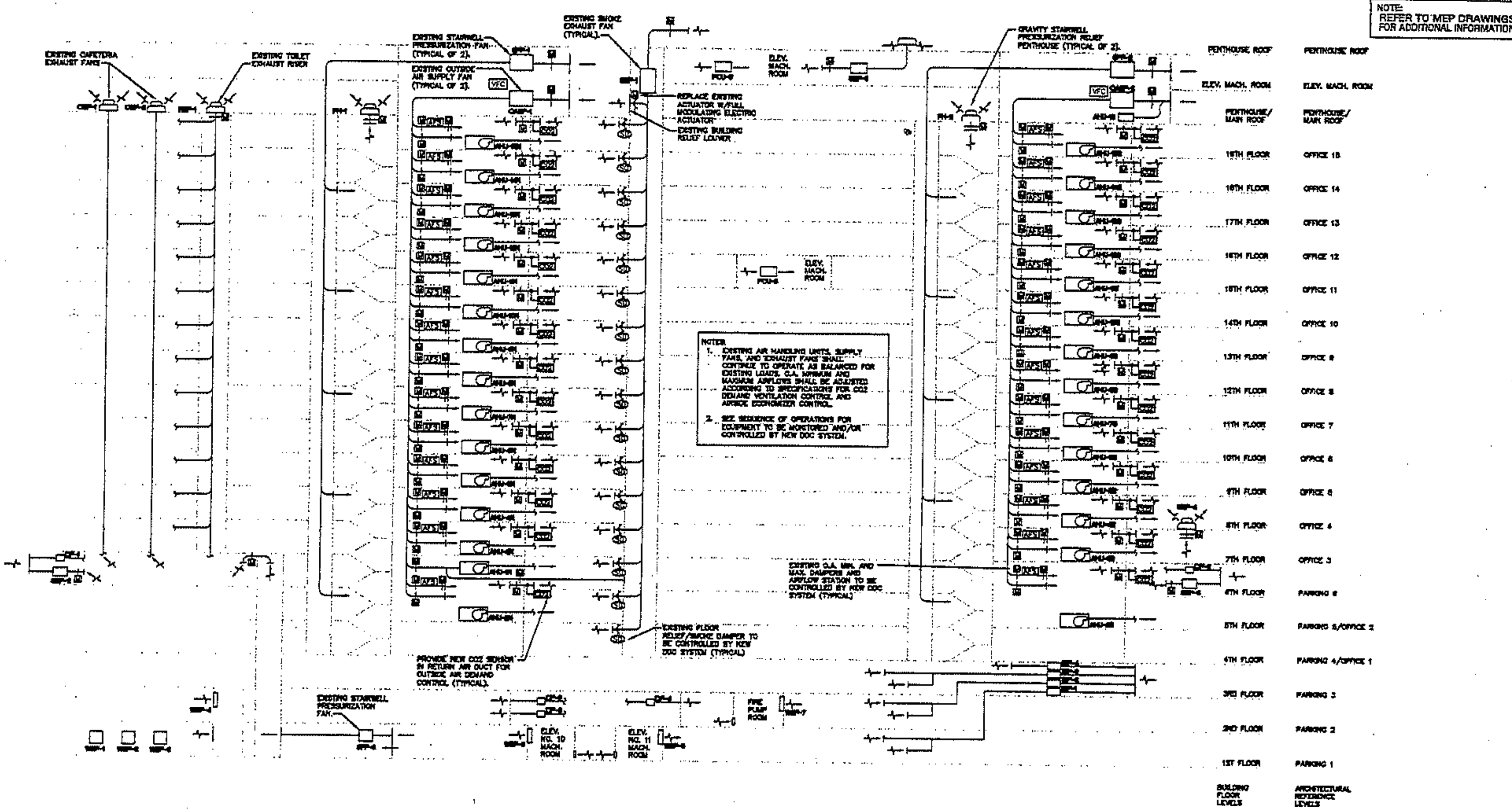
AREA SERVED: HARTFORD, CT **TECH:** J. FLANAGAN

TRAVERSE LOCATIONS	DUCT SIZE	AREA SQ FT	DESIGN FPM	DESIGN CFM	CENTERLINE STATIC PRES	FINAL FPM	FINAL CFM	NOTES
DF-2								
TLT'S P-6	10X8	.56	714	400	-.30	824	461	
DF-1								
TLT'S P-6	10X8	.56	714	400	-.264	839	470	(4)
DF-3								
TLT'S P-2	10X7	.486	617	300	-.188	725	352	
DF-4								
MAINT. P-2	6" Ø	.196	306	60	0.0	0	0	(1,2,5)
DF-5								
SHIPPING P-2	6X6	.196	255	50				(2,3)

REMARKS

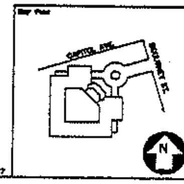
(1) INLETS FOUND OPEN ENDED AND TAPED OFF.
(2) FAN FOUND IN OFF POSITION.
(3) FAN DOES NOT RUN.
(4) FAN NO LONGER SERVES TOILETS. CURRENTLY SERVICES KITCH. AREA. TOILETS TIED INTO CEF.
(5) FAN WAS ORIGINALLY DESIGNED TO BE O.A. SUPPLY.

NOTE:
REFER TO MEP DRAWINGS
FOR ADDITIONAL INFORMATION



NOTES:

1. EXISTING AIR HANDLING UNITS, SUPPLY FANS, AND EXHAUST FANS SHALL CONTINUE TO OPERATE AS BALANCED FOR EXISTING LOADS. O.A. MINIMUM AND MAXIMUM AIRFLOWS SHALL BE ADJUSTED ACCORDING TO SPECIFICATIONS FOR CO2 DEMAND VENTILATION CONTROL AND AIRSIDE ECONOMIZER CONTROL.
2. SEE SEQUENCE OF OPERATIONS FOR EQUIPMENT TO BE MONITORED AND/OR CONTROLLED BY NEW DDC SYSTEM.



BVH integrated services

CIVIL, STRUCTURAL, MECHANICAL AND ELECTRICAL ENGINEERS

drawing title: HVAC AIR RISER DIAGRAM

REVISIONS

mark	date	description

STATE OF CONNECTICUT
DEPARTMENT OF PUBLIC WORKS

Engineer: BVH Integrated Services, Inc. Bloomfield, CT

project: 25 SIGOURNEY ST., HARTFORD, CT ENERGY CONSERVATION IMPROVEMENTS BID PACKAGE 1

scale: N.T.S.

drawn by: JRC

approved by: NHC

drawing no. M-400

2102137

Sones and LwA(A) decibels are shown in curve form on the performance charts on pages 7 through 10.

CERTIFIED CFM & BRAKE HORSEPOWER VS. STATIC PRESSURE

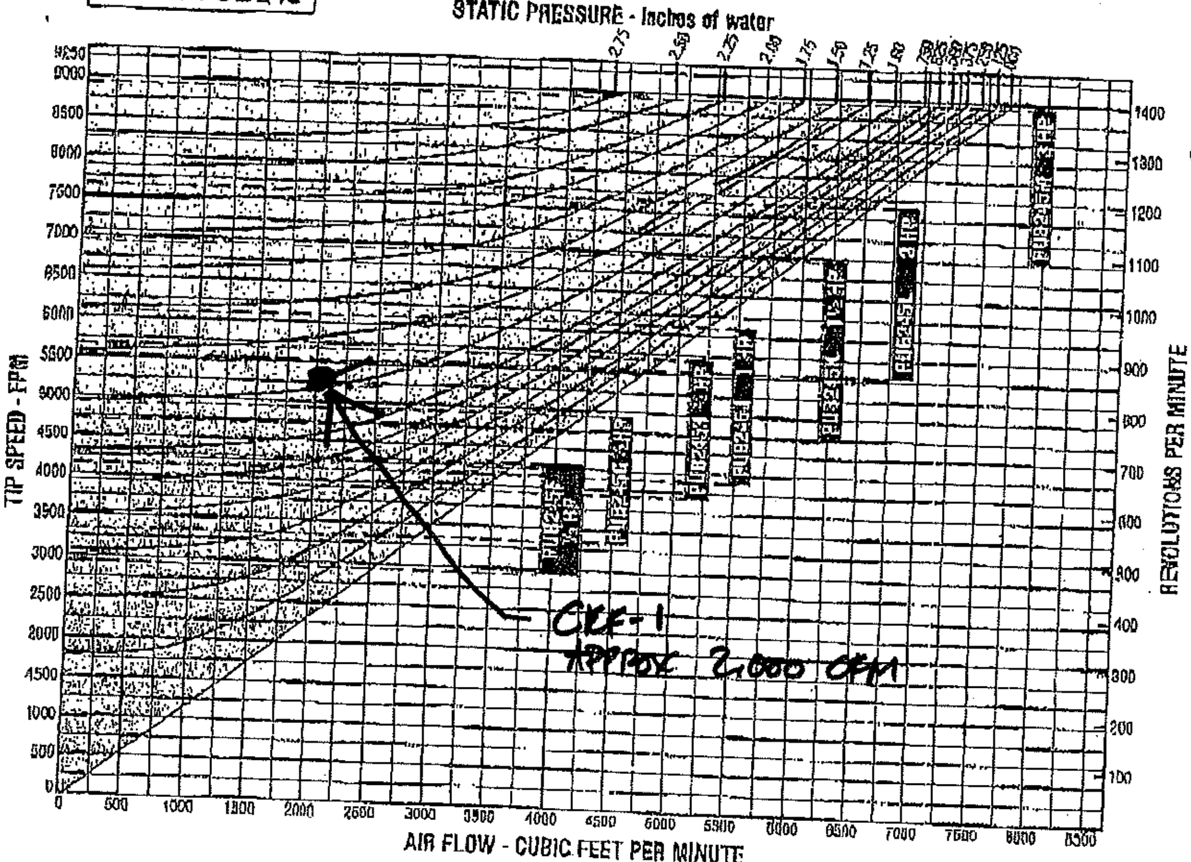
MODEL NO.	FAN: RPM (MIN./MAX.)	TIP SPEED	HP	0" CFM	0" BHP	.125" CFM	.125" BHP	.250" CFM	.250" BHP	.375" CFM	.375" BHP	.500" CFM	.500" BHP	.750" CFM	.750" BHP	1.000" CFM	1.000" BHP	1.500" CFM	1.500" BHP	2.000" CFM	2.000" BHP	EST. SHIP WT.
PN300F	286 414	2246 3251	1/3	4480 6480	.08 .23	3430 5760	.11 .28	5030	.33	4110	.36											330
PN300G	321 473	2521 3714	1/2	6010 7360	.11 .34	4100 6770	.15 .40	2840 6140	.17 .46	5490	.51	4600	.53									337
PN300H	399 550	3139 4318	3/4	6230 8580	.20 .53	5500 8060	.25 .60	4740 7530	.30 .67	3080 6980	.32 .73	6420	.79	4710	.82							340
PN300J	438 604	3440 4743	1	6030 9420	.27 .70	6170 8950	.32 .78	5490 8470	.38 .85	4720 7970	.42 .93	3390 7470	.41 1.00	6800	1.10	3460	.93					343
PN300K	488 670	3817 5262	1 1/2	7580 10450	.36 .95	7000 10020	.43 1.04	6390 9590	.49 1.13	5750 9150	.54 1.21	4960 8710	.57 1.29	7780	1.43	6530	1.50					355
PN300L	545 752	4280 5906	2	8500 11730	.51 1.34	7870 11350	.58 1.44	7440 10970	.65 1.54	6890 10560	.72 1.64	6310 10190	.77 1.73	4520 9890	.79 1.90	8640	2.05	8470	2.00			361
PN300M	602 843	5120 6620	3	10170 13150	.88 1.89	9730 12810	.96 2.00	9290 12470	1.05 2.11	8840 12130	1.13 2.22	8380 11780	1.21 2.33	7410 11100	1.34 2.53	6000 10380	1.38 2.72	8620	2.98			366
PN365G	240 361	2368 3449	1/3	6290 9100	.14 .42	4710 8000	.18 .47	2500 7000	.19 .54	5800	.57	4240	.56									445
PN365H	286 417	2733 3984	3/4	7210 10510	.22 .63	5860 9550	.26 .70	4390 8650	.29 .77	7760	.83	6700	.98									448
PN365J	295 445	2818 4252	1	7440 11220	.24 .76	6180 10320	.28 .84	4760 9480	.32 .91	8630	.99	7740	1.05	6340	1.04							451
PN365K	358 520	3373 4968	1 1/2	8900 13110	.40 1.24	7800 12330	.43 1.30	6730 11800	.51 1.38	8400 10900	.54 1.47	3800 10200	.52 1.57	8000	1.68	6500	1.66					463
PN365L	423 571	4042 5458	2	10870 14400	.67 1.63	9720 13700	.73 1.70	8820 13000	.80 1.78	7950 12330	.88 1.88	6930 11600	.91 1.98	10360	2.17	[illegible]40	2.22					470
PN365M	508 656	4884 6288	3	12610 16540	1.15 2.45	12010 15920	1.22 2.54	11290 15310	1.30 2.62	10510 14720	1.39 2.72	8790 14140	1.48 2.84	8100 13020	1.57 3.[illegible]	5850 11850	1.34 3.28	8850	3.33			484
PN365N	640 775	6118 7405	5	16140 19940	3.20 4.03	15600 19010	2.36 4.12	14880 18490	2.43 4.22	14270 17900	2.35 4.33	13660 17480	2.66 4.45	12640 16800	2.89 4.72	11310 15960	3.07 5.00	8090 13550	3.08 5.45	11000	3.49	498
PN490H	180 252	2309 3232	3/4	11000 15400	.25 .61	8120 13300	.30 .70	11300	.80	8800	.85											717
PN490J	182 278	2334 3566	1	11100 16960	.23 .82	8200 15030	.30 .91	13250	1.03	11290	1.11	8740	1.10									720
PN490K	226 318	2880 4079	1 1/2	13800 19400	.44 1.22	11500 17700	.53 1.32	9130 16100	.60 1.45	5700 14590	.58 1.58	12000	1.66									732
PN490L	230 390	3027 4468	2	14400 21350	.50 1.62	12170 19800	.59 1.73	10000 18330	.68 1.86	7000 16920	.68 2.02	15460	2.15	11700	2.20							739
PN490M	314 400	4028 5131	3	19150 24400	1.17 2.41	17440 23037	1.27 2.53	15820 21720	1.40 2.67	14240 20480	1.53 2.84	12400 19230	1.60 3.02	16560	3.27	13140	3.27					794
PN490N	338 475	4836 6093	5	20620 26960	1.40 4.02	19020 27820	1.58 4.16	17800 26700	1.70 4.31	16040 25800	1.85 4.49	14900 24540	1.96 4.70	10420 22400	1.97 5.11	20240	5.43	14380	5.43			808
PN490P	431 543	5529 6969	7 1/2	26300 33120	4.01 5.99	25000 32110	5.14 6.15	23800 31110	3.28 6.32	22600 30140	3.46 6.51	21450 29200	3.61 6.73	19100 27300	4.00 7.19	16300 25630	4.12 7.67	21390	8.21	15900	8.08	827
PN543J	169 239	2400 3394	1	14000 19800	.31 .86	10620 17320	.40 .97	6120 15020	.41 1.11	12310	1.17	8860	1.14									760
PN543K	185 273	2627 3877	1 1/2	15300 22600	.40 1.28	12200 20400	.50 1.49	8890 18400	.55 1.53	16300	1.70	13600	1.74									772
PN543L	200 296	2840 4203	2	16560 24500	.51 1.62	13660 22480	.61 1.75	10600 20570	.69 1.93	18730	2.09	16700	2.21	11200	2.17							779
PN543M	243 341	3451 4843	3	20120 28230	.90 2.47	17700 26460	1.01 2.62	15420 24770	1.16 2.79	12830 23180	1.25 2.99	9280 21540	1.21 3.19	17800	3.39	12800	3.32					804
PN543N	305 400	4331 5681	5	25250 33110	1.77 3.99	23280 31600	1.90 4.15	21420 30130	2.07 4.33	19890 28700	2.23 4.55	17730 27330	2.39 4.79	12720 24570	2.40 5.24	21880	5.46					839
PN543P	350 460	4971 6533	7 1/2	28980 38077	2.67 6.05	27250 36780	2.82 6.24	25600 35470	2.99 6.44	24100 34200	3.20 6.66	22450 32870	3.41 6.92	18940 30350	3.66 7.17	14340 28180	3.62 7.98	22200	8.29			850
PN543R	397 508	5638 7172	10	32900 41800	3.90 8.00	31300 40800	4.06 8.20	29900 39400	4.24 8.42	28400 38200	4.46 8.65	27000 37100	4.69 8.91	24200 34800	5.14 9.30	21000 32700	5.34 10.10	28000	10.93	21900	10.88	881

REF-1

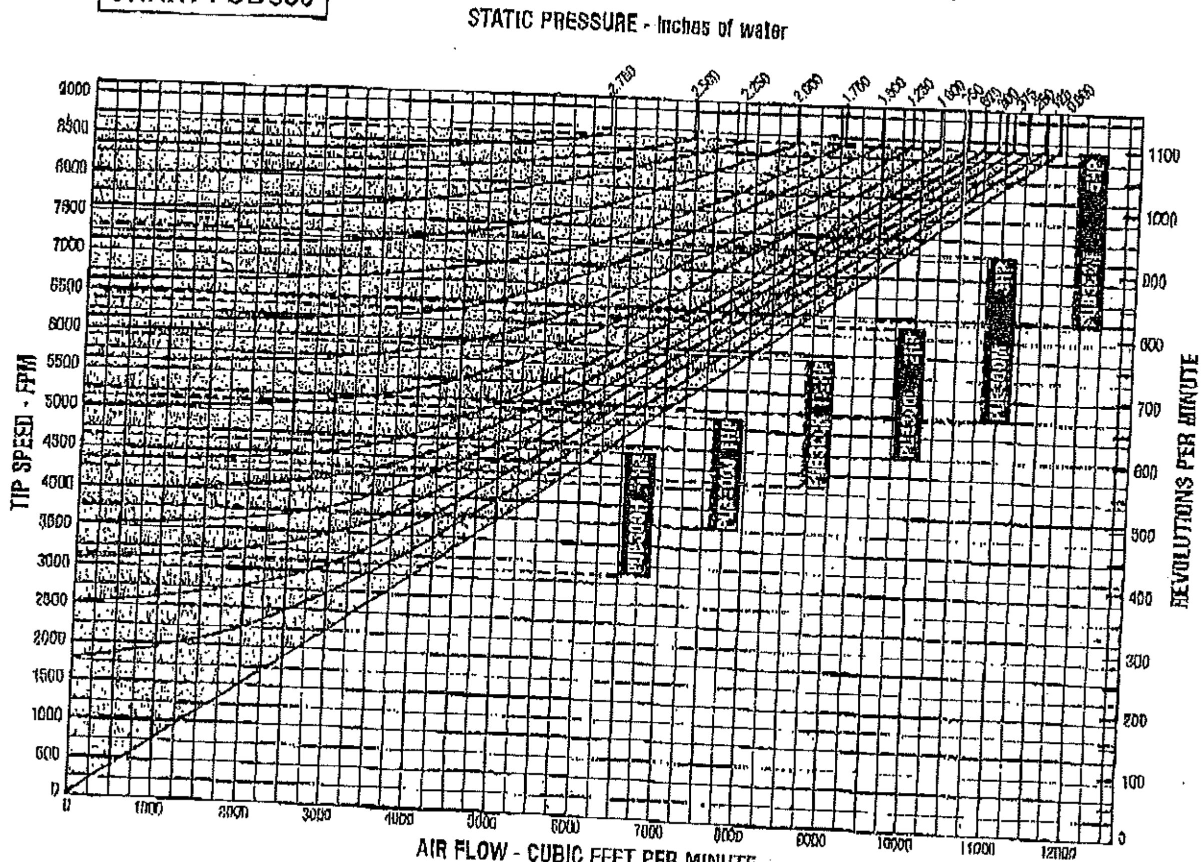
INTERPOLATION: 16,490 CFM

CENTRIFUGAL EXHAUSTERS Certified Performance Specifications

PERFORMANCE CHART PUB 245



PERFORMANCE CHART PUB 300



Performance shown is for units without ducts. BHP for belt driven units does not include drive losses.

BELT DRIVEN

CERTIFIED CFM, BHP AND SOUND vs. STATIC PRESSURE TO 2.50"

MODEL NO.	FAN: RPM	MIN./MAX. TIP SPEED	HP	1.000" CFM	1.000" ★BHP	1.250" CFM	1.250" ★BHP	1.500" CFM	1.500" ★BHP	1.750" CFM	1.750" ★BHP	2.000" CFM	2.000" ★BHP	2.250" CFM	2.250" ★BHP	2.500" CFM	2.500" ★BHP	EST. SHIP WT.
PUB135F	1032 / 1540	3847 / 5471	¼	755	.31													
PUB135G	1242 / 1848	4390 / 6524	⅓	1420	.30	1140	.54	786	.46									148
PUB145E	775 / 1275	2983 / 4849	¼															150
PUB145F	918 / 1378	3465 / 5823	⅓	560	.37													150
PUB145G	1148 / 1680	4362 / 6418	½	1845	.68	1170	.55	698	.48									160
PUB145H	1300 / 1910	4936 / 7260	¾	2078	.84	1785	.88	1470	.82	1096	.70	695	.63					160
PUB163E	741 / 1110	3102 / 4722	½															169
PUB163F	835 / 1228	3582 / 5228	⅓	830	.33													188
PUB163G	934 / 1476	3870 / 6082	½	1720	.98	1190	.63											186
PUB163H	1068 / 1577	4540 / 6663	¾	2270	.79	1835	.77	1360	.71									188
PUB200E	600 / 920	2776 / 4294	¼															190
PUB200F	632 / 906	3209 / 4744	⅓															256
PUB200G	710 / 1048	3716 / 5493	½	2000	.57	1510	.63											258
PUB200H	807 / 1169	4228 / 6125	¾	2680	.79	2205	.75											268
PUB200J	904 / 1310	4736 / 6863	1	3330	1.10	3015	1.11	2625	1.11	1909	1.02							268
PUB200K	1070 / 1479	5606 / 7793	1½	3140 / 3905	.87 / 1.64	3770	1.07	3600	1.59	3190	1.68	2770	1.56	2040	1.44			209
PUB200L	1184 / 1633	6203 / 8556	2	2756 / 4860	.92 / 2.04	2315 / 4360	.92 / 2.08	1290 / 4185	.98 / 2.12	3960	2.14	3898	2.18	3390	2.15	2860	2.08	287
PUB245F	491 / 690	2957 / 4205	⅓															277
PUB245G	523 / 769	3388 / 4932	½															277
PUB245H	610 / 864	3915 / 5670	¾	3115	.83													277
PUB245J	645 / 949	4137 / 6087	1	3695	1.03	3070	1.02											285
PUB245K	738 / 1090	4724 / 6950	1½	4720	1.52	4093	1.54	3600	1.63	3140	1.81							293
PUB245L	862 / 1190	5529 / 7633	2	2880 / 5425	.77 / 1.85	5088	2.00	4750	2.02	4320	2.02	3780	2.00	1875	1.50			287
PUB245M	1001 / 1390	6388 / 8916	3	4780 / 6695	1.84 / 3.00	4375 / 6450	1.58 / 3.08	3900 / 6128	1.95 / 3.14	3225 / 5915	1.53 / 3.19	3010	3.29	0250	3.22	4055	3.20	287
PUB300H	395 / 593	3102 / 4857	¾															303
PUB300J	481 / 653	3778 / 5129	1	2580	.84													412
PUB300K	553 / 751	4343 / 5898	1½	5530	1.62	4550	1.60											413
PUB300L	603 / 810	4736 / 6361	2	5686	2.00	5555	2.02	4440	1.99									411
PUB300M	653 / 887	5307 / 7200	3	3720 / 8180	1.08 / 3.03	7620	3.07	5955	3.04	6183	3.01	4175	2.89					425
PUB300N	820 / 1100	6440 / 8639	5	8880 / 10206	2.10 / 4.98	5650 / 9805	2.09 / 5.02	4880 / 9495	2.06 / 5.09	9080	5.12	8480	5.10	7846	5.04	7249	5.08	462
PUB365H	279 / 420	2656 / 4071	¾															479
PUB365J	313 / 462	2991 / 4482	1															518
PUB365K	375 / 532	3583 / 5084	1½															519
PUB365L	385 / 593	3778 / 3657	2	7980	2.22													517
PUB365M	494 / 677	4727 / 6469	3	10100	3.34	8960	3.31	6755	3.09									528
PUB365N	580 / 798	6307 / 7626	5	8840 / 12595	3.00 / 5.33	8369 / 12305	3.05 / 5.45	5305 / 11520	2.70 / 5.40	10500	5.40	8915	5.21	3455	3.61			548
PUB490K	298 / 325	2900 / 4169	1½															561
PUB490L	289 / 363	3479 / 4657	2															766
…490M	380 / 419	3823 / 5588	3	7465	2.64													773
…490N	410 / 505	5200 / 6478	5	8448 / 10705	2.41 / 5.61	14510	6.88	9930	4.78									808
																		884

CEF-2

INTERPOLATED 6550 CFM

★ [illegible] (drive losses). The [illegible] capability of an [illegible] motor [illegible] motor loadings do not overheat the motor and are in accordance with the motor manufacturer's recommendations. [illegible] shown is for units without ducts. BHP for belt driven units does not include drive losses. [illegible]

Acme Engineering & Manufacturing Corp.

WING'S TESTING & BALANCING CO., INC.

94 No. Branford Rd., Branford, CT 06405
203-481-4988 Fax 203-488-5634

25 Sigourney St.
ATC Upgrades

* * * *

Invensys
Attn.: Ron Duplin
29 Kripes Road
PO Box 575
East Granby, CT 06026

January 17, 2005

Reviewed For Record

1) were The Defective Device's Noted Repaired
2) Revise and Resubmit as Noted
3) Reference Tube Must Be Repaired For system TO operate properly

WING'S TESTING & BALANCING CO., INC.

94 No. Branford Rd., Branford, CT 06405
203-481-4988 Fax 203-488-5634

July 2004
25 Sigourney Street
ATC Upgrades
Pressure Testing

Floors	Test 1	Final
	Actual/Invensys	Actual/Invensys
6TH FLOOR		
SPACE	.20/.10	
SA SPN	1.13/1.15	1.13/1.14
SA SPS	1.25/1.26	1.25/1.26
MIN. O.A. N.	.033/.03	.030/.03
MIN. O.A. S.	.038/.04	.030/.03
5TH FL. MEZZ.		
MESS. SPACE	.08/.07	.08/.07
LOBBY SPACE	.08/.08	.08/.08
SA SPN	.77/.78	.77/.78
SA SPS	1.06/1.07	1.06/1.07
MIN. O.A. N.	.015/.02	.019/.02
MIN O.A. S.	.026/.03	.029/.03
10TH FLOOR		
SPACE	.18/.10	
SA SPN	1.31/1.34	1.30/1.30
SA SPS	1.12/1.15	1.14/1.14
MIN. O.A.N.	.028/.03	.031/.03
MIN. O.A.S.	.030/.03	.030/.03
9TH FLOOR		
SPACE	.23/.10	
SA SPN	1.28/1.31	1.28/1.28
SA SPS	1.12/1.15	1.14/1.14
MIN. O.A.N.	.031/.03	.031/.03
MIN. O.A.S.	.03/.03	.03/.03
8TH FLOOR		
SPACE	.29/.10	
S.A. SPN	1.095/1.12	1.11/1.11
SA SPS	1.12/1.14	1.15/1.15
MIN. O.A.N.	.030/.03	.030/.03
MIN. O.A.S.	.030/.03	.030/.03

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July 2004
25 Sigourney Street
ATC Upgrades
Pressure Testing

Floors	Test 1	Final
	Actual/Invensys	Actual/Invensys
7TH FLOOR		
SPACE	.31/.10	
SA SPN	1.18/1.22	1.21/1.21
SA SPS	1.12/1.14	1.14/1.14
MIN. O.A. N.	.028/.03	.03/.03
MIN. O.A. S.	.024/.03	.031/.03
15TH FL.		
SPACE	.04/.04	.04/.04
SA SPN	1.04/1.06	1.04/1.06
SA SPS	.81/.83	.81/.83
MIN. O.A. N.	.038/.04	.04/.04
MIN O.A. S.	.05/.07	.029/.03
14TH FLOOR		
SPACE	.04/.04	.04/.04
SA SPN	1.12/1.14	1.12/1.14
SA SPS	1.20/1.18	1.20/1.18
MIN. O.A.N.	.031/.03	.030/.03
MIN. O.A.S.	.03/.03	.03/.03
12TH FLOOR		
SPACE	.17/.10	OVER RANGE (VERIFY)
SA SPN	1.13/1.15	1.13/1.15
SA SPS	1.13/1.19	1.13/1.13
MIN. O.A.N.	.03/.03	.03/.03
MIN. O.A.S.	.03/.03	.021/.02
11TH FLOOR		
SPACE	.22/.10	OVER RANGE (VERIFY)
S.A. SPN	1.23/1.25	1.23/1.25
SA SPS	1.13/1.15	1.13/1.15
MIN. O.A.N.	.03/.03	.03/.03
MIN. O.A.S.	.033/.03	.03/.03

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Pressure Testing

Floors	Test 1	Final
	Actual/Invensys	Actual/Invensys
19TH FLOOR (1)		
SPACE/ATMOS.	+.17/+.10	OUT OF RANGE
SA SPN	1.17/1.18	1.17/1.18
SA SPS	1.13/1.15	1.13/1.14
MIN. O.A. N.	.023/.02	.02/.02
MIN. O.A. S.	.009/.01	.01/.01
18TH FL.		
SPACE	+.29/+.10	OUT OF RANGE
SA SPN	1.16/1.19	1.21/1.20
SA SPS	1.12/1.15	1.13/1.13
MIN. O.A. N.	.05/.05	.05/.05
MIN O.A. S.	.042/.04	.04/.04
17TH FLOOR (2)		
SPACE	+.19/+.10	OUT OF RANGE
SA SPN	1.24/1.29	1.24/1.26
SA SPS	1.13/1.13	1.13/1.13
MIN. O.A.N.	.029/.03	.029/.03
MIN. O.A.S.	.04/.04	.04/.04
16TH FLOOR		
SPACE	.02/.02	.02/.02
SA SPN	1.29/1.30	1.29/1.30
SA SPS	1.17/1.17	1.17/1.17
MIN. O.A.N.	.03/.03	.03/.03
MIN. O.A.S.	.02/.02	.03/.03

(1) ACTUAL SPACE PRESSURE = +.05.
(2) ACTUAL SPACE PRESSURE = +.065

WINGS TESTING & BALANCING CO., INC.
94 No. Branford Rd., Branford, CT 06405
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July 2004
25 Sigourney Street
ATC Upgrades
Pressure Testing

O.A. SF-1 NORTH	TEST 1	FINAL
	ACTUAL/INVENSYS	ACTUAL/INVENSYS
6TH FLOOR	.17/.17	.17/.17
8TH FLOOR	.17/.17	.17/.17
16TH FLOOR	.17/.15	.18/.18
AVG.	.17/.16	.17/.17 SPT = .17"

O.A. SF-2 SOUTH	TEST 1	FINAL
	ACTUAL/INVENSYS	ACTUAL/INVENSYS
6TH FLOOR	.21/.21	.21/.21
8TH FLOOR	.20/.20	.20/.20
16TH FLOOR	.21/.21	.21/.21
AVG.	.21/.21	.21/.21 SPT = .21"

WING'S TESTING & BALANCING CO., INC., 94 NO. BRANFORD RD., BRANFORD, CT 06405

NOT W/IN SPECIFIED TOLERANCE
BVH

AIR DEVICE/BOX REPORT

PROJECT: 25 SIGOURNEY ST. ATC UPGRADES — DATE: 7-15-04

SYSTEM/AREA SERV: OASF/MEZZ. 20TH FL. — TECH: J.F.

LOCATION	NO.	SIZE	FREE AREA	DESIGN CFM MIN	DESIGN CFM MAX	TEST I	FINAL CFM MIN	FINAL CFM MAX	PRESS. DIFF. MIN	PRESS. DIFF. MAX	NOTES
OASF-1 NO.											
											(1,2)
FLR. # 19		28X16	3.11	2200	3600	1956	1956	2660	.02	.037	(3)
18		28X16		2000	3275	2985	1969	2612	.025	.044	(3)
17		28X16		2000	3275	1978	1978	2545	.029	.048	(3)
16		28X16		2200	3600	2264	2264	2647	.03	.041	(3)
15		28X16		2200	3600	2183	2183	2183	.04	.04	(3)
14		28X16		2200	3600	2333	2333	2520	.03	.035	(3)
12		28X16		2200	3600	2027	2027	2510	.03	.046	(3)
11		28X16		2200	3600	2403	2403	2740	.03	.039	(3)
10		28X16		2200	3600	2224	2224	2526	.031	.040	(3)
9		28X16		2200	3600	2158	2158	2451	.031	.040	(3)
8		28X16		2200	3600	2074	2074	2731	.03	.052	(3)
7		28X16		2200	3600	2127	2127	2932	.03	.057	(3)
6		28X16		2200	3600	2258	2258	2856	.03	.048	(3)
MEZZ. 2N		28X16		1600	2625	1696	1696	1725	.029	.03	(3)
AHU-1		48X20		0	0	0	0	0			(4)

IS THIS OCCUPIED SPACE?
BVH

REMARKS

(1) OASF-1 OPERATING @ 54 HZ 27.2 AMPS UNDER MIN. CONDITION.
(2) OASF-2 OPERATING @ 59.6 HZ 31.7 AMPS UNDER MAX. CONDITION.
(3) DAMPER IS 100% OPEN UNDER MAX. CONDITION.
(4) DAMPER IS CLOSED 100%.

WING'S TESTING & BALANCING CO., INC., 94 NO. BRANFORD RD., BRANFORD, CT 06405

AIR DEVICE/BOX REPORT

PROJECT: *25 SIGOURNEY ST. ATC UPGRADES* DATE: *7-15-04*

SYSTEM/AREA SERV: *OA SF-2/MEZZ-20TH FLR. SO.* TECH: *J.F.*

LOCATION	NO.	SIZE	FREE AREA	DESIGN CFM MIN	DESIGN CFM MAX	TEST 1	FINAL CFM MIN	FINAL CFM MAX	PRESS. DIFF. MIN	PRESS. DIFF. MAX	NOTES
OASF-2 SO.											(1,2)
FLR. # 19		28X16		2200	3600	1424	2210	2500	0.025	0.032	(3)
18		28X16		2000	3275	3163	1891	3275	0.015	0.045	(3)
17		28X16		2000	3275	2528	2070	2738	0.028	0.049	(3)
16		28X16		2200	3275	2285	2255	2882	0.03	0.049	(3)
15		28X16		2200	3600	2152	2152	2516	0.03	0.041	(3)
14		28X16		2200	3600	2137	2137	2529	0.03	0.042	(3)
12		28X16		2200	3600	2488	2136	3229	0.021	0.048	(3)
11		28X16		2200	3600	2507	2186	3662	0.022	0.049	(3)
10		28X16		2200	3600	2087	2087	2951	0.03	0.06	(3)
9		28X16		2200	3600	2280	2280	3561	0.03	0.074	(4)
8		28X16		2200	3600	2451	2234	3562	0.024	0.061	(3)
7		28X16		2200	3600	2472	2299	3562	0.025	0.06	(3)
6		28X16		2200	3600	2563	2130	3230	0.02	0.046	(3)
MEZZ. 2S		28X16		2100	3435	2348	1954	3120	0.02	0.051	(3)
AHU-20		20X46		1200	—	256	1042	2525			(4)

NOT W/IN SPECIFIED TOLERANCE.

BVM

REMARKS

GENERAL NOTE: OUTSIDE AIR DAMPER HUNT WHILE TRYING TO MAINTAIN CFM SETPOINTS. RESOLUTION OF SENSORS = +/-

(1) OASF-2 OPERATING @ 44 HZ 21 AMPS UNDER MIN. CONDITION.

(2) OASF-2 OPERATING @ 59.5 HZ 33.6 AMPS UNDER MAX. CONDITION.

(3) DAMPER IS 100% OPEN UNDER MAX. CONDITION.

(4) ACTUATOR DOES NOTWORK. DAMPER MANUALLY POSITIONED FOR TEST PURPOSES.

WING'S TESTING & BALANCING CO., INC., 94 NO. BRANFORD RD., BRANFORD, CT 06405

VELOCITY PRESSURE READINGS

PROJECT: 25 SIGOURNEY ST., ATC UPGRADES

DATE: 7-6-04

LOCATION: AIR HANDLER TOTALS

TECH: S.W. & J.F.

TRAVERSE LOCATIONS		DUCT SIZE	AREA SQ.FT.	DESIGN		CENTERLINE STATIC PRES.	FINAL		NOTES
				FPM	CFM		FPM	CFM	
MEZZ. NORTH		82X22	12.52	839	10500	W/GRID	731	9152	
MEZZ SOUTH		104X28.75	19.11	743	14200	W/GRID	752	14370	
6 NORTH		104X28.75	19.11	759	14500	W/GRID	804	15364	
6 SOUTH		104X28.75	19.11	759	14500	W/GRID	860	16435	
7 NORTH		104X28.75	19.11	759	14500	W/GRID	886	16931	
7 SOUTH		104X28.75	19.11	759	14500	W/GRID	859	16415	
8 NORTH		104X28.75	19.11	759	14500	W/GRID	852	16282	
8 SOUTH		104X28.75	19.11	759	14500	W/GRID	877	16759	
9 NORTH		104X28.75	19.11	759	14500	W/GRID	770	14715	
9 SOUTH		104X28.75	19.11	759	14500	W/GRID	767	14657	
10 NORTH		104X28.75	19.11	759	14500	W/GRID	874	16702	
10 SOUTH		104X28.75	19.11	759	14500	W/GRID	917	17524	
11 NORTH		104X28.75	19.11	759	14500	W/GRID	958	18307	
11 SOUTH		104X28.75	19.11	759	14500	W/GRID	870	16626	
12 NORTH		104X28.75	19.11	759	14500	W/GRID	874	16702	
12 SOUTH		104X28.75	19.11	759	14500	W/GRID	855	16339	
14 NORTH		104X28.75	19.11	759	14500	W/GRID	883	16874	
14 SOUTH		104X28.75	19.11	759	14500	W/GRID	948	18116	
15 NORTH		104X28.75	19.11	759	14500	W/GRID	814	15555	
15 SOUTH		104X28.75	19.11	759	14500	W/GRID	848	16205	
16 NORTH		104X28.75	19.11	759	14500	W/GRID	721	13778	
16 SOUTH		104X28.75	19.11	759	14500	W/GRID	743	14199	
17 NORTH		104X28.75	19.11	706	13500	W/GRID	836	15976	
17 SOUTH		104X28.75	19.11	706	13500	W/GRID	845	16148	
18 NORTH		104X28.75	19.11	706	13500	W/GRID	838	16014	

REMARKS

WING'S TESTING & BALANCING CO., INC., 94 NO. BRANFORD RD., BRANFORD, CT 06405

VELOCITY PRESSURE READINGS

PROJECT: 25 SIGOURNEY ST., ATC UPGRADES
DATE: 7-6-04
LOCATION: AIR HANDLER TOTALS
TECH: S.W. & J.F.

TRAVERSE LOCATIONS		DUCT SIZE	AREA SQ.FT.	DESIGN FPM	DESIGN CFM	CENTERLINE STATIC PRES	FINAL FPM	FINAL CFM	NOTES
18 SOUTH		104X28.75	19.11	706	13500	W/GRID	877	16759	
19 NORTH		104X28.75	19.11	759	14500	W/GRID	684	13071	
19 SOUTH		104X28.75	19.11	759	14500	W/GRID	691	13205	
20TH		32X49.5	11	545	6000	W/GRID	450	4950	(1)
LOBBY AHU-1		78X20	10.83	942	10200	-.98	752	8144	

REMARKS

(1) VFD @ 89.3%.