Spring 2007 Senior Thesis Project

Mechanical Systems Analysis of

The Hauptman-Woodward Medical Research Institute

Buffalo, New York

Prepared For

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Written By

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Mechanical Option

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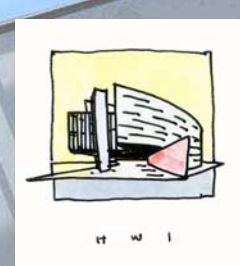


Table of Contents

Hauptman-Woodward Medical Research Institute

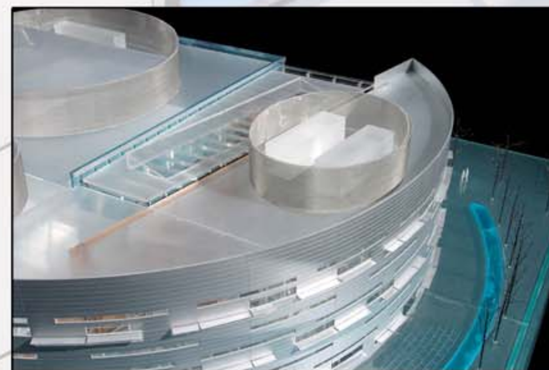
Buffalo, New York

Project Team:

Owner: Hauptman-Woodward Medical Research Institute, Inc.
Architects/Engineers: Cannon Design
Construction Manager: Ciminell-Cowper, Inc.

Project Scope:

Size: 73, 289 sq. ft.
Delivery Method: Cost-Plus
Building Cost: $24,000,000
Schedule: Jan 2003- May 2005
Function: Biomedical Research Lab
Occupancy: Laboratories, research offices, conference rooms, classrooms and multipurpose gathering spaces



Architecture:

- Striking curved metal panel curtain wall system with varied casement windows and solar shading
- 3-story central atrium with exposed structural system and skylights bridging lab/office spaces
- Isolated laboratory space with inter locking fritted glass wall assembly

Structural System:

- 5" Slab on Grade Contstruction with 4' poured concrete footings
- Structural steel building skeleton with oversized members for rigidity
- 4.5" Slab on Deck with blended fiber reinforcement for floors 2 and 3, as well as the roof
- King-Post Truss System supports 4" slab on deck and atrium skylights

Mechanical System:

- (1) 300 Ton Air Cooled Screw Chiller provides chilled water for AHU 1&2 cooling coils
- Office/Atrium served by (2) RTU's ducted to VAV boxes with reheat for individual zones
- Laboratory space served by (2) 29,000 CFM dedicated AHU's and exhaust fans with heat recovery coils
- (6) 2,000 MBH Gas-fired modulating hot water boilers provide heat ventilation air and space heat
- Atrium equipped with (4) 42,380 CFM dedicated smoke control ventilation units
- Garage monitored by CO_2 control system and (2) 7850 CFM exhaust fan units

Lighting/Electrical System:

- 480/277V 3 Phase, 4 Wire Primary Service from Transformer
- 120V and 277V Lumniaires with a varying fixtures for task and accent lighting.
- 450kW/563kVA Fuel Fired Emergency Generator

Justin Schultz **Mechanical Systems Option**
http://www.arche.psu.edu/thesis/eportfolio/2007/portfolios/jds417/

Acknowledgements

I would like to take a moment to express gratitude to all who have made this senior thesis and my Penn State career a success. First, thank you to the team at Cannon Design for their generosity for making this project possible, especially Eric Lindstrom and Dorothy Kuntz for their expertise and promptness in answering all my questions. In addition, I'd like to express thanks to Dr. Walter Pangborn at the Hauptman Woodward Institute for being my point of contact and taking the time to give me a tour and countless background information on the site and building.

Thank you to thank the faculty of the Architectural Engineering department, especially Dr. Freihaut for critiquing my thesis and helping me along the way over the past year. In addition, I'd like to thank Moses for always being a great mentor and advisor throughout my career at Penn State and abroad in the UK.

Growing up, I have been blessed with the infinite wisdom and generosity of my family, and I whole-heartedly have them to thank in my success throughout my academic career and my life. Without them, I'm not sure if I would have made it this far.

Finally, as I embark on the next phase of my life, I will always remember all the countless memories of my childhood and at Penn State… thanks to all my friends for making me the person I am today. No matter how far apart we are, you all have a place in my heart.

"The thing always happens that you really believe in;
and the belief in a thing makes it happen."
-Frank Lloyd Wright

Executive Summary

The Hauptman-Woodward Medical Research Institute is a 74,000 ft^2 mixed laboratory, office and learning space in Downtown Buffalo, New York and was designed by Cannon Design in 2004. The mechanical system consists of two DX rooftop units on the office side that provide approximately 42,000cfm of conditioned air, and two 100% outdoor air handling units that provide the laboratory space with 58,000cfm of conditioned air. The cooling coils for the laboratory air-handling units are served by a 300 ton air-cooled screw chiller. In addition, the laboratory system is equipped with a run-around loop which provides heat recovery between the supply and exhaust air. The laboratory is fully exhausted by means of 3 Laboratory Exhaust Fans that provide a total fan exhaust of 81,000 cfm.

This report proposes the incorporation of two dedicated outdoor air systems (DOAS) at the Hauptman-Woodward Medical Research Institute. On the office side, the DOAS system shall consist of an enthalpy and sensible wheel, and the remaining sensible load will be covered by a parallel VAV system. On the more critical laboratory side, the DOAS system shall consist of a single enthalpy wheel equipped with desiccants able to capture particles as small as 3Å. In addition, a purge section will be equipped to further eliminate contaminants in the building. The laboratory system will be supplemented with chilled beams to satisfy the remaining space sensible loads.

Based on the proposed design, the system was modeled using Trane TRACE 700 software and it was found that the required amount of supply air was reduced drastically due to the fact that DOAS systems only require the ventilation air set forth by ASHRAE Std. 62.1. As a result, the amount of electrical energy consumed annually is

reduced by approximately 534,474 kWh, or approximately 25 percent. This will save the Institute approximately $19,997 per year. In addition to the reduced annual consumption, the proposed DOAS system was compared to the existing system using Costworks and the R.S. Means catalog to determine first cost, and the proposed system is approximately $248,145 cheaper than the existing system. This is in part due to the smaller chiller, associated pumps, ductwork and plenum required, which offset the costs of the added parallel systems and expensive DOAS units. Finally, an emissions analysis was done based upon the current and proposed electric output and it was determined that there was a 15% reduction in emissions due to the proposed system.

In light of these findings, it appears that the proposed dedicated outdoor air systems can provide the same quality of conditioned air to critical laboratory spaces while at the same time saving on first costs and annual utility costs. In addition, the reduced electrical consumption reduces emissions and ultimately helps reduce the building impact on the environment. In these respects, the proposed system is an appropriate fit at the Hauptman-Woodward Medical Research Institute.

The Hauptman-Woodward Medical Research Institute

Section 1: Project Background

HWI and the Buffalo-Niagara Medical Research Campus

1.01: Program History and Growth

The Hauptman-Woodward Medical Research Institute was founded in the 1950's as the Medical Foundation of Buffalo (MFB). In the 1960's, research began to focus intensely on the science of crystallography. The development of improved drugs requires knowledge of 3-D structures of the biological substances found in disease processes. During that time period, the goal of the MFB was to establish itself as a world-class crystallographic laboratory in Buffalo.

At the forefront of the crystallography field, Dr. Herbert Hauptman has since became the principal investigator and continues to today to build upon the foundation of the MFB. In the 1980's Hauptman received the Nobel Prize for his research in the field of chemistry and the foundation changed its name to the Hauptman-Woodward Institute (HWI) in 1994.

Over the past decade, HWI has become a founding partner of the Buffalo-Niagara Medical Research Campus and has created the Department of Structural Biology at the University of Buffalo. As the University and Roswell Park Cancer Institute began to construct new facilities, HWI decided to relocate to best serve the collaborative culture of the research campus.

In April 2005, the brand-new 73,000 square foot, 3-story building opened its doors to provide a full service biomedical research lab and supporting office and classroom space to the Buffalo-Niagara Medical Campus in Buffalo, New York. Not only does it serve as a center for research and development, the large atrium and classroom spaces make the Hauptman-Woodward Institute a prime gathering place for seminars and gatherings on the Medical Campus.

The main design objective at the Hauptman-Woodward Medical Research Institute is to provide a safe, accommodating atmosphere for improving human health through molecular studies of the causes and potential cures of many diseases. In contrast to clinical research, the focus of Hauptman-Woodward's basic research is to determine the structures of individual substances such as proteins that play a role in the development of specific diseases. In order to achieve this task, the Institute required a biomolecular research lab that would minimize outside contamination, in addition to office, library and classroom space that would support the program faculty, staff and students who frequent the facility on a daily basis. In addition to these strict requirements, the not-for-profit organization wanted to make an architectural design statement in the heart of downtown Buffalo, while at the same time reducing total building cost so that the focus of their efforts could be on research. One of the typical laboratory spaces within the finished building is shown in Figure II, below. As you can see, the laboratory overlooks the glass atrium, giving visitors a prime view of what's happening at the Institute.

Figure II: Typical Laboratory Space at HWI

1.02: Architecture

As stated in the previous section, the architecture of the new 73,000 square foot building for the Hauptman-Woodward Medical Research Institute expresses one overriding idea: *openness*. Jane Griffin, Principal research scientist at the institute, explained it best. "We were very interested in having a very open building so people in the surrounding community could see what was going on inside, and a building where no one could hide inside."

To achieve this feeling of "openness", the Institute sought out the expertise of architect Mehrdad Yazdani of Cannon Design. Yazdani's vision consisted of a three-part complex, comprised of a block laboratory wing lined with transparent channel glass, an aluminum-clad curved office wing and a three-story glass atrium that connects them (Figure III). According to Yazdani, the glass allows transparency throughout all the spaces. In addition, visibility is maintained between the offices and labs through channel and vision glass. "A visitor could get glimpses of scientists working in the labs right upon entering the atrium," he noted in a July 2006 article to Glass Magazine.

Figure III: Atrium at the Hauptman-Woodward Medical Research Institute, as viewed from main entrance

From the atrium, one can branch into the many different areas of the complex. On the first floor, executive offices and the Board Room are found to the south. To the north is the main lecture/assembly hall, followed by several specialized laboratories, storage rooms and shipping and receiving for the facility.

Housed in the second floor atrium are the employee's lunchroom and kitchen, plus a large central area furnished with chairs and other seating for informal meetings. To the south are offices for scientists and study tables for students. To the north is the Crystal Growth Lab, a number of individual labs and central shared equipment and research support rooms.

The third floor atrium houses research library at HWI. To the north are additional cold rooms, laboratories, and shared research and support facilities. To the south are more offices for research scientists and technicians as well as additional areas for student research.

1.03 Building Envelope

In addition to providing transparency, interior and exterior glazing throughout the research center provides ample natural lighting. "Their previous building was three stories of all brick with tiny windows," Yazdani says. "If you drove by, you would not know there were Nobel Laureates working inside. Now, the channel glass, interrupted with portions of vision glass, allows diffused natural lighting to enhance the quality of the lab space…I've been told they don't turn the lights on at all in some of the labs." [1]

The Institute features numerous wall systems, the most prominent being a translucent Pilkington Profilit channel glass system application on the laboratory façade (Figure IV). The atrium glass is held by a combination of vertical structural support members and horizontal mullions. Clayton B. Obersheimer Inc. located in Buffalo served as the glazing contractor and was responsible for the installation of all channel and vision glass. The office wing consists of an aluminum-clad curtain wall. This panel system integrates windows of varying sizes to enhance the buildings façade.

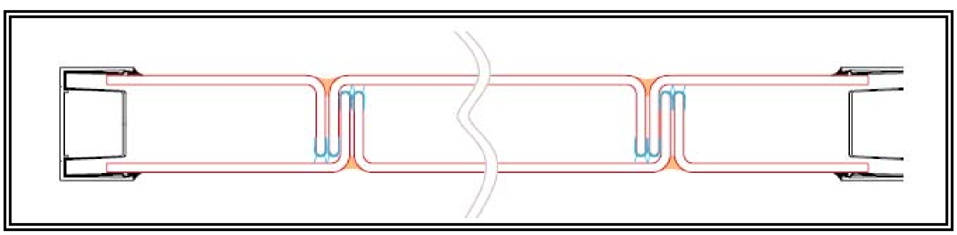


Figure IV: Pilkington Profilit Channel Glass System Horizontal Cross-Section

Section 02: Existing Building Systems

2.01: Structural

The structural system at the Hauptman-Woodward Medical Research Institute consists of structural steel columns, beams and flanges. The structural members are sized larger than required to provide extra rigidity and prevent unnecessary vibration within the critical lab space. The floors are comprised of a 4.5" slab on deck construction with blended fiber reinforcement. The foundation is 5" slab-on-grade, atop 4' poured concrete footings. The atrium consists of a King-Truss roof support system that supports a 4" slab on deck roof assembly in addition to the atrium skylights.

2.02: Lighting/Electrical

The primary distribution system at the Hauptman-Woodward Medical Research Institute is a 480/277V, 3 Phase system, rated at 2000A. The electrical service is installed in the main electrical room, which is located in the center of the ground-floor parking garage. Luminaires are predominantly 120V or 277V, with a variety of fixtures providing task and accent lighting throughout the building.

In addition to the main distribution system, a 450kW/563kVA emergency generator provides power to lab-critical and life support systems within the building, such as fire suppression, alarms, the atrium smoke control and ventilation systems, as well as certain laboratory equipment.

2.03: Telecommunications

The Hauptman-Woodward Medical Research Institute is equipped with a public address system that will allow user access via telephone headsets to zone speakers throughout the building. In addition, a sound reinforcement system was implemented in the lecture hall and seminar rooms in the event that sound amplification is required. Wireless microphones were supplied and local inputs for computer and media devices were provided to assist in presentations at the institute. In addition, a data network system is installed to meet the needs of the facility now and in the future. An interabuilding backbone system connects the main telecom room to satellite rooms and provides the sharing of resources such as printers, internet and data storage devices. A telephone cabling system is also provided to ensure that data and telecommunication is available throughout the building and that users have easy access to telephones, internet and data stations. Telecom outlets are positioned throughout the building so that each workstation can be equipped with all necessary technology.

2.04: Transportation

The large atrium invites people into the space and promotes access to all three floors of the building. A grand staircase that runs from the ground to the third floor is a focal point within the space. Two elevators, one in the atrium and another at the rear of the building, provide vertical transportation in addition to three fire-rated stairwells throughout the building. The hydraulic lobby elevator has a maximum load of 2500 lbs, and hoists at a maximum speed of 125fpm. The service elevator at the rear provides a maximum load of 5000lbs, and provides access to all three floors as well as the mechanical penthouse level at a speed of 100fpm. On the exterior, there is a parking bay on the first floor that can accommodate 10 automobiles. These spaces are reserved for department and administrative heads. Adjacent to the parking bay is additional parking that can accommodate all other faculty and visitors to the building.

2.05: Fire Protection

The Hauptman-Woodward Medical Research Institute is equipped with a wet-pipe fire protection system that employs automatic sprinklers in the event of a fire-related emergency. Sprinklers are connected to a piping system containing water and connected to a water supply such that water will discharge immediately from sprinklers that detect fire. The system is equipped with fusible link or bulb-type sprinkler heads, as required per each space, and the system is separated by floor and into two distinct zones: laboratory space and office space.

Section 03: Existing Mechanical Conditions

3.01: Mechanical System Location

The Hauptman-Woodward Medical Research Institute is located in the heart of the Buffalo-Niagara Medical campus – an area of the city of Buffalo, NY that is quickly revitalizing itself. Its close proximity to the Roswell Park Cancer Institute, Buffalo General Hospital, as well as the downtown theatre district gave the owners and designers the opportunity to provide an architecturally stunning building in an area that had been in decline over the past few decades. As such, it was necessary to take added precautions to shield the mechanical systems from public view. A mechanical penthouse was built in keeping with the radical design of the building, and as such masks the majority of the equipment. The two rooftop units (RTU-1,2) and the chiller were both hidden from view by means of architectural screening, as shown in Figure V.

Figure V: Street-Level View of Mechanical Penthouse and Equipment Screening.

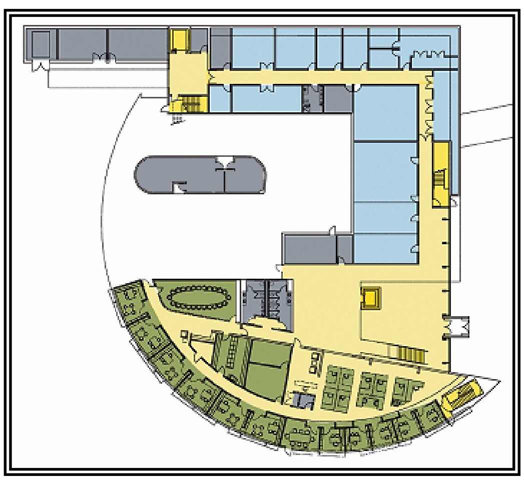


Figure VI: Location of main electrical and Telecom rooms on Ground Floor

One of the primary design considerations at the Hauptman-Woodward Medical Research Institute was the separation of the mechanical systems from the critical laboratory spaces. This was achieved rather simply by placing the majority of the mechanical equipment in the roof penthouse or directly on the roof. The only major lost space within the building was located on the ground floor adjacent to the atrium, where it was necessary to place makeup supply fan for the smoke exhaust system. The main electrical, fire protection and telecommunication rooms are located on the ground level separate from the building itself, adjacent to the covered parking and highlighted in gray in the figure below (Figure VI). All in all, the designers did a spectacular job of isolating the mechanical equipment from the building. Any necessary maintenance to the system can be achieved without setting foot in the laboratory space. This is noted in the breakdown in figure VII, which shows that approximately 55% of the mechanical space allotted was in the penthouse. As a whole, only 12% of the entire building was required for mechanical equipment and shaft space, allowing for the maximum allowable research space.

Space Description	Area (sq.ft.)
First Floor	2405
Second Floor	600
Third Floor	295
Penthouse	4780
Elevator Shafts	630
Total Building Area	73289
Total Lost Rentable Space	8710
Percent Lost Rentable Space	**11.9%**

Figure VII: Breakdown of Lost Rentable Space at HWI.

3.02: Existing Site Energy Sources and Rates

The Hauptman-Woodward Medical Research Institute utilizes two energy sources for operation of its building mechanical systems. These sources include electric power (kWh) and natural gas (therm), and are provided directly to the site. Since monthly utility data was not available from the owner, rates were determined based on site and city data for Buffalo, New York, and are used later in this report to determine approximate annual building costs using Trane TRACE-700 modeling software.

Electricity and Natural Gas were the two most practical energy sources based on site conditions. Due to the specialized nature of the Buffalo Niagara Medical Campus, it would not be practical to have a centralized plant. Therefore, the Hauptman-Woodward Medical Research Institute is self-contained with chiller and boiler plants located within the 4th floor mechanical penthouse. These localized systems provide the necessary heating and cooling required for the building to operate as it was intended.

Electric Service at the Hauptman-Woodward Medical Research Institute is provided by National Grid, a primary electric service provider throughout Western New York. The electric rate is broken down into specific charges, as shown in Figure VIII.

	Charge
Basic Service Charge	$51.60
Delivery Charge for Demand (per kW)	$9.48
Delivery Charge (per kWh)	2.032¢
Delivery Charge Adjustment	0¢
Customer Service Credit (per kWh)***	0.2¢ per KWh
System Benefits Charge (per kWh)	.1619¢
Renewable Portfolio Surcharge (per kWh)	.0491¢
Electricity Supply Charge	0.05585¢

Figure VIII: National Grid Electric Tariffs
(Courtesy of National Grid, Inc. Oct. 2006)

The Natural Gas Service for the Hauptman-Woodward Medical Research Institute is provided by National Fuel, which serves residential buildings and businesses in

Western New York and Northern Pennsylvania. The building falls under the category SC-3: General Sales for buildings of like size and occupancy.

National Fuel Gas Distribution Corporation
New York Division
Rate Summary - March 2007
This Rate Summary Does Not In Any Way Supersede The Tariff

Unbundled Sales Service	Base Delivery Service Rates		Billing Charge	Refund Credit	Delivery Adj. Charge	Monthly Total Transportation	Natural Gas Supply Charge	Total Sales
SC-3 General Sales & Transportation Service (Non-Residential)								
First 1 Mcf	$17.55		$2.00	($5.71)	$0.03	$13.87	$10.19	$24.06
Next 49 Mcf	$2.57806	/Mcf	$0.00	$0.0000	$0.03111	$2.60917	$10.19234	$12.80151
Next 950 Mcf	$1.99656	/Mcf	$0.00	$0.0000	$0.03111	$2.02767	$10.19234	$12.22001
All Over 1,000 Mcf	$1.62309	/Mcf	$0.00	$0.0000	$0.03111	$1.65420	$10.19234	$11.84654
SC-3 Incremental Natural Gas Supply Charge for Transportation Customers above 3,500 Mcf who return to sales service							$10.19234 /Mcf	
Base Cost of Gas (SC-1 & SC-3)	$0.14632	/Mcf	(included in SC 1 & SC 3 Base Delivery Rates)					

Figure IX: National Fuel Natural Gas Tariffs (courtesy of National Fuel, March 2007)

As shown in Figure IX, natural gas is provided on a tier basis, with a base charge of $10.1934/Mcf, which does not include city taxes of 3.0928%.

3.03: Existing System Design and Operation

Rooftop Units (RTU-1,2) w/ VAV Control

The Hauptman-Woodward Medical Research Institute is equipped with two rooftop air handling units to supply conditioned air to the remaining areas of the building with the exception of the laboratory. Although they are significantly different in size, each operate under the same conditions, and are equipped with variable air volume control which are monitored by traverse fan inlet probes and static pressure sensors at supply and return fans. Heating is provided by natural gas and cooling is provided by DX cooling units, which maintain 55ºF supply air to each zone. VAV terminal reheat boxes are installed in each zone and space temperature sensors modulate the terminal unit supply air damper in sequence with the reheat coil to maintain space temperature. During occupied periods, the space shall be maintained at 72ºF, and when it is unoccupied, the system shall automatically maintain a minimum temperature of 55ºF. Each zone is supplied with a manual thermostat to adjust the temperature for comfort.
For a schematic of this system, please consult Appendix A-1.

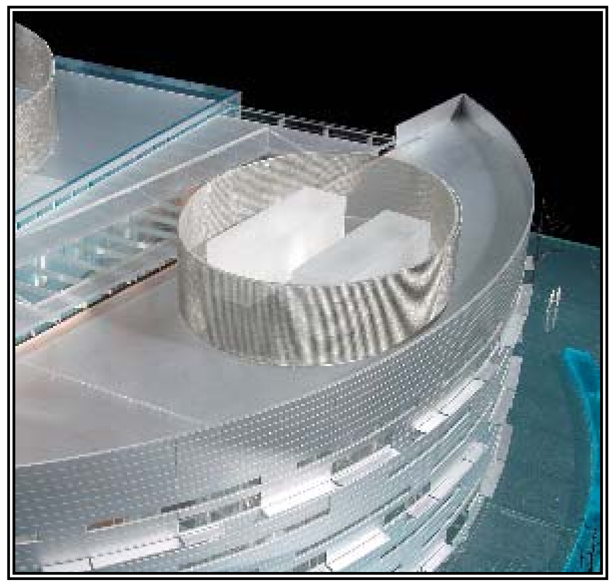


Figure X: Location of Rooftop Units RTU-1 and RTU-2.

Air Handling Units (AHU-1,2) with Variable Supply and Exhaust

The primary purpose of this 100% OA system is to provide 58,000 cfm of conditioned air to the laboratory space. It consists of 2 air handlers, each with pre and final filters, chilled water cooling coil, glycol preheat coil, glycol heat recovery coil, supply fans, and variable speed VAV control.. The system operates continuously to serve HVAC requirements at each individual zone. Scheduling is programmed on a zone by zone basis. The two units operate in parallel and serve a common supply duct. The units operate together, simultaneously varying temperature and airflow to meet SA requirements. The Supply air temperature is adjustable between 55ºF and 60ºF, however design dictates that 55ºF is the standard for sequence with the VAV terminals.

Low temperature controllers provide freeze protection to the supply air fan when the air temperature drops before 53^{O}F. The SA fan is equipped with variable air volume control, which requires static pressure sensors to keep the flow rate at 1 inch WC. For a schematic of this system, please consult Appendix A-2.

Figure XI: Air-Handling Units AHU-1 and AHU-2 In Mechanical Penthouse

Laboratory Heat Recovery Exhaust System

The laboratory general exhaust system consists of three exhaust fans that share a common intake plenum, and together provide 81,000 cfm removal of exhaust air. Velocity Sensors modulate air dampers in order to maintain 4,000 FPM velocity though the exhaust stack. The heat recovery system recovers heat from the general exhaust to preheat or pre-cool the incoming supply air. The system uses a single pump to circulate a 40% glycol solution between coils located in the exhaust and supply air streams. The pump is controlled via temperature sensor to operate continuously when the outside air is below 55^{O}F or above 80^{O}F. The system is equipped with a bypass in the event that the temperature drops below 10^{O}F to prevent freezing of the system. For a schematic of this system, please consult Appendix A-3.

Figure XII: Laboratory Exhaust Fans

Cooling Chilled Water System

The chilled water system consists of a 300-ton air-cooled water chiller and chilled water pumping system. The system supplies chilled water to the building in addition to serving the cooling coils located in AHU-1 and AHU-2. The system operates when the air outside is above 55^{O}F and is monitored by temperature sensors. The chiller is set to maintain a constant 44^{O}F chilled water supply. The pumping system is staged to run continuously when chilled water is needed. The system consists of 2 pumps, of which only one is needed. They are controlled automatically to alternate to maintain equal run time. For a schematic of this system, please consult Appendix A-4.

Hot Water Boiler Systems

The hot water and glycol heating systems each consist of three hot water boilers with dedicated hot water pumps, and a secondary pumping system, as shown in Figure XII. The system is DDC controlled and utilized electric actuation. Boilers are sequenced to equalize equipment runtime. Selection of the lead boiler will be evaluated on a weekly basis, with the boiler having the least runtime becoming the lead boiler.

Figure XII: Hot Water and Glycol Boiler Systems

For the hot water boiler system, the lead boiler shall start when the outdoor temperature drops below 65^{O}F. The lead boiler is sequenced to maintain the loop temperature at 190^{O}F. Should additional heating be required to maintain this temperature, the lag boilers will come online. Temperature sensors monitor loop temperature and dictate system operation.

The glycol hot water system operates in much the same way. When the outdoor air temperature drops below 55^{O}F, the lead boiler shall start. The lead boiler is sequenced to maintain the loop temperature at 190^{O}F. Again, should additional heating be required to maintain loop temperature, the lag boilers will be automatically enabled. For a schematic of this system, please consult Appendix A-5.

Penthouse Air Handling Unit (AHU-3)

The boiler make-up air unit is set up to run continuously and provide fresh air to the mechanical penthouse. The unit provides 3000 cfm of outside air to the space and a space temperature sensor modulates outdoor air dampers to maintain space conditions at 70^{O}F. Controls will override space sensor and open outdoor air dampers when boilers are started, allowing for additional make-up air to the penthouse and removal of excess boiler exhaust gases. For a schematic of this system, please consult Appendix A-6.

Atrium Smoke Control Ventilation System

The atrium smoke control system consists of four exhaust fans (E/F-6,7,8,9), make-up air from RTU-2, and two supply fans (SF-1,2). The system is designed to exhaust smoke from the atrium in order to keep smoke above an interface level of 42ft. Upon signal from the fire alarm, the system will open exhaust fan dampers and OA dampers from the air handling units, in addition to automatically opening all atrium entry doors. The rooftop unit return fan shall shut down and associated smoke dampers will close. Once these procedures have been initiated, the four exhaust fans shall exhaust the required 160,000 cfm of air until deactivated at the firefighter control center (FCC). For a schematic of this system, please consult Appendix A-7.

3.04: Existing System Analysis: ASHRAE Standard 62.1-2004 Compliance

ASHRAE Standard 62.1-2004 describes the procedure to verify the required amount of outdoor air that must be supplied to the building. At the Hauptman-Woodward Medical Research Institute, the Ventilation Rate procedure was used to complete this task. This procedure has a very straightforward approach in that it consists of a series of equations for find the rate of outside air intake to the building when all floor areas, occupancies, and space uses are known. Table 6-1 of Standard 62.1-2004 describes general contaminant concentrations in various space designations, and provides design values based on floor areas and occupancy levels.

According to the ventilation rate procedure, the required amounts of outdoor air are summarized in Table XIII.

System	Max Zp	Ev	Vou (cfm)	ΣVoz (cfm)	Required OA (Vot)	Design OA (cfm)	Total SA (cfm)	Complies to Standard 62.1-2004
RTU-1	0.77	0.95	2,003	2,504	**2,635**	3,500	14,175	Yes
RTU-2	0.31	0.6	2,823	3,530	**5,885**	7,075	28,300	Yes
AHU-1&2			4,713	5,892	**5,892**	58,000		Yes

Table XIII: Required Outdoor Air Summary for Existing Air Handling Units

It was found that for each rooftop unit, the sum of the zone outdoor airflow (ΣV_{OZ}) was less than the design outdoor air intake airflow (V_{OT}). According to the design schedules, the minimum outdoor air was sufficient to comply with Standard 62.1. In addition, the air-handling units that supply the laboratory spaces provide 100% outdoor air, thus provide a significantly greater amount of required outside air than is required to the laboratory. It is therefore in compliance with Standard 62.1. These required values of outdoor air will be necessary in the next portion of the report, which will deal with the incorporation of Dedicated Outdoor Air Systems at HWI.

3.05: Existing System Design: ASHRAE 90.1-2004 Compliance

The purpose of ASHRAE Standard 90.1-2004 is to provide minimum requirements for the energy-efficient design of buildings. The Standard is broken down into sections that analyze aspects such as building envelope, heating, power, lighting and electric motors. For our purposes, we will concentrate on the building lighting systems at the Hauptman-Woodward Medical Research Institute, and will be further discussed in the breadth section of this report.

The existing lighting power density was analyzed using the Space-by-Space method, as prescribed in Section 9 of ASHRAE Std. 90.1-2004. Building area types were taken from Table 9.6.1 of the standard. After completing the power density calculations for each space, it was determined that many of the spaces did not comply with Standard 90.1-2004. There could be many reasons for this to be the case. First and foremost, the Standard has changed since the last revision in 1999, and could account for some discrepancies. In addition, many of the spaces within the Hauptman Woodward Institute have redundant lighting systems that provide architectural merit to the building. Upon inspection, each lighting system is switched independently, which allows for the building occupants to monitor the light output at any one time.

For a complete summary of the existing lighting power densities of each space at the Hauptman Woodward Institute, consult Appendix B.

Section 04: Mechanical System Redesign

4.01: Proposed Goals and Scope

Due to it's primary function as a laboratory and learning space, in addition to the need to employ a 100% outdoor air system, the Hauptman-Woodward Medical Research Institute has an estimated yearly utility bill of $75,136. Laboratory spaces have requirements that naturally increase the operational costs of the building. Since all of the conditioned air is exhausted from these spaces, there is a great deal of energy that is expended into the atmosphere that could be reused.

The primary goal of this report is to modify the existing HVAC system in an effort to reduce energy consumption and yearly utility costs. If these objectives can be achieved, emissions from the building will be decreased as well. In addition to the mechanical redesign, an evaluation of wind power as well as lighting power density requirements will be assessed in the breadth section of this report. While considering the alternatives, it is important to preserve the integrity of the lab and incorporate a design that will not be unfavorable to the program requirements.

The scope of the design process will include the following:

- Model the existing building conditions in Trane Trace to establish base.
- Design and Incorporate a parallel DOAS/ DX VAV System in non-lab critical spaces
- Design and incorporate a parallel DOAS/Hydronic Radiant System with Desiccant Wheel in Lab-critical spaces.
- Model Alternative designs to establish comparison
- Compare existing system to proposed system to determine feasibility

Disclaimer: The remainder of this report provides alternative solutions for the mechanical design at the Hauptman-Woodward Medical Research Institute. These solutions have been put forth for academic purposes only. As such, the modifications described do not suggest flaws in the original design by Cannon Design or others involved on the design or construction of this project.

4.02: Considered Alternatives

Ground Source Heat Pumps

The first consideration for the thesis report was implementing a Ground Source Heat Pump (GSHP) system (Figure XIV). GSHP's use geothermal sources, such as groundwater, surface water or other water mass as a heat source. Most have a reverse refrigeration cycle and either an open or closed geothermal loop. They are preferred over Air-Source Heat Pumps due to the fact that the ground water temperature is nearly constant and shallow depths. Although GSHP's have good response times in terms of allowing a switch between heating and cooling, they require large tracts of land for boring holes into the earth. The Hauptman-Woodward Medical Research Institute does not have a large lot, and there is most likely not enough space to layout the ground loops. In addition, the first costs of drilling boreholes and laying out piping loops would be much higher than the current system that is in place, giving it a very poor payback time. For these reasons, this option will not be considered for the project.

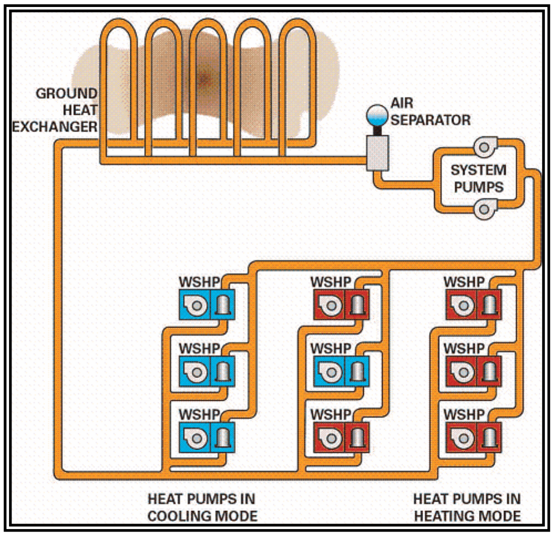


Figure XIV: Typical GSHP Schematic

Latent Energy Storage

High on-peak electric demand charges gave way to the consideration of latent energy storage. Latent storage at first glance seems like a viable option considering the fact that the building occupancy schedule coincides with the on-peak electric demand schedule. After preliminary investigation, this option was discarded to the small building footprint of HWI. There would not be significant space available for ice storage containers. In addition, the structural system of the building would have to be increased a great deal due to the fact that the only location for ice storage would be in the mechanical penthouse. The building was constructed on a slab foundation; therefore there is no basement available to house equipment. This option was disregarded without further review.

4.03: Justification of Proposed Systems

System 1:

As discussed in section 4.01, this report details the addition of two Dedicated Outdoor Air Systems (DOAS) to the Hauptman-Woodward Medical Research Institute, and comparing them to the current systems. At the present time, Laboratory AHU-1,2 supply 100% outdoor air and utilize a runaround loop to recover some of the energy that is being exhausted. This report will determine whether a DOAS with a parallel chilled beam system (Figure XV) will be an economical alternative to the existing design. The system will utilize a desiccant wheel equipped with a 3Å molecular sieve material. This material that has been developed by SEMCO provides "selective absorption", unlike other desiccants that cannot provide trap pollutants. Molecular sieves are structurally stable, chemically inert and have a strong affinity for water vapor. This accounts for the high rate of absorption and high latent transfer performance. In addition the unit will be equipped with a purge section to further eliminate possibility of cross contamination. Although this type of application will always bring out worry of such contamination, there have many laboratories that have utilized this type of system. For example, Johns Hopkins University has successfully implemented a 14' diameter desiccant system at its Ross Research Laboratory, which was completed in 1991. Further tests over the past 15 years have shown no signs of cross contamination. In addition, there are only 8 fume hoods attached to the general exhaust at HWI. The two fume hoods that serve potentially hazardous material are on their own dedicated exhaust, and would never enter the desiccant wheel. Figure XVI shows a cross-sectional view of the desiccant wheel that is proposed for this system.

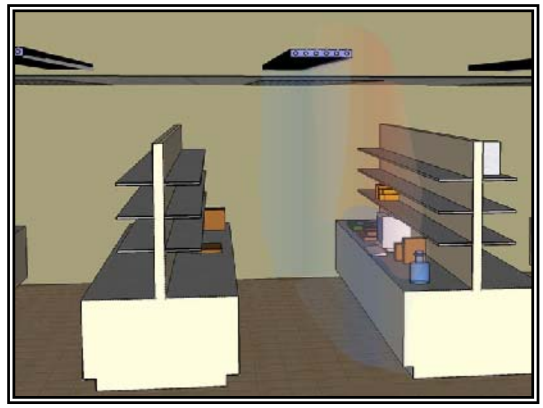


Figure XV: Proposed Chilled Beam Application in Lab

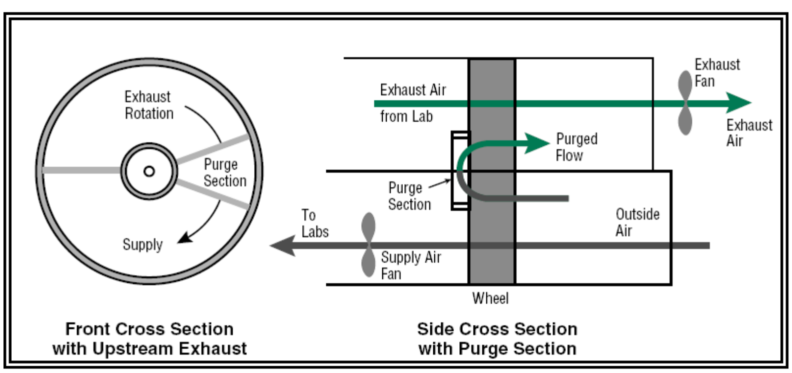


Figure XVI: Cross Sections (Front and Side) of Enthalpy Wheel with Purge Section for Laboratory System (Image Provided by SEMCO, inc.)

System 2:

This existing system consists of two DX rooftop units, RTU-1 and RTU-2, which serve the remainder of the space at HWI. This system supplies outside air and return air to the space, without any further means of heat recovery. Much like the first system, the portions of the building that are not part of the laboratory core will also be served by a dedicated outdoor air system. This proposed redesign shall be set up differently from the first, and shall employ a parallel VAV system to supplement the sensible loads to the space. In this respect, the office will benefit from the improved dehumidification from the DOAS system and space temperature control from VAV boxes in the office areas. In addition, this dedicated outdoor system will employ both latent and sensible wheels (Figure XVII), whereas the laboratory system will only utilize a desiccant wheel that will serve both latent and sensible loads.

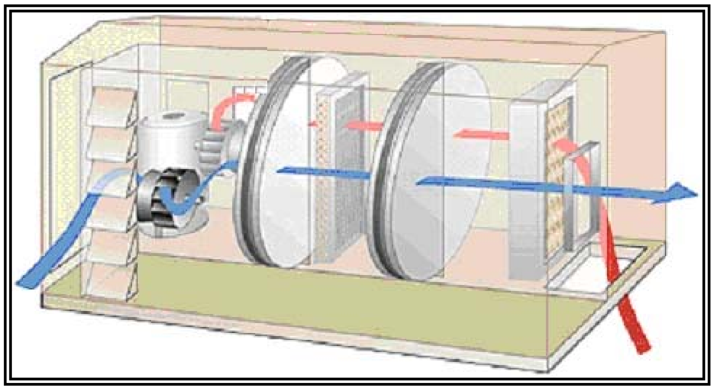


Figure XVII: DOAS System with both Latent and Sensible Wheels for Office-Side
(Image provided by SEMCO, Inc.)

4.04: System 1 Calculations – Laboratory

This section describes the DOAS Unit Selection process using the SEMCO Unit Selection Procedure. Cut sheets from the manufacturer can be found in Appendix C-1.

Design Criteria		Summer	Winter
Supply Air Flow	[cfm]	9400	9400
Return Air Flow	[cfm]	8500	8500
Outdoor Air Conditions			
Temperature	[°F]	86	2
Relative Humidity	[%]	46	10
Moisture Content	[gr/lb]	82	4
Enthalpy	[btu/lb]	34.3	1.1
Return Air Conditions			
Temperature	[°F]	72	70
Relative Humidity	[%]	50	50
Moisture Content	[gr/lb]	55	50
Enthalpy	[btu/lb]	26.6	25.4
Purge Pressure Difference			
ΔP	[in. wg]	3.0	3.0

Table XVIII: Laboratory Design Conditions

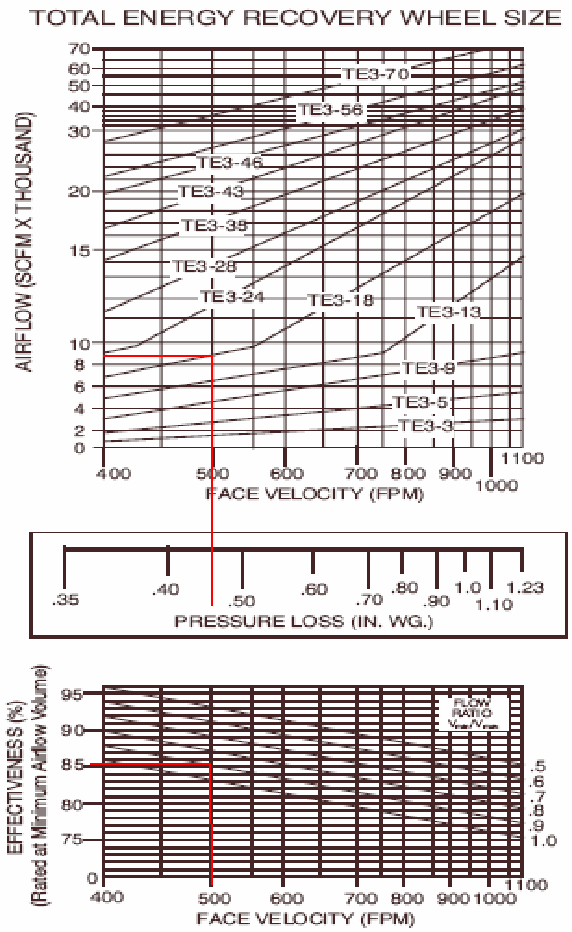


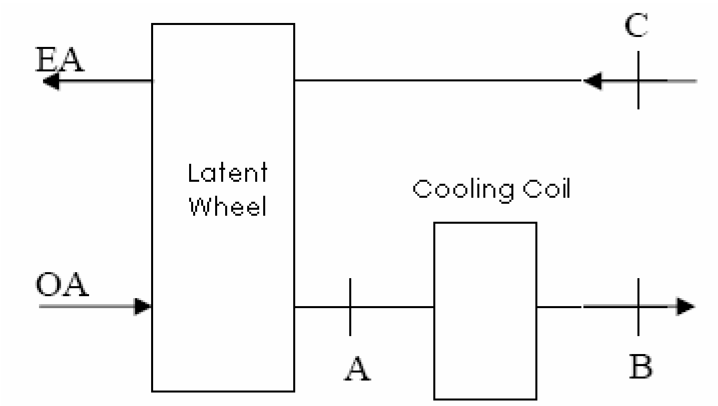
Figure XIX: Enthalpy Wheel Selection
(Chart Provided by SEMCO, Inc.)

Step 1: Enthalpy Wheel Selection, Effectiveness and Pressure Loss

The main component of air-to-air energy recovery in a DOAS system is the enthalpy wheel. The wheel selection is determined based on face velocity and the desired room airflow rate. Based on an airflow rate of 8,500 cfm, the initial wheel size is selected is the **SEMCO TE3-13**. From Figure XIX, we can calculate the Face Velocity, Pressure Loss and Effectiveness of the Wheel. These Values are summarized as Follows:

SEMCO TE3-13 Enthalpy Wheel	
Face Velocity [fpm]	500
Effectiveness	0.85
Pressure Loss [in. w.g.]	0.45

Step 2: Calculate Performance Setpoints



Outside Air Conditions: Cooling (Point A)

DBT
$(Tdb)_2$ = 86 °F - [ϵ (8500cfm / 9400 cfm) (86 °F - 72 °F)
$(Tdb)_2$ = 75 °F

Humidity Ratio
W_2 = 82 gr/lb. - [ϵ (8500cfm / 9400 cfm) (82 - 55)
W_2 = 60.9 gr/lb.

Enthalpy
H_2 = 34.3 Btu/lb - [ϵ (8500cfm / 9400 cfm) (34.3-26.6)
H_2 = 28.3 Btu/lb

Supply Air Conditions: Heating (Point A)

DBT
$(Tdb)_2$ = 2 °F - [ϵ (8500cfm / 9400 cfm) (2°F-70°F)
$(Tdb)_2$ = 54.9°F

Humidity Ratio
W_2 = 4 gr/lb. - [ϵ (8500cfm / 9400 cfm) (4-50)
W_2 = 39.7 gr/lb.

Enthalpy
H_2 = 1.1Btu/lb - [ϵ (8500cfm / 9400 cfm) (1.1-25.4)
H_2 = 20.0 Btu/lb

Cooling Coil Load:
$Q_{CC,S} = 1.08 \times CFM \times (T_{DB,A} - T_{DB,B})$
$Q_{CC,S}$ = 1.08 x 8500cfm x (75 °F – 45 °F) = 275,400 Btu/hr

$Q_{CC,L} = 0.68 \times CFM \times (W_A - W_B)$
$Q_{CC,L}$ = 0.68 x 8500cfm x (60.9-44) = 98,260 Btu/hr

$Q_{TOTAL} = Q_{CC,S} + Q_{CC,L}$
Q_{TOTAL} = 275,400 Btu/hr + 98,260 Btu/hr = 373,660 Btu/hr = **31.1 tons**

Step 3: Calculate Chiller and Boiler Reduction Capacity

C= [9,400cfm x 4.5 x (34.3-28.3) Btu/lb] / 12000Btu/ton
C= 22 tons reduced

B= [9,400cfm x 4.5 x (20.0-1.1) Btu/lb] / 33,000 Btu/ bhp
B= 24 bhp reduction

Step 4: Determine Wheel Speed to avoid Frost Formation

Due to the fact that the Hauptman-Woodward Medical Research Institute is located in Buffalo, NY, it is important to take into consideration the possibility of frost formation on the enthalpy wheel and vary the wheel speed accordingly to prevent such occurrences. According to the manufacturer (SEMCO) this procedure will determine the system setpoint for preheat, should it be necessary.

a. Locate Return Air Point on Psychometric Chart
b. Locate Winter OA design condition (stated above in Table XX)
c. Determine Higher DBT at which line intercepts saturation curve
d. Add 2 °F to this temperature and mark as preheat setpoint to avoid freezing.

After completing this method, the psychrometric chart in Figure XX below shows that, the line will never reach saturation. Therefore, there is no need to preheat the Enthalpy Wheel at the Hauptman-Woodward Medical Research Institute.

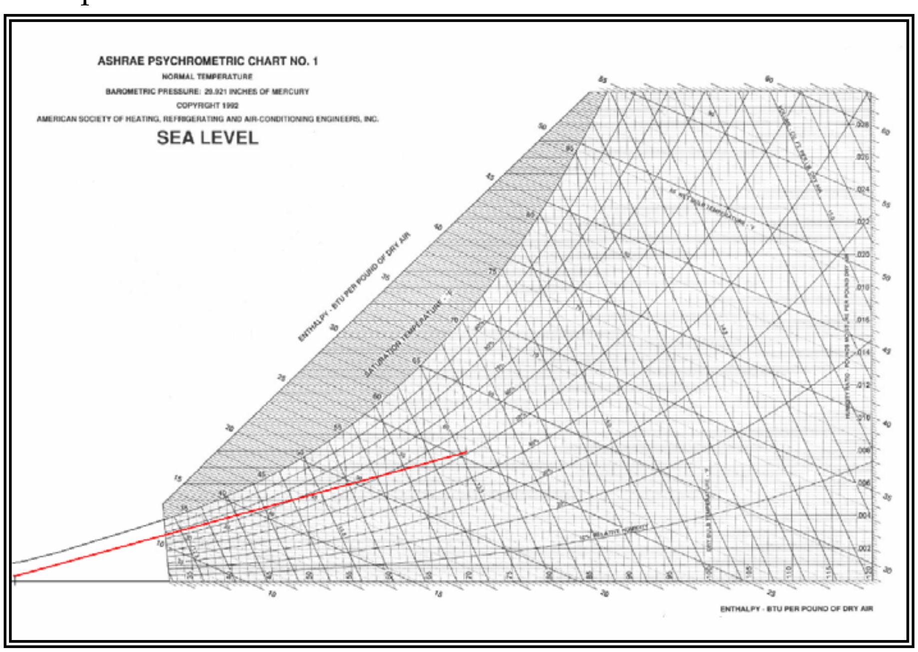


Figure XX: Psychrometric Chart Showing Freeze Precaution Line

Step 5: Resizing the Air-Handling Units

The current configuration at the Hauptman-Woodward Medical Research Institute is the incorporation of two 29,000 cfm air-handling units to meet the 100% outdoor air requirements in the laboratory space. With a Dedicated Outdoor Air System, only the ventilation air will need to be supplied by the air-handling unit. Due to this criterion, only one unit will be necessary and shall be significantly smaller than the existing units. This will hopefully reduce initial cost, and will be determined later in the report.

Based on the design criteria, a comparison of the existing 100% OA System and the designed DOAS system brought about a significant drop in required supply air. When comparing the redesigned laboratory space with the existing system, there is approximately a 83% reduction in supply air, as shown in Table XXI below.

System	Existing SA (cfm)	Redesign SA (cfm)	Reduction (%)
AHU-1,2	58,000	9,400	83.8%

Table XXI: Parallel VAV System Supply Air Reduction

4.05: System 1: Parallel Equipment (Chilled Beam Application)

One of the great things about DOAS systems is the fact that they can significantly reduce the required amount of supply air being sent through the system. The drawback to this scenario is the fact that there must be a supplemental system to remove the additional sensible loads that cannot be removed with the DOAS system. This also holds true in the heating season, when extra heat may be required to satisfy comfort in the building. For these reasons, parallel systems must be employed. As discussed in the redesign scope, the laboratory system will employ chilled beams to accommodate these loads. For the redesign, chilled beams by Halton, Ltd. were used due to their architectural styling and integration to the building design. Specifications are found in table XXII below, however detailed cut sheets can be found in Appendix C-2.

Step 5: Calculate Parallel System Cooling Capacity

DOAS Cooling Capacity:

$Q_{SA} = 1.08 \times CFM_{OA} \times (T_{DB,C} - T_{DB,B})$

$Q_{SA} = 1.08 \times 8500 \text{ cfm} \times (72\,^{O}F - 45\,^{O}F) = 247{,}860 \text{ Btu/hr}$

Parallel System Cooling Capacity

$Q_{PARALLEL} = Q_{SENSIBLE} - Q_{SA}$

$Q_{SENSIBLE} = 743{,}000 \text{ Btu/hr}$

$Q_{PARALLEL} = 743{,}000 - 247{,}860 \text{ Btu/hr} = 495{,}140 \text{ Btu/hr}$

Step 6: Select Equipment + Number of Beams

$Q_{PARALLEL} = 495{,}140 \text{ Btuh} \times 1\text{W}/3.142\text{Btuh}$
$= 145{,}117 \text{ W}$

Area of Beam Coverage: 145,117 W / 510 W/m
= 284.5 m

Brand	Halton
Model	CPA-130/100-615
Cooling Capacity	510 [W/m]
Room Temp	72°F (22°C)
EWT	52°F (11°C)
ΔT	11°C
Length	1122 [mm]
Width	615 [mm]
Height	80 [mm]

Table XXII: Chilled Beam Specification

\# of Beams = Total Coverage Area / Beam Length
=284.5 m / 1.21 m
= 236 Chilled Beams required

4.06: System 2 Calculations (DOAS w/Parallel VAV)

The DOAS system that will be incorporated on the office/learning wings of the building is similar to the previously selected system for the laboratory; however it shall utilize both an enthalpy wheel and a sensible wheel. Manufactured by SEMCO, this unit shall provide an EXCLU-SIEVE energy recovery wheel, a sensible energy wheel, backward-curved supply and exhaust fans, outdoor air and return filtration, and a chilled water cooling coil which will be supplied by the existing chiller. This DOAS unit shall serve the office and support core of the building and will be supplemented by two VAV air-handling units, RTU-1 and RTU-2. The following steps were taken to size the appropriate DOAS Unit by SEMCO, based on space air conditions found in Table XXIII. Cut sheets from the manufacturer can be found in Appendix C-1.

Step 1: Select Unit based on SA quantity:
Total Supply Air Quantity = 10,500 cfm – therefore select SEMCO Model EPD-18

		RTU-1		RTU-2	
Design Criteria		Summer	Winter	Summer	Winter
Supply Air Flow	[cfm]	3500	3500	7000	7000
Return Air Flow	[cfm]	3500	3500	7000	7000
Outdoor Air Conditions					
Temperature	[°F]	86	2	86	2
Relative Humidity	[%]	46	10	46	10
Moisture Content	[gr/lb]	82	4	82	4
Enthalpy	[btu/lb]	34.3	1.1	34.3	1.1
Return Air Conditions					
Temperature	[°F]	72	70	72	70
Relative Humidity	[%]	50	50	50	50
Moisture Content	[gr/lb]	55	50	55	50
Enthalpy	[btu/lb]	26.6	25.4	26.6	25.4
Purge Pressure Difference					
ΔP	[in. wg]	3.0	3.0	3.0	3.0

Table XXIII: Office-Side Air Conditions

Model	Capacity		Effectiveness in %
EPD-18	Low	8,000	85
	Mid	10,000	82
	High	14,000	77

Table XXIV: Model Information from SEMCO Selection Guide

Step 2: Determine ISP pressure for the SA side of EPD-18 at 10000 cfm.

Size	EPD-18	
CFM	8000	10000
Sens. wheel purge	1440	1440
Enth. wheel purge	1718	1718
Fan cfm	11158	13158
OA opening (w/hood)	0.01	0.02
EA opening (w/hood)	0.03	0.04
RA or EA opening	0.12	0.17
SA or OA opening	0.04	0.06
Damper	0.06	0.09
OA filter	0.27	0.38
RA filter	0.22	0.34
Enth. wheel	0.48	0.59
Sens. wheel	0.41	0.51
Cooling coil	0.32	0.47
Heating coil	0.05	0.08
Casing losses	0.30	0.30
Int. static pressure		
Ext. static pressure		
Total static pressure		

SA@10,000 CFM	
OA Opening	0.02
SA Opening	0.06
Damper	0.09
OA Filter	0.38
Enthalpy Wheel	0.59
CHW Coil	0.47
Sensible Wheel	0.51
Casing	0.30
ISP	**2.42 in. w.g.**

RA@10,000 CFM	
EA Opening	0.04
RA Opening	0.17
Damper	0.09
RA Filter	0.34
Enthalpy Wheel	0.59
Sensible Wheel	0.51
Casing	0.30
ISP	**2.04 in. w.g.**

Table XXV: Model Information from SEMCO Selection Guide (steps 2-4))

Step 3: Determine Total Static Pressure

Formula: **TSP = ISP+ ESP**

ESP [supply] = 1.0 in.w.g
TSP = 2.42 + 1.0 = **3.42 in. w.g.**

ESP [return] = 0.5 in.w.g
TSP = 2.04 + 0.5 = **2.54 in. w.g**

Step 4: Determine Total Supply Air Volume

Using Table XXV above, the sensible wheel purge volume = 1,440 cfm and the enthalpy wheel purge volume = 1,718 cfm

Total Supply Air = 10,000 CFM + 1,440 CFM + 1718 CFM = **13,160 CFM**

Step 5: Determine Motor Horsepower

Supply Fan – Size 13, 9x @ 13.28 HP
Return Fan – Size 9, 5xx , @ 10.55 HP

Step 6: Determine Base Wheel Effectiveness

From Table XXIV on the previous page, the base wheel effectiveness @ 10,000 CFM is 0.82.

Step 7: Determine Summer and Winter Setpoint Conditions:

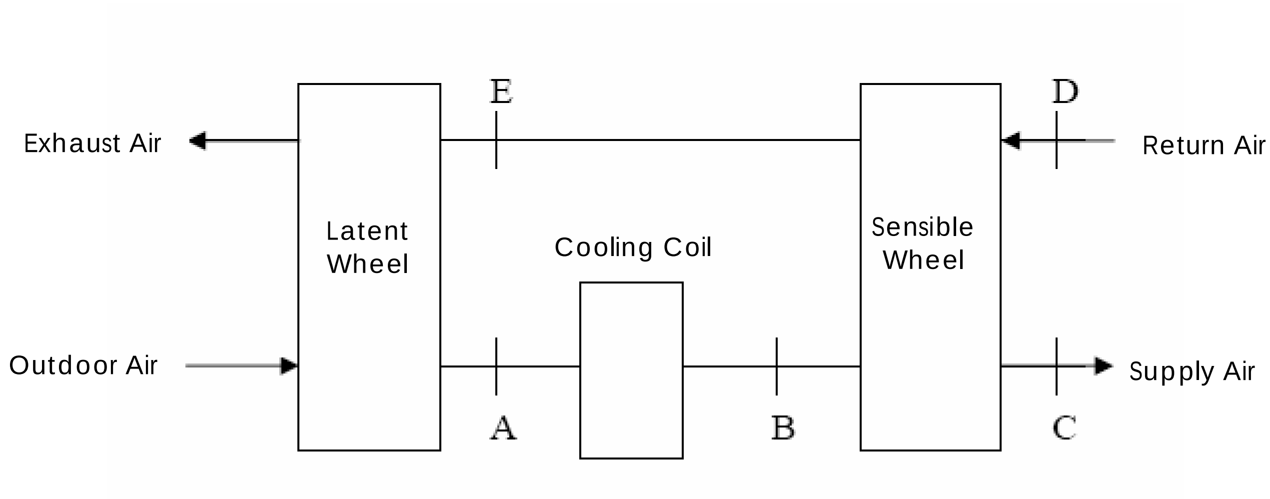


Figure XXVI: Office-Side DOAS

$W_A = W_{OA} – 0.76 (W_{OA}-W_E)$
$(W_E = W_D)$
$W_A = 72 – 0.76 (72-55)$
$W_A = 58.57$ gr/lb
$T_A = 68\ ^oF$

$T_C = T_B – 0.79 (T_B-T_D)$
$T_C = 45\ ^oF – 0.76 (45\ ^oF- 72\ ^oF)$
$T_C = 51.48\ ^oF$

$W_C = W_B = 43$ gr/lb

$T_E = T_D – 0.79 (T_D - T_B)$
$T_E = 72\ ^oF – 0.79 (72\ ^oF - 45\ ^oF)$
$T_E =63\ ^oF$

	TDB [^{0}F]	TWB [^{0}F}	%RH	W [gr/lb]
OA	86	66	46	72
A	68	59.5	60	58
B	45	45	100	46
C	51.5	54.5	50	46
D	72	60	50	55
E	63	56	70	55

Table XXVII: DOAS System 2 Setpoints

Cooling Coil Load:
$Q_{CC,S}$ = 1.08 x CFM x ($T_{DB,A}$ – $T_{DB,B}$)
$Q_{CC,S}$ = 1.08 x 10,500 cfm x (68°F – 45°F) = 260,820 Btu/hr

$Q_{CC,L}$ = 0.68 x CFM x (W_A –W_B)
$Q_{CC,L}$ = 0.68 x 10,500cfm x (58-46) = 85,680 Btu/hr

Q_{TOTAL} = $Q_{CC,S}$ + $Q_{CC,L}$
Q_{TOTAL} = 210,600 Btu/hr + 74,698 Btu/hr = 346,500 Btu/hr = **28.9 tons**

Step 8: Calculate Chiller and Boiler Reduction Capacity

C= [10,500 cfm x 4.5 x (34.3-28.3) Btu/lb] / 12000Btu/ton
C= 23.6 tons reduced

B= [10,500 cfm x 4.5 x (20.0-1.1) Btu/lb] / 33,000 Btu/ bhp
B= 27 bhp reduction

4.07: Sizing Parallel Equipment (Parallel VAV) for System 2

Just like system one, this DOAS system will require a parallel system to make up for additional space loads. The laboratory system employed chilled beams to complete this task; however for the office and laboratory side I will incorporate a parallel VAV system that will closely resemble the existing system. The benefit to this scenario is that the building will definitely be able to accommodate a VAV set-up, since that is what is currently installed. Ducts and VAV boxes will be considerably smaller, however. This would hopefully contribute to cost savings in the initial mechanical design.

Step 9: Calculate Parallel System Cooling Capacity

DOAS Cooling Capacity:

$Q_{SA} = 1.08 \times CFM_{OA} \times (T_{DB,D} - T_{DB,C})$

$Q_{SA} = 1.08 \times 10{,}500\ \text{cfm} \times (72\ ^{O}F - 51.5\ ^{O}F) = 232{,}470\ \text{Btu/hr}$

Parallel System Cooling Capacity

$Q_{PARALLEL} = Q_{SENSIBLE} - Q_{SA}$

$Q_{SENSIBLE} = 923{,}000\ \text{Btu/hr}$

$Q_{PARALLEL} = 923{,}000 - 232{,}470\ \text{Btu/hr} = \mathbf{690{,}530\ Btu/hr}$

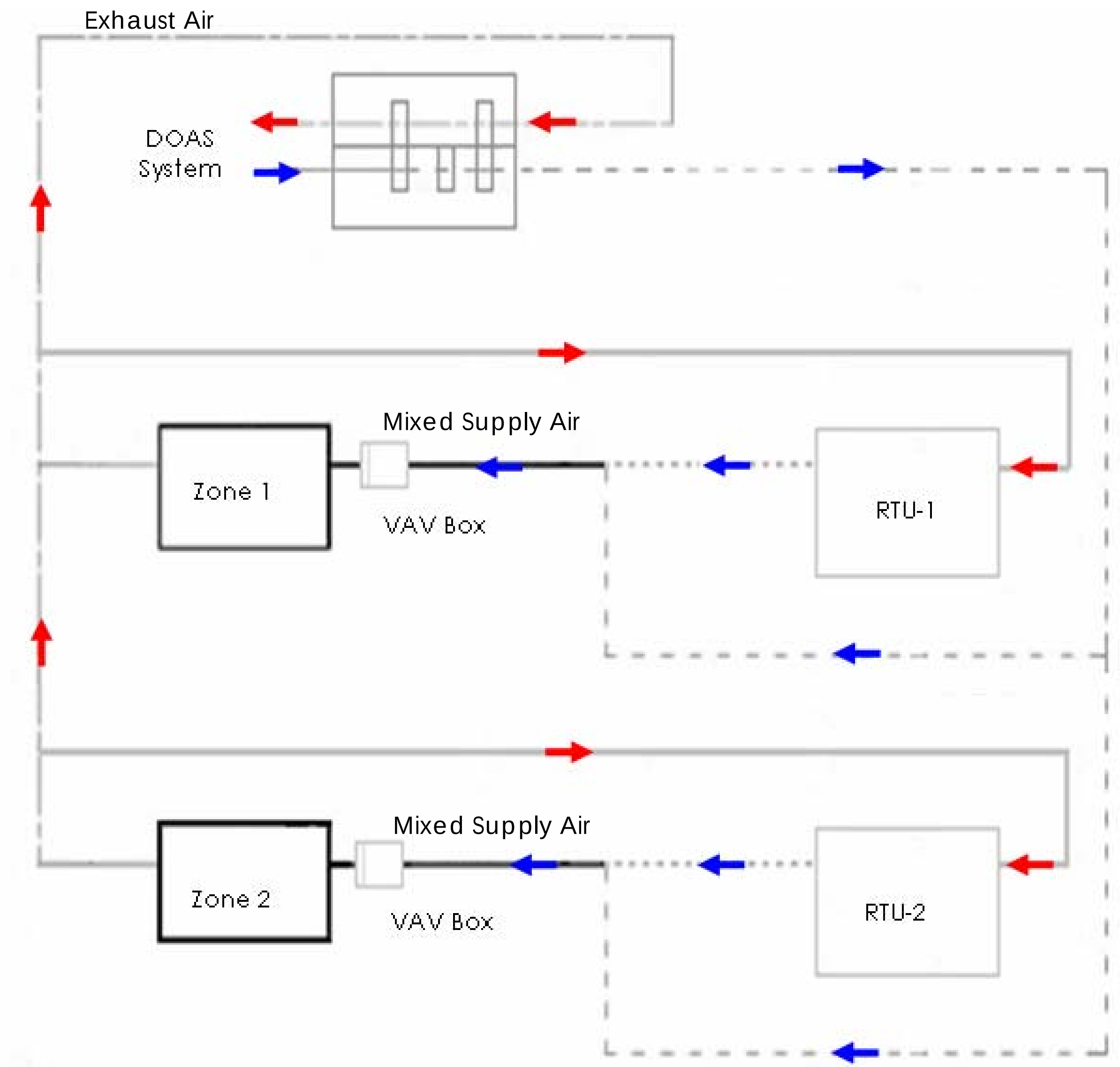


Figure XXVIII: DOAS/Parallel VAV Schematic

Step 10: Calculate Supply Air required for Parallel VAV System

In the previous step, the sensible load that could not be met by the DOAS system was determined to be 690,530 btu/hr. Using the following equation, we can determine the required amount of supply air for the parallel VAV system.

$$CFM_S = \frac{Q_S}{1.08 \times (T_{RA} - T_{SA})} = \frac{690,530 \text{ btu/hr}}{1.08 \times (72^{O}F - 55^{O}F)} = \mathbf{37,528 \text{ cfm}}$$

When compared to the existing VAV system, this is approximately a 12% reduction in fan size, as shown in Table XXIX.

System	Existing SA (cfm)	Redesign SA (cfm)	Reduction (%)
RTU-1	14,175	12,500	11.8%
RTU-2	28,300	25,000	11.7%
Total	42,475	37,528	11.6%

Table XXIX: Parallel VAV System Supply Air

Step 11: Calculate the Final Mixed Supply Air Temperature of the System.

As shown in the Figure XXVIII on the previous page, the actual supply air of the DOAS/Parallel VAV System is supplied by air from both the DOAS unit and the VAV Air Handler. For this reason, we must calculate the actual mixed air temperature of the two air streams, using the following equation:

$$T_{S,MIX} = T_{S,VAV} \times \frac{CFM_{VAV}}{CFM_{TOTAL}} + T_{S,DOAS} \times \frac{CFM_{DOAS}}{CFM_{TOTAL}}$$

RTU-1

$T_{S,MIX}$ = 55^{O}F x (12,500cfm/16,000cfm) + 45^{O}F x (3,500cfm/16,000cfm) = **52.8^{O}F**

RTU-2

$T_{S,MIX}$ = 55^{O}F x (25,000cfm/32,000cfm) + 45^{O}F x (7,000cfm/32,000cfm) = **52.8^{O}F**

4.08: Annual Energy and Cost Analysis

Trane TRACE 700 was used extensively for the design load and energy simulation at the Hauptman-Woodward Medical Research Institute. By modeling design criteria into the Trane software, the program is able to estimate Heating and Cooling Loads, Ventilation Rates and Energy Consumption for each space, in addition to emissions and annual operation cost estimates.

Due to the fact that energy consumption data could not be obtained for the existing building, it was crucial that the building be modeled as closely as possible to the actual design in order to establish an appropriate base-case scenario. The following Figure XXX shows the estimated monthly energy and utility costs at the Hauptman-Woodward Medical Research Institute, based on data taken from Trane TRACE 700. A complete set of raw data from the simulation can be found in Appendix D.

	Original Design	Proposed Design	Savings	%
Cost ($/yr)	75,166	55,069	20,097	26.74%
Consumption (kWh/yr)	2,116,058	1,581,585	534,473	25.26%

Figure XXX: Annual Energy and Utility Costs for Base and Proposed Designs

As shown in Figure XXX, the proposed design reduces the annual electricity consumption by approximately 534,473 kWh and saves $20,097 annually on utility costs. This is most likely in part due to reduced chiller and pump sizes, in addition to reduced fan power required by the air-handling units.

4.09: Emissions Analysis

The Hauptman-Woodward Medical Research Institute receives its electricity from National Grid, a global energy generation and distribution company that serve approximately 3.4 million customers across 29,000 square miles in New York, Massachusetts, Rhode Island, and New Hampshire. In New York State, electricity is generated using a mix of technologies including nuclear, fossil fuel power plants, hydro, and others. By 2013, the state will require that 25% of the electricity sold in New York State come from clean renewable resources, such as wind, solar and hydro.

By knowing the amount of electricity and natural gas consumed by the HVAC system, we can determine the emissions that are exhausted by the building. At the present time, National Grid distributes power from the sources found in Figure XXXI. Nuclear and Hydro energy account for approximately 46% of the generated electricity in the area, which is ideal due to the fact that it does not release emissions into the atmosphere. Other sources, such as oil and coal, release NOx, SOx and other particulates due to the fact that these sources must be burned to utilize their energy.

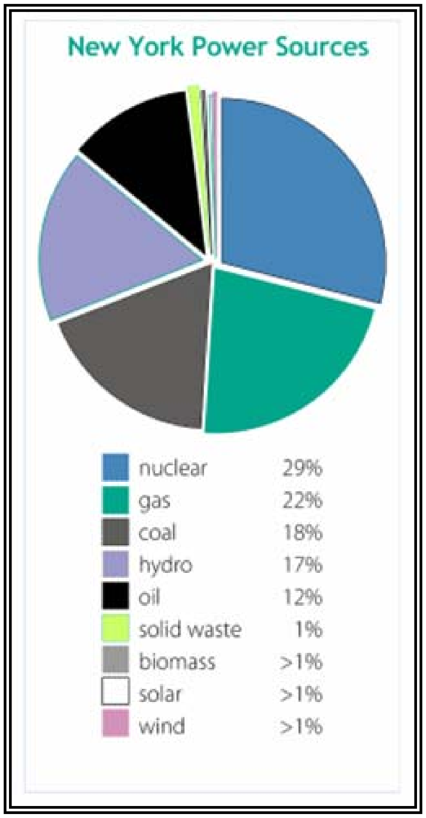


Figure XXXI: National Grid Electricity Generation Sources for New York State

Base Case			lbm Pollutant /kWh				lbm Pollutant			
Fuel	% Total	kWh	Particulates	SO_2/kWh	NO_x/kWh	CO_2/kWh	lbm Particulates	lbm SO_2	lbm Nox	lbm CO_2
Coal	18%	379387	1.80E-02	2.13E-02	1.40E-01	4.15E+01	6828.96	8080.94	53114.17	15736968.61
Oil	12%	252925	2.70E-02	3.80E-01	7.07E-02	3.35E+01	6828.96	96111.35	17886.83	8472974.10
Nat. Gas	22%	463695	0.00E+00	1.35E-03	2.54E-01	1.34E+02	0.00	625.99	117639.45	62158328.16
Nuclear	29%	611234	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydro	17%	358310	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wind	1%	21077	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar	1%	21077	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	***100%***	***2107705***					***13657.93***	***104818.28***	***188640.44***	***86368270.87***

Figure XXXII: Estimated Emissions for Existing Base Case at

DOAS Redesign			lbm Pollutant /kWh				lbm Pollutant			
Fuel	% Total	kWh	Particulates	SO_2/kWh	NO_x/kWh	CO_2/kWh	lbm Particulates	lbm SO_2	lbm Nox	lbm CO_2
Coal	18%	334656	1.80E-02	2.13E-02	1.40E-01	4.15E+01	6023.80	7128.17	46851.81	13881523.41
Oil	12%	223104	2.70E-02	3.80E-01	7.07E-02	3.35E+01	6023.80	84779.47	15777.91	7473979.98
Nat. Gas	22%	409024	0.00E+00	1.35E-03	2.54E-01	1.34E+02	0.00	552.18	103769.33	54829637.71
Nuclear	29%	539168	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydro	17%	316064	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wind	1%	18592	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Solar	1%	18592	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	***100%***	***1859199***					***12047.61***	***92459.83***	***166399.05***	***76185141.10***

Figure XXXIII: Estimated Emissions for Redesigned Case at

As shown in the preceding Figures XXXII and XXXIII, the DOAS scenario that has been proposed consumes approximately %25 less electricity as compared to the existing mechanical system at the Hauptman-Woodward Medical Research Institute. Likewise, the emissions were reduced by approximately the same amount as a direct result of this reduction in the building electrical load.

4.10: First Cost Analysis

One of the primary factors in mechanical system design is the first cost of the system. Although customers tend to prefer spending the least amount of money up-front on their mechanical systems, the prospect of saving money in the future on energy costs may entice the owner to spend more money up front. CostWorks was used to analyze the equipment costs of the existing system and the proposed alternative. CostWorks is a program that utilizes the R S Means catalog to determine equipment and labor costs. A summary of the existing system costs versus the proposed system costs is shown below. Based upon the load calculations for the DOAS design with VAV and Chilled Beam Parallel Systems, the chiller capacity is reduced to half the original size. In addition, the amount of supply air required is significantly reduced due to the fact that the dedicated outdoor air units are only supplying the necessary ventilation air to the space. This allowed for a 55% decrease in the size and cost of the air-handling units. Due to these reductions in initial costs, the added cost of the chilled beam parallel system to meet the sensible loads to the space were covered. Other reductions in initial cost that were not considered but would further improve this scenario would be a reduction in a reduced plenum height and a reduced electrical service due to smaller mechanical equipment. A complete breakdown of the initial costs of each alternative is shown in Figure XXXIV.

	Existing System	**Proposed DOAS Systems**
Chiller [tons}	300	150
Boilers [mbh]	10,200	5100
AHU's	$154,500	$72,025
Chiller	$163,500	$97,500
Pumps (Primary)	$10,850	$5,150
Boilers	$21,000	$10,500
Pumps (Boiler)	$30,900	$15,450
Parallel Systems		
VAV	$137,770	$98,070
Chilled Beams		$187,000
Pumps (Parallel)		$5,150
Piping (Parallel)		$7,500
Ductwork	$304,000	$76,000
Totals:	**$822,520**	**$574,345**

Figure XXXIV: Mechanical System First-Cost

4.11: Depth Results and Conclusions

The task of providing an alternative mechanical system at the Hauptman-Woodward Medical Research Institute has been a sensitive one. The existing system is a prime example of a standard laboratory mechanical system with 100% outdoor air handling units which are proven to provide clean air and are trusted by owners whose main concern is indoor air quality. Alternatives must provide identical indoor air quality and there are few options which do so.

The incorporation of a dedicated outdoor air system in this setting has proven to live up to the task of the existing 100% outdoor air system. Based on existing case studies at the Johns Hopkins Ross Research Institute, DOAS systems have proven to be a viable alternative for over 20 years. With the use of SEMCO's desiccant wheel equipped with a 3Å molecular sieve material, "selective absorption" takes place allowing water vapor to pass through without trapping pollutants.

A first-cost analysis done with Costworks shows that the proposed system is approximately 30% cheaper than the existing system. This is in part due to smaller air handling units and supporting equipment based on the nature of a DOAS system. In addition, the energy analysis completed with Trane TRACE 700 has shown a reduction in electricity and as a result a savings of over $20,000 in yearly utility bills.

As a result of the reduced electric and natural gas loads, building emissions were also reduced with the incorporation of the dedicated outdoor air systems. An initiative set forth by the State of New York has mandated that by 2013, twenty-five percent of all electricity must be generated by renewable resources. This will further reduce the building emissions in the coming years.

Based on the results of this report, it is recommended that dedicated outdoor air systems are incorporated into the design at Hauptman-Woodward Medical Research Institute. The provide an energy efficient alternative to the 100% outdoor air systems and DX Rooftop units that are currently serving the space, and drastically reduce energy consumption, first costs, and annual utility costs to the owner.

Section 05:

Wind Energy Feasibility Breadth

5.01: Historic Background:

Western New York has a rich history and vibrant present in renewable energy. Perhaps the greatest example of such technology was the emergence of hydroelectric power at Niagara Falls, over a century ago. Even today, it is still a significant contributor to the region's electric supply. The city of Buffalo also has a distinct advantage in the ability to harvest wind power, due to its close proximity to the Great Lakes.

It has been observed over time that as winds move over large bodies of water, their speeds increase drastically as compared to winds over forested and urbanized land. Buffalo, New York has a strong reputation of taking the brunt force of these winds year around, and blows in the harsh lake-effect snowstorms that have grown to be associated with the region. Some of the best wind sites are along the eastern shorelines of the lakes, where prevailing westerly winds have traveled considerable distances across bodies of water. These factors ultimately make wind power a significantly larger renewable energy source than the total hydroelectric potential of the Great Lakes. Appendix E-1 contains wind maps detailing the average yearly wind speeds in the region.

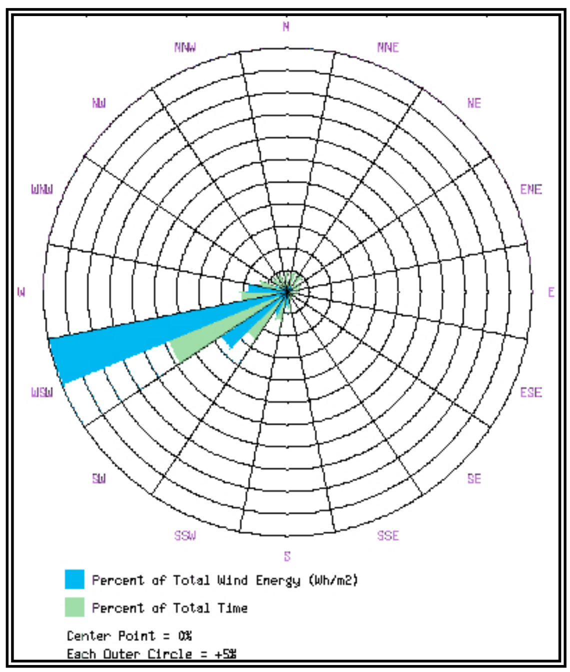


Figure XXXV: Wind Rose for Buffalo, NY

As shown on the wind map in Figure XXXV, prevailing winds tend to flow across Lake Erie from the west-southwest direction to the east-northeast direction, paralleling the major orientation of the lake.

Figure XXXV1: Wind Farm in Ontario, NY

The winds for the Great Lakes region are constantly monitored by more than a dozen stations by the National Oceanic and Atmospheric Administration (NOAA). According to the NOAA, the average yearly wind speed for Buffalo, NY is 5.5 m/s. With this average wind speed, I suspect that wind power could be a viable supplement to the electric power supply at the Hauptman Woodward Institute.

5.02: Economic Background:

The New York State Energy Research and Development Authority (NYSERDA) is a public benefit corporation that was founded in 1975, and provides cash incentives for wind turbines to be used in community, planning, economic development and educational buildings. Under the terms of the program, buildings such as the Hauptman Woodward Medical Research Institute are eligible for 70% of the total funding provided the project can increase community knowledge of wind power and spur knowledge of renewable energy in the region. New York State has a very progressive renewable energy program, in that currently 18% of all electricity generation within the state is done by means of renewable sources. NYSERDA is currently supporting extensive wind resource efforts and encouraging the development of upwards of 500MW across the state. Although the generation at HWI would only be a small fraction of this amount, other sites across the state are cooperating in the efforts to provide New York State with upwards of 25% of the total electricity generation by renewable resources over the next 10 years.

In addition to the NYSERDA first-cost incentives, the New York State legislature recently passed a bill requiring New York's utility co

Figure XX: Wind Farm in Ontario, NY

turbine owners for excess electricity provided to the grid. This policy of "net-metering" will allow wind generation to offset normal electricity usage and run the electric meter backwards when the turbine produces more electricity than the building uses. This allows owners to receive actual retail price for the electric power their wind turbine produces.

5.03: Wind Turbine Analysis:

One of the greatest concerns facing this retrofit was the location of the actual wind turbines. Upon consultation with the engineers at Cannon Design, it was found that the structural members of the building had been oversized to allow extra rigidity as well as for possible expansion to the rooftop penthouse. Of greater concern in this redesign is the architectural impact on the site. Due to the high-design of the building, it was necessary to incorporate the turbines in such a way that they would be aesthetically pleasing

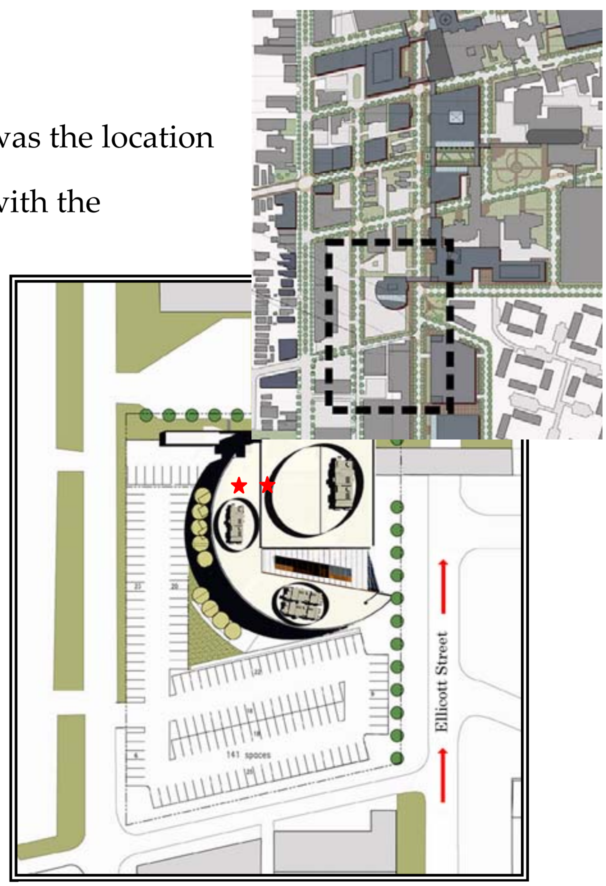
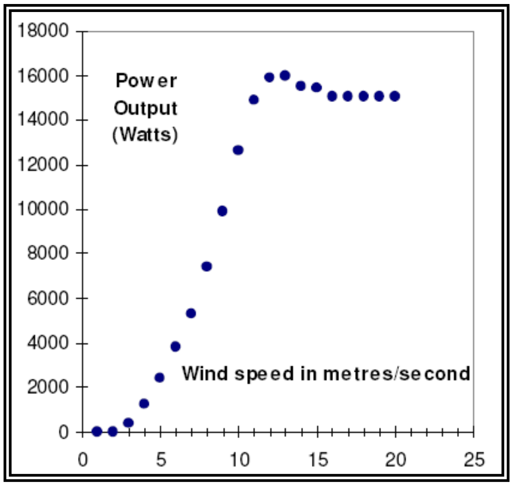


Figure XXXVII: Site and Location of Turbines

Figure XXXVIII: Proven 6kW Turbine Power



to those approaching the building. In this respect, I have decided to locate the wind turbines along the north-facing wall, while the blades will face in the south-westerly direction. (Figure XXXVII) In this respect, attention will not be taken away from the aluminum-clad façade. Due to the northern one-way flow of vehicular traffic on Ellicott Street, the north façade of the building will be the least obtrusive location for the turbines to be placed. After researching a number of small to medium size wind turbines, I have decided to incorporate two 6kW wind turbines by Proven Energy, Ltd. into the design at the Hauptman Woodward Medical Research Institute. Figure XXXVII shows the power curve for the turbine as published by the manufacturer. The highest output is between 15-20 m/s, however the

Manufacturer	Proven Energy, Ltd.
Rated Output @ 12.5 m/s	6 kW
Rated Output @ 5.5 m/s (Buffalo, NY)	1 kW
Rotor Diameter	5.5m
Total Weight	860 kg

Table XIL: Rooftop Wind Turbine Specifications

average wind speed in Buffalo, NY is approximately 5.5 m/s. Although this value is considerably less than the maximum output, Proven Energy, LTD actually anticipates an average wind speed of 5 m/s in its calculations. As shown in Table XIL, the anticipated rated output at the Hauptman Woodward Institute would be approximately 1kW per turbine. Although I had originally anticipated using one 15kW turbine, the initial cost was actually cheaper to install two 6kW turbines which provided the same power output at wind speeds found on site. In addition, the roof will not be as cluttered and the architecture of the building and surrounding area will not be as affected. Cut sheets from the manufacturer can be found in Appendix E-2.

5.04: Turbine Payback and Conclusions:

A summary of the installation costs are found below in Table XLI. As noted, a majority of the project cost would be subsidized by the New York State Energy Research and Development Authority. With a peak electric rate of 9.5c per kWh in Buffalo, NY, the payback period was found using the method below.

Figure XL: Proven 6kW Wind Turbine

Table XLI: Rooftop Wind Turbine Costs

Proven 6kW Wind Turbine w/Grid Connect	$18,160
Isolation and Rectification Controller	$1,090
Tilt-up self-supporting mast (9m)	$6,860
Total Cost per Turbine	$26,110
Total Installed Cost	$52,220
Total Cost with 70% NYSERDA discount	**$15,666**

$$\text{Payback Period (years)} = \frac{\text{Initial Investment}}{\text{Annual Savings}}$$

Assume Annual Savings at Peak Electric Rate:

Annual Savings = 12,000 kWh * $0.0095/kWh = $1,140

$$\text{Payback Period} = \frac{\$15,700}{\$1,140} = \textbf{14 years}$$

Table XLII: Wind System Payback

No. Units	2
Total Weight	1720 kg
Initial Investment	$15,700
Total Power Output	2 kW
Annual Electric Savings	12,000 kWh
Payback	**14 years**

According to the payback calculation described above, the Hauptman Woodward Medical Research Institute would require a 14 year payback on the wind turbine and related equipment before seeing a profit. Although this length of time is somewhat high, these units have a typical life span of 20-25 years provided they are maintained properly. In that case, this system would prove profitable for perhaps a decade or more. It is important to note that this is only the case when NYSERDA subsidizes the cost of the units. Had the owner been forced to pay the full installation costs, the payback period would be 46 years – well beyond the life span of the units. A summary of the findings can be found in Table XLII.

Section 06:
ASHRAE Std. 92.1-2004 Lighting Power Density Breadth

6.01: Purpose and Background

The purpose of ASHRAE Standard 90.1-2004 is to provide minimum requirements for the energy-efficient design of buildings. In the second technical assignment, an analysis was done on the lighting system to determine whether or not the Hauptman-Woodward Medical Research Institute was compliant with the standard. Since there are no provisions for a laboratory mixed-use building, the building area method was not used in the calculation of the total power density at HWI. Instead, the space-by-space method was utilized as prescribed in Section 9 of ASHRAE Std. 90.1-2004. Building area types were taken from Table 9.6.1 of the standard. For a complete breakdown of the lighting power density of each space at the Hauptman Woodward Institute, consult Appendix B-1.

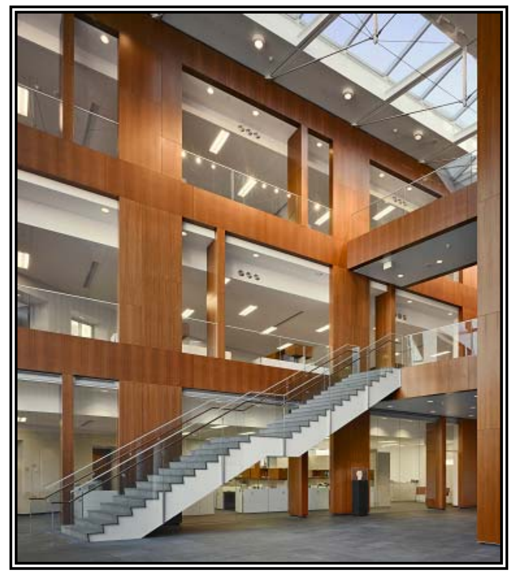


Figure XLIII: Atrium Task and Accent Lighting

6.02: Lighting System Redesign

After completing the power density calculations in the second technical assignment, it was determined that a majority of the spaces outside of the laboratory area did not comply with Standard 90.1-2004. There could be many reasons for this to be the case. First and foremost, the Standard has changed since the last revision in 1999, and could account for some discrepancies. In addition, many of the spaces within the Hauptman Woodward Institute have redundant lighting systems that provide architectural merit to the building. Upon inspection, each lighting system is switched independently, which allows for the building occupants to monitor the light output at any one time. Upon further inspection of Standard 92.1-2004, I discovered that there is a provision in section 9.6.3 that discusses the increase of the interior lighting power allowance. It states:

9.6.3 (a) An increase in the interior lighting power allowance is permitted for spaces in which lighting is specified to be installed in addition to the general lighting for the purpose of decorative appearance, such as chandelier-type luminaires or sconces, or for highlighting exhibits, provided the additional lighting power shall not exceed 1.0 W/ft². (Taken from ASHRAE Std 92.1-2004, Copyright ASHRAE)

After going through each space and applying this provision where appropriate, it appears that many spaces still do not pass the requirements of Standard 92.1-2004. The provision did help substantially in many areas, including the atrium, individual offices, seminar and classrooms, and other high-profile areas. The first step of the redesign is to determine how to reduce power consumption without sacrificing lighting quality. Since only a handful of spaces in the laboratory core were above the power allowance, I decided to keep those spaces as is, since there are no specific provisions for the work that is being done at HWI and there could be reasons why these areas have excess lighting requirements. However, in the South and West wings, there is plenty of room for improvement.

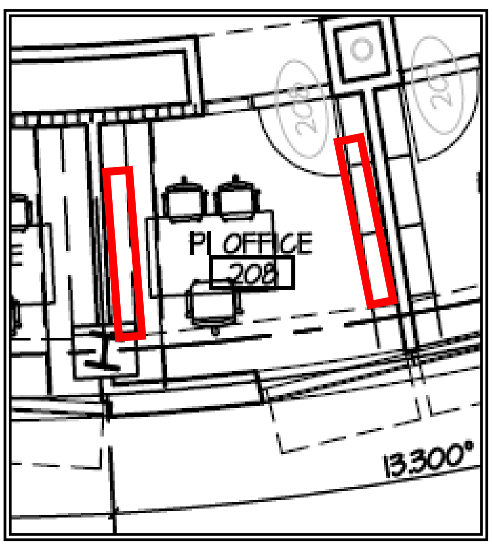


Figure XLIV: Typical Office Space (120

For example, a typical office at the Hauptman-Woodward Institute is approximately 120 square feet, and contains two indirect fixtures, as shown in Figure XLIV. Each fixture is equipped with 2xF39 T5 lamps which brings the total power density to the space to 1.3 W/ft². If the lamps were replaced with 2x28W T5 lamps designed to work in the same ballast, then the new power density of the space would be 1.07 W/ft² while only sacrificing 7% lumen output. This data is shown in the following, Table XLV.

	Lamp	Watts	Length	Lumens (25°C)	2 lamp Fixture
Origional	39W T5	39W	45.2"	3100	78W
Retrofit	28W 75	28W	45.2"	2900	58W

Table XLV: Original and Redesign Lamp Choices for Office 208.

This change reflects all of the private office spaces, and has been adjusted accordingly. In addition to the office space, the second area of main concern was the Seminar and Lecture spaces. These spaces have very high lighting loads to do decorative fixtures, as shown in Figure XLVI. According to the initial ASHRAE 90.1 Analysis done in the second technical assignment, the larger lecture hall currently has a power density of 3.25 W/ft². According to Standard 90.1-2004, the space is allotted 2.75 W/ft², in accordance with the provisions for decorative lighting (+1.0 W/ft²) and visual display lighting (+0.35 W/ft²). Each fluorescent fixture is equipped with 2xF3239 T85 lamps, and pendant fixtures are fitted with 2xCF26W bulbs.

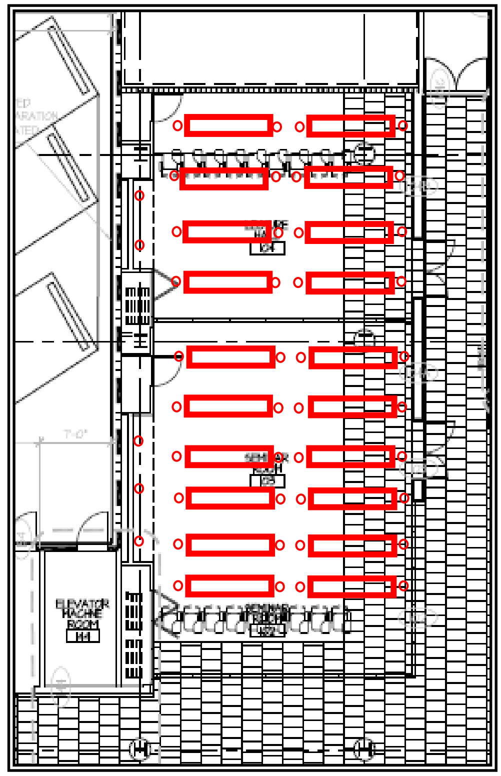


Figure XLVI: Seminar and Lecture

After researching the different bulb-type alternatives, it was not cost-effective to replace the bulbs with lower watt-bulbs due to the higher initial cost. The first cost of a typical 32W T8 lamp is approximately $2.68. In comparison, an energy-saving 28W T8 lamp costs approximately $11.65, as found on the Osram-Sylvania website. Since the building is already complete, I would recommend that the space be left untouched; however if the building still had been under construction, I would have recommended the removal of a handful of the pendant fixtures, as the remainder of them can achieve the same task while conserving energy.

6.03: LPD Redesign Conclusions

After these major spaces were addressed, it was found that all were in compliance with the standard. The only exceptions were corridor and storage spaces, as shown in Appendix B-2.

A quick check of the total building power density shows that the building indeed has an acceptable amount of energy used for lighting. The total output is approximately 1.33 W/ft², as compared to the original design of 1.46W/ft², a reduction of approximately 9%. This reduction in energy will in turn reduce annual energy use and therefore reduce annual electric costs and emissions.

It is important to note that most of the wattage from building lighting will end up as sensible heat that will in turn be removed by the building mechanical system. We can estimate that 98% of the input wattage will result in heat that must be removed. Therefore, with a drop of 35,350 Btu/hr, the lighting redesign reduces the building cooling load by 2.97 tons, as shown in Table XLVII.

	W	LPD	Btu/hr
Original	108,040	1.46	368,653
Redesign	97,680	1.32	333,302
Difference			35,351
			2.95 ton

Table XLVII: Reduction in Cooling Load due to Lighting Redesign

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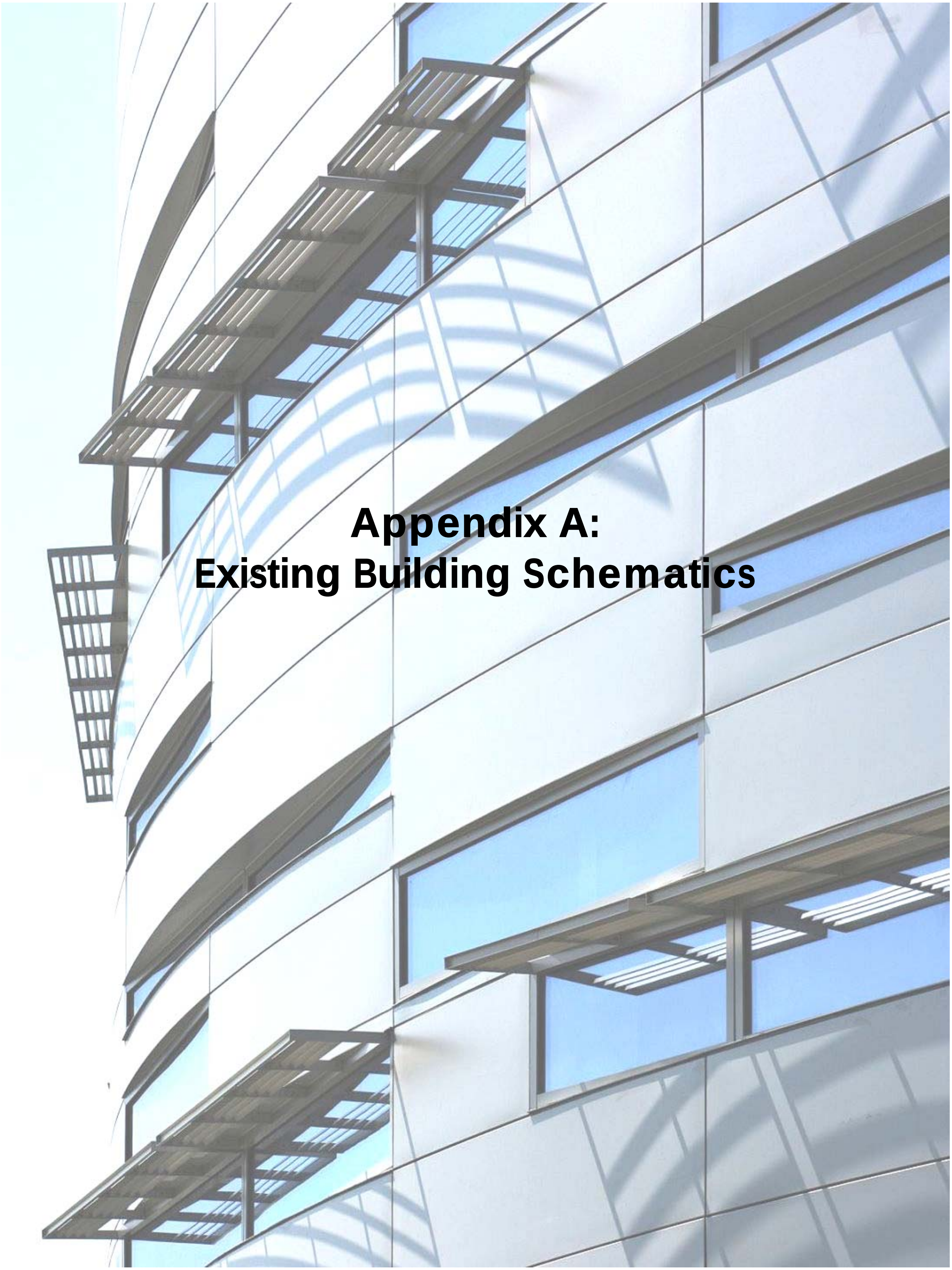
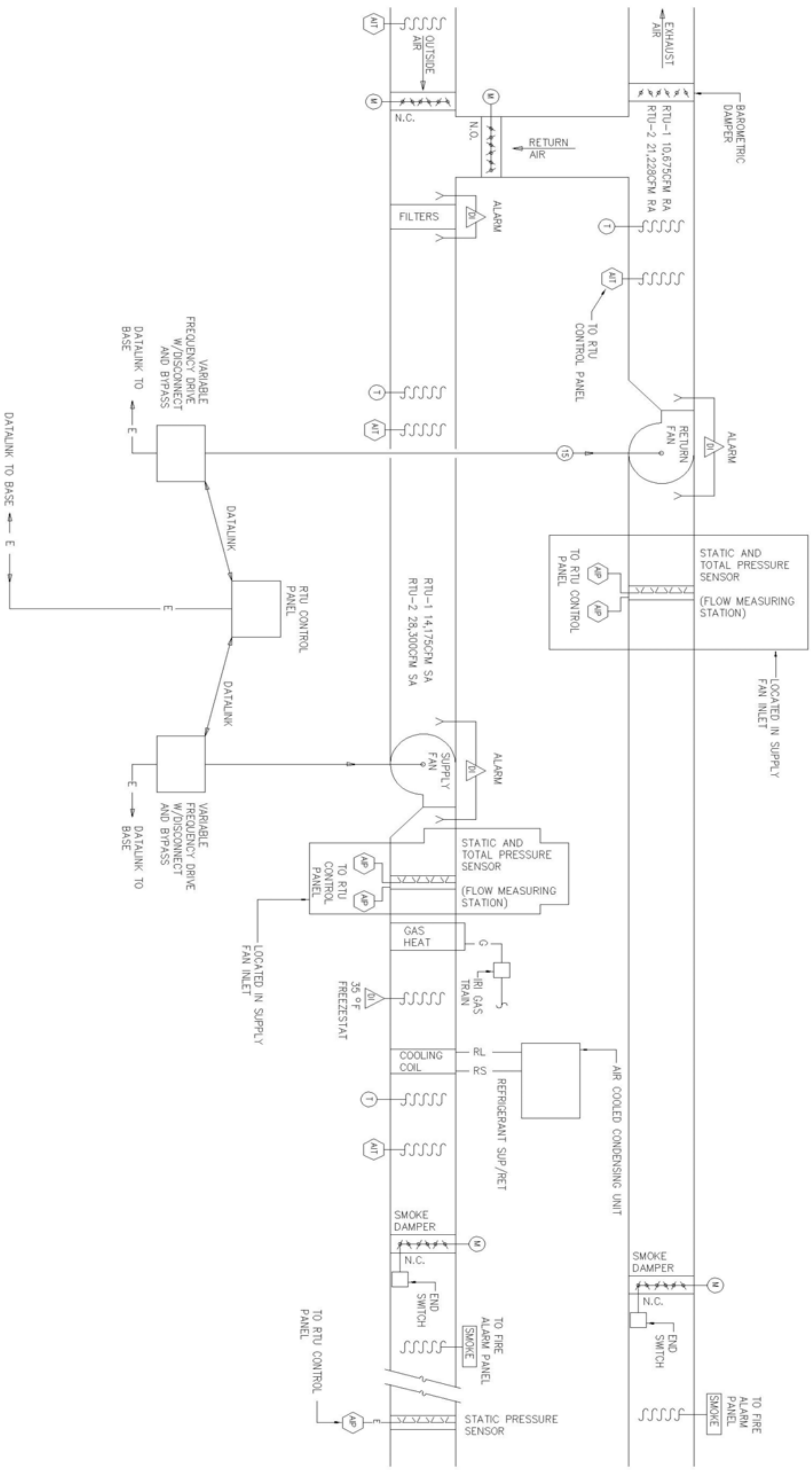
Appendices

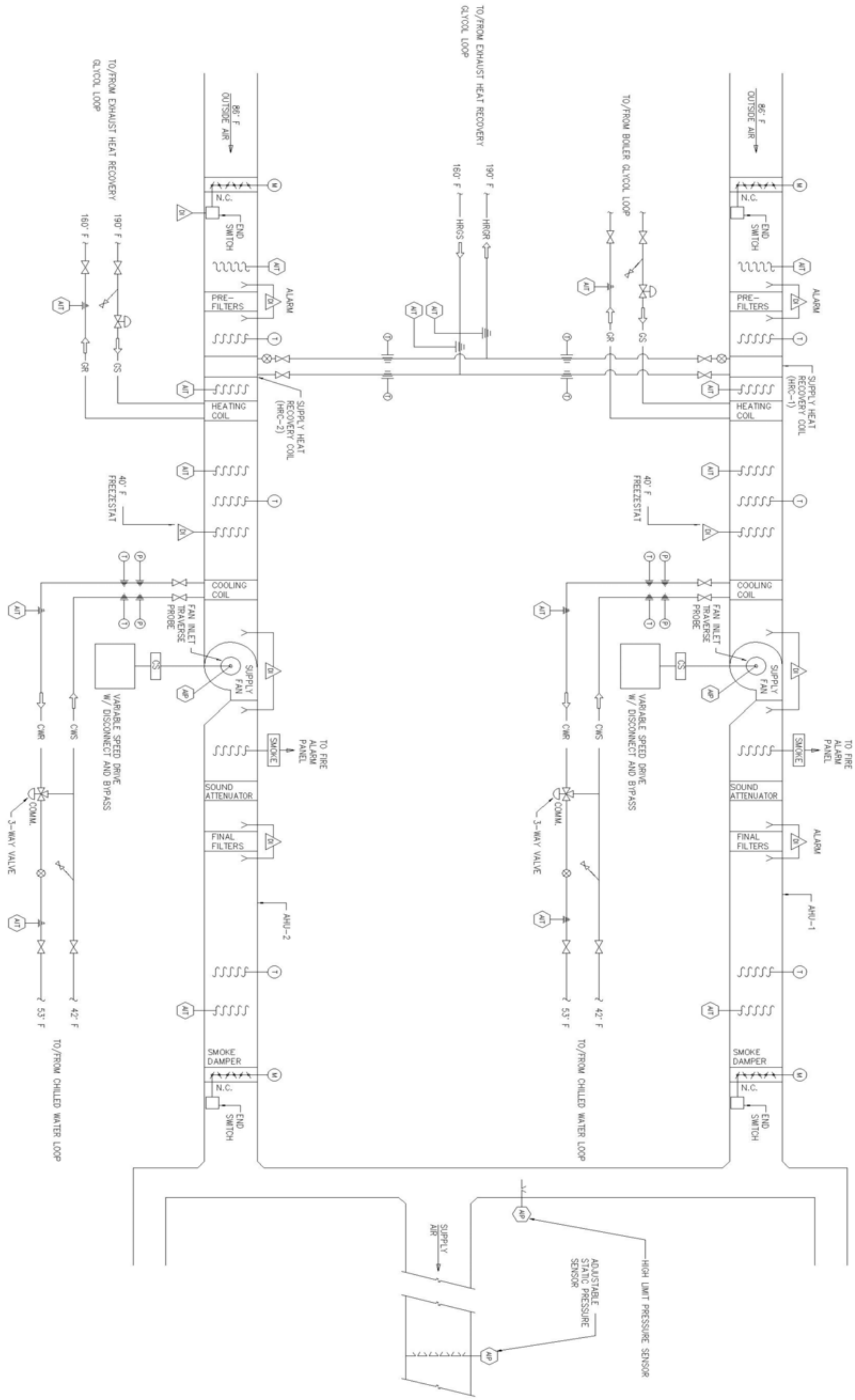
Appendix A:
Existing Building Schematics



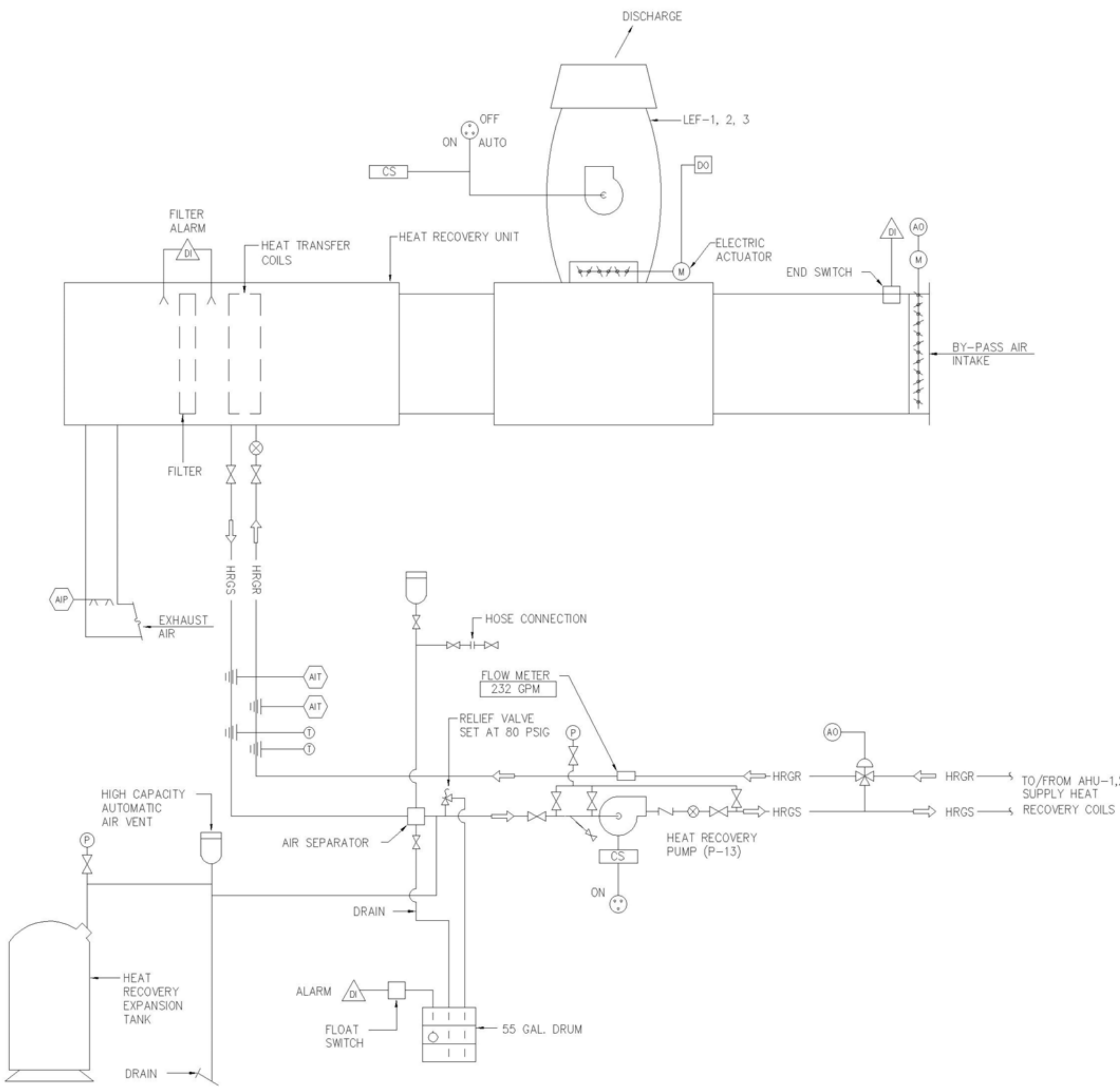
A.1 – Rooftop Units (RTU-1, RTU-2) Flow and Control Schematic



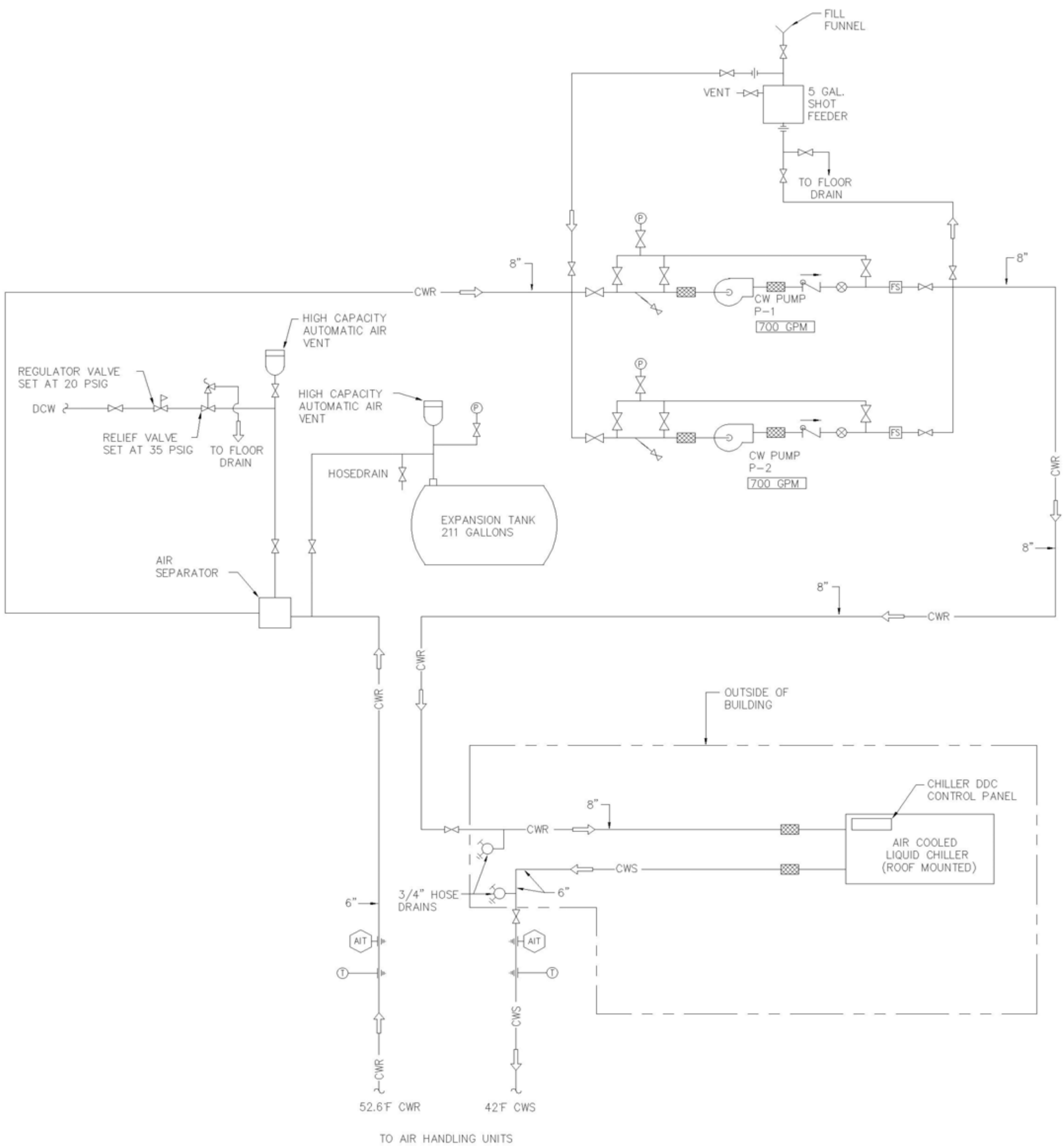
A.2 – Laboratory Air Handling Units (AHU-1,2) Flow and Control Schematic



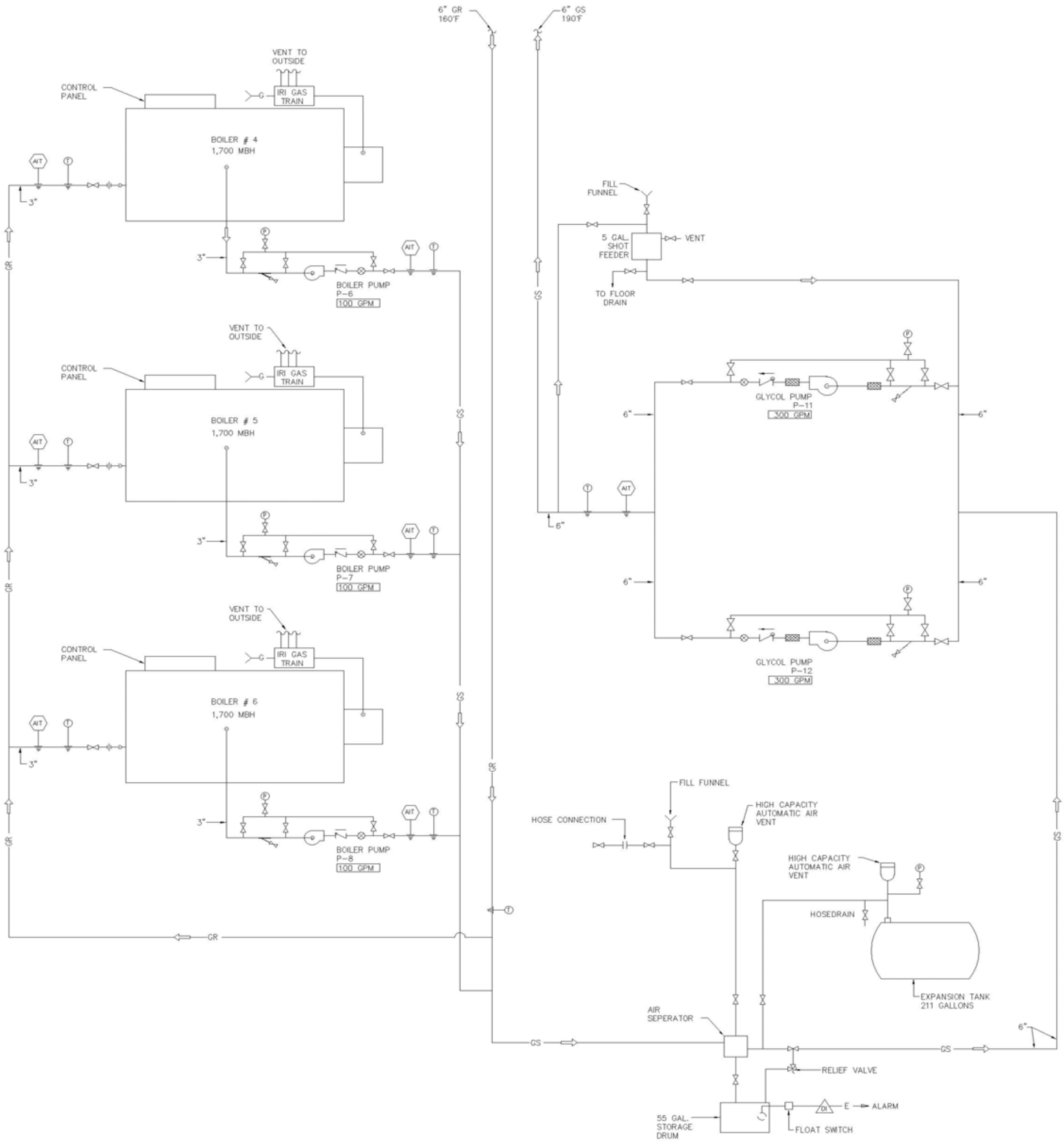
A.3 – Laboratory Heat Recovery System



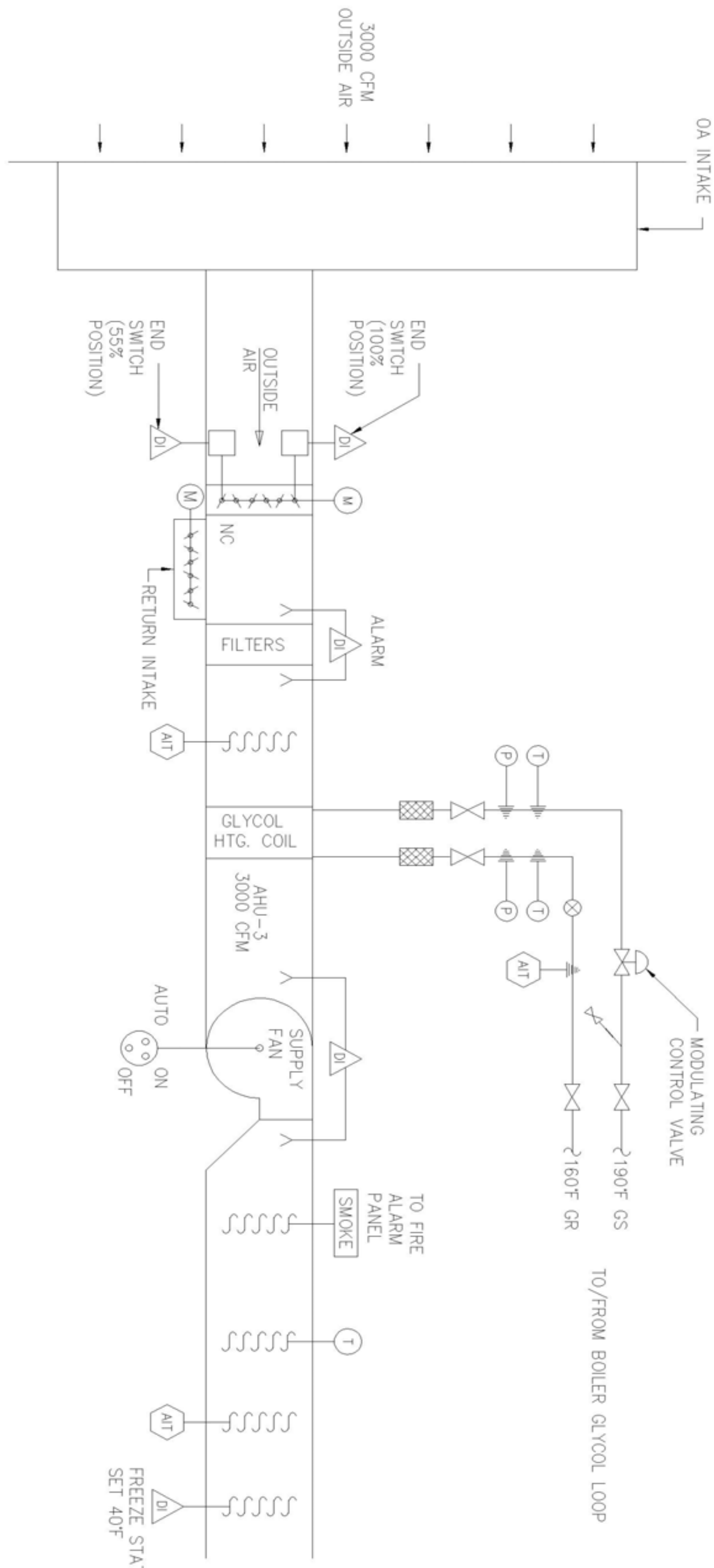
A.4 – Chilled Water System



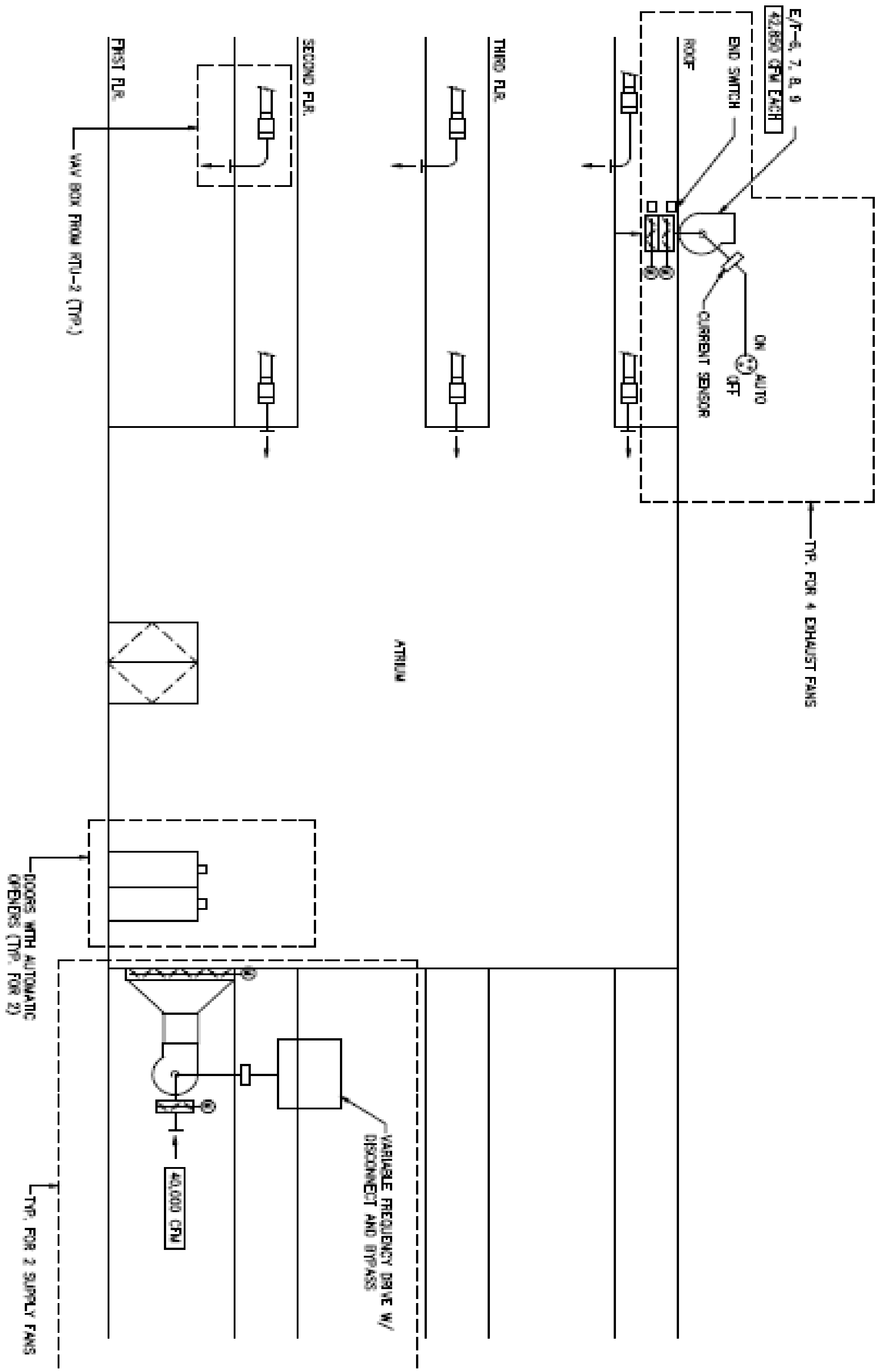
A.5 – Hot Water Boiler System



A.6 – Penthouse Air-Handling Unit



A.7 – Atrium Smoke Exhaust System



Appendix B:

ASHRAE Standard 92.1-2004 Lighting Power Densities by Space

B.1: Existing Lighting Power Densities by Space

Zone 1 - West Wing, Floors 1-3 Design											
Room Number	**Room Name**	**Space Discription**	**Area (sq.ft)**	**Lamp**	**Wattage Per Lamp**	**Lamps per Fixture**	**Number of Fixtures**	**Watts**	**Power Density (W/SqFt)**	**Required PD (W/sqft)**	**Std 90.1 Compliant ?**
103	Seminar Room	Lecture Room	830	PC1	26	2	5	260	0.31	2.4	No
			830	FF2	32	2	12	768	0.93		
			830	PB2	26	2	4	208	0.25		
			830	PB2D	26	2	24	1248	1.50		
104	Lecture Room	Lecture Room	550	PC1	32	3	3	288	0.52	2.4	No
			550	FF2	32	2	8	512	0.93		
			550	PB2	26	2	3	156	0.28		
			550	PB2D	26	2	16	832	1.51		
114	Shower/Locker	Restroom	120	PC1	26	2	3	156	1.30	1.2	No
115	Storage	Storage	290	FC1	32	3	4	384	1.32	1.2	No
116	Storage	Storage	490	FR4	32	2	9	576	1.18	0.8	No
117	Purchasing	Office	350	FD1	32	4	4	512	1.46	1.1	No
119	Building Facilities	Office	210	FD1	32	4	2	256	1.22	1.1	No
120	Receiving/Storage/Loading	Shipping/Receiving	310	FR4	32	2	4	256	0.83	0.8	No
144	Elevator Machine Room	Mechanical	110	FR4	32	2	2	128	1.16	1.4	Yes
147	Telecommunications	Electrical	225	FR4	32	2	4	256	1.14	1.4	Yes
148	Electrical Room	Electrical	680	FR4	32	2	9	576	0.85	1.4	Yes
150	Elevator Machine Room	Mechanical	130	FR4	32	2	1	64	0.49	1.4	Yes
151	Plumbing	Mechanical	380	FR4	32	2	6	384	1.01	1.4	Yes
152	Generator	Electrical	300	FR6	48	2	6	576	1.92	1.4	No
154	Fan Room	Mechanical	255	FR6	48	2	5	480	1.26	1.4	Yes
202	Lunch Room/Kitchen	Multi-Purpose	1250	PC1	26	2	37	1924	6.41	1.2	No
			1250	PK1	150	1	4	600	2.35		
			1250	FX1	25	1	3	75	0.06		
219	IT Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
220	IT Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
221	Computer/ Visual Room	Computer Lab	270	FN3	39	4	2	312	1.16	1.1	No
			270	PL2	50	1	2	100	0.37		
223	Conferece Room	Conference Room	440	PC2	18	2	2	72	0.16	1.3	No
			440	PB2D	26	2	10	520	1.18		
224	Server Room	Computer Room	350	FH3	32	3	4	384	1.10	1.1	Yes
225	Mens Restroom	Restroom	210	PC1	26	2	5	260	1.24	0.9	No
			210	FW2	25	1	2	50	0.24		
226	Womens Restroom	Restroom	190	PC1	26	2	5	260	1.37	0.9	No
			190	FW2	25	1	2	50	0.26		
227	Corridor	Corridor	780	FN3	39	4	10	1560	2.00	0.5	No
229	Elevator Vestibule	Corridor	250	PC1	26	2	3	156	0.62	0.5	No
230	Telephone	Office Space	60	FR4	32	2	1	64	1.07	1.1	Yes
231	Electrical	Mechanical Room	140	FR4	32	2	3	192	1.37	1.4	Yes
262	Storage	Storage	60	FA1	32	2	1	64	1.07	0.8	No
	Corridor	Corridor	330	PC1	26	2	11	572	1.73	0.5	No
301	Library	Library	1200	PC1	26	2	30	1560	1.30	1.3	Yes
319	ACA Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
320	ACA Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
321	IT Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
322	IT Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
323	IT Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
324	Conferece Room	Conference Room	440	PC2	18	2	2	72	0.16	1.3	No
			440	PB2D	26	2	10	520	1.18		
325	IT Room	Office Space	350	FH3	32	3	4	384	1.10	1.1	Yes
326	Mens Restroom	Restroom	210	PC1	26	2	7	364	1.73	0.9	No
			210	FW2	25	1	2	50	0.24		
327	Womens Restroom	Restroom	190	PC1	26	2	8	416	2.19	0.9	No
			190	FW2	25	1	2	50	0.26		
328	Corridor	Corridor	780	FN3	39	4	10	1560	2.00	0.5	No
330	Elevator Vestibule	Corridor	250	PC1	26	2	3	156	0.62	0.5	No
331	Electrical	Mechanical Room	120	FR4	32	2	2	128	1.07	1.4	Yes
331	Telephone	Office Space	80	FR4	32	2	2	128	1.60	1.1	No
262	Storage	Storage	60	FA1	32	2	1	64	1.07	0.8	No
	Corridor	Corridor	330	PC1	26	2	11	572	1.73	0.5	No
100	Parking	Parking	7650	FR5	32	2	46	2944	0.38	0.2	No

Zone 2 - South Wing, Floors 1-3 Design

Room Number	Room Name	Space Discription	Area (sq.ft)	Lamp	Wattage Per Lamp	Lamps per Fixture	Number of Fixtures	Watts	Power Density (W/SqFt)	Required PD (W/sqft)	Std 90.1 Compliant ?
AT	Atrium	Atrium	4800	PF3	42	1	25	1050	0.22	0.6	No
			4800	PF2	32	1	25	800	0.17		
			4800	PC1	26	2	6	312	0.07		
			4800	PG1	350	1	9	3150	0.66		
			4800	PY2	100	1	14	1400	0.29		
			4800	PY3	70	1	14	980	0.20		
			4800	PP1	32	2	9	576	0.12		
121	Open Office	Office Space	1115	FK1	32	2	15	960	0.86	1.1	No
			1115	PF3	42	1	7	294	0.26		
			1115	PC2	18	2	7	252	0.23		
122	Personnel Manager	Office Space	105	FN3	39	4	2	312	2.97	1.1	No
123	Accounting	Office Space	110	FN3	39	4	2	312	2.84	1.1	No
124	Accounting	Office Space	110	FN3	39	4	2	312	2.84	1.1	No
125	Development	Office Space	110	FN3	39	4	2	312	2.84	1.1	No
126	Development	Office Space	110	FN3	39	4	2	312	2.84	1.1	No
127	Conference	Conference	190	FQ1	150	2	4	1200	6.32	1.3	No
			190	PC1D	26	2	3	156	0.82		
128	Development	Office Space	200	PL2	50	1	2	100	0.5	1.1	No
			200	FN3	39	4	1	156	0.78		
			200	FN4	54	4	1	216	1.08		
129	Board Member	Office Space	200	PL2	50	1	2	100	0.5	1.1	No
			200	FN3	39	4	1	156	0.78		
			200	FN4	54	4	1	216	1.08		
130	CFO	Office Space	200	PL2	50	1	2	100	0.5	1.1	No
			200	FN3	39	4	1	156	0.78		
			200	FN4	54	4	1	216	1.08		
131	Vice President	Office Space	200	PL2	50	1	2	100	0.5	1.1	No
			200	FN3	39	4	1	156	0.78		
			200	FN4	54	4	1	216	1.08		
132	President	Office Space	200	PL2	50	1	2	100	0.5	1.1	No
			200	FN3	39	4	1	156	0.78		
			200	FN4	54	4	1	216	1.08		
133	Executive Director	Office Space	200	PL2	50	1	2	100	0.5	1.1	No
			200	FN3	39	4	1	156	0.78		
			200	FN4	54	4	1	216	1.08		
134	Board Room	Conference Room	775	PC3	18	2	1	36	0.05	1.3	No
			775	PW2D	26	2	9	468	0.60		
			775	PC1D	26	2	8	416	0.54		
			775	FQ1	150	2	5	1500	1.94		
135	Mens Restroom	Restroom	230	PC1	26	2	7	364	1.58	0.9	No
			230	FW2	25	1	2	50	0.22		
136	Womens Restroom	Restroom	220	PC1	26	2	8	416	1.89	0.9	No
			220	FW2	25	1	2	50	0.23		
137	Corridor/Kitchenette	Corridor	460	PC1	26	2	34	1768	3.84	0.5	No
			460	FX1	25	1	2	50	0.11		
139	Workroom Storage	Storage	300	FD1	32	4	3	384	1.28	0.8	No
140	Graphics	Office Space	340	FH3	32	3	7	672	1.98	1.1	No
145	Telephone Room	Electrical Room	90	FR4	32	2	1	64	0.71	1.5	Yes
146	Electrical Closet	Electrical Room	30	FR4	32	2	1	64	2.13	1.5	No
143	Reception	Office Space	530	FK1	32	2	5	320	0.60	1.1	No
			530	PB2	26	2	4	208	0.39		
			530	FR2	32	2	2	128	0.24		
			530	PF3	42	1	2	84	0.16		
204	Open Office	Office Space	2325	FK1	32	2	37	2368	1.02	1.1	No
			2325	PF3	42	1	17	714	0.31		
			2325	PC2	18	2	17	612	0.26		

Zone 2 - South Wing, Floors 1-3 Design

Room Number	Room Name	Space Discription	Area (sq.ft)	Lamp	Wattage Per Lamp	Lamps per Fixture	Number of Fixtures	Watts	Power Density (W/SqFt)	Required PD (W/sqft)	Std 90.1 Compliant ?
205	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
206	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
207	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
208	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
209	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
210	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
211	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
212	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
213	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
214	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
215	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
216	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
217	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
218	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
302	Open Office	Office Space	2325	FK1	32	2	37	2368	1.02	1.1	No
			2325	PF3	42	1	17	714	0.31		
			2325	PC2	18	2	17	612	0.26		
305	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
306	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
307	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
308	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
309	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
310	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
311	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
312	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
313	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
314	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
315	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
316	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
317	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No
318	PI Office	Office Space	120	FN3	39	4	2	312	2.60	1.1	No

B.2- Redesign Lighting Power Densities by Space

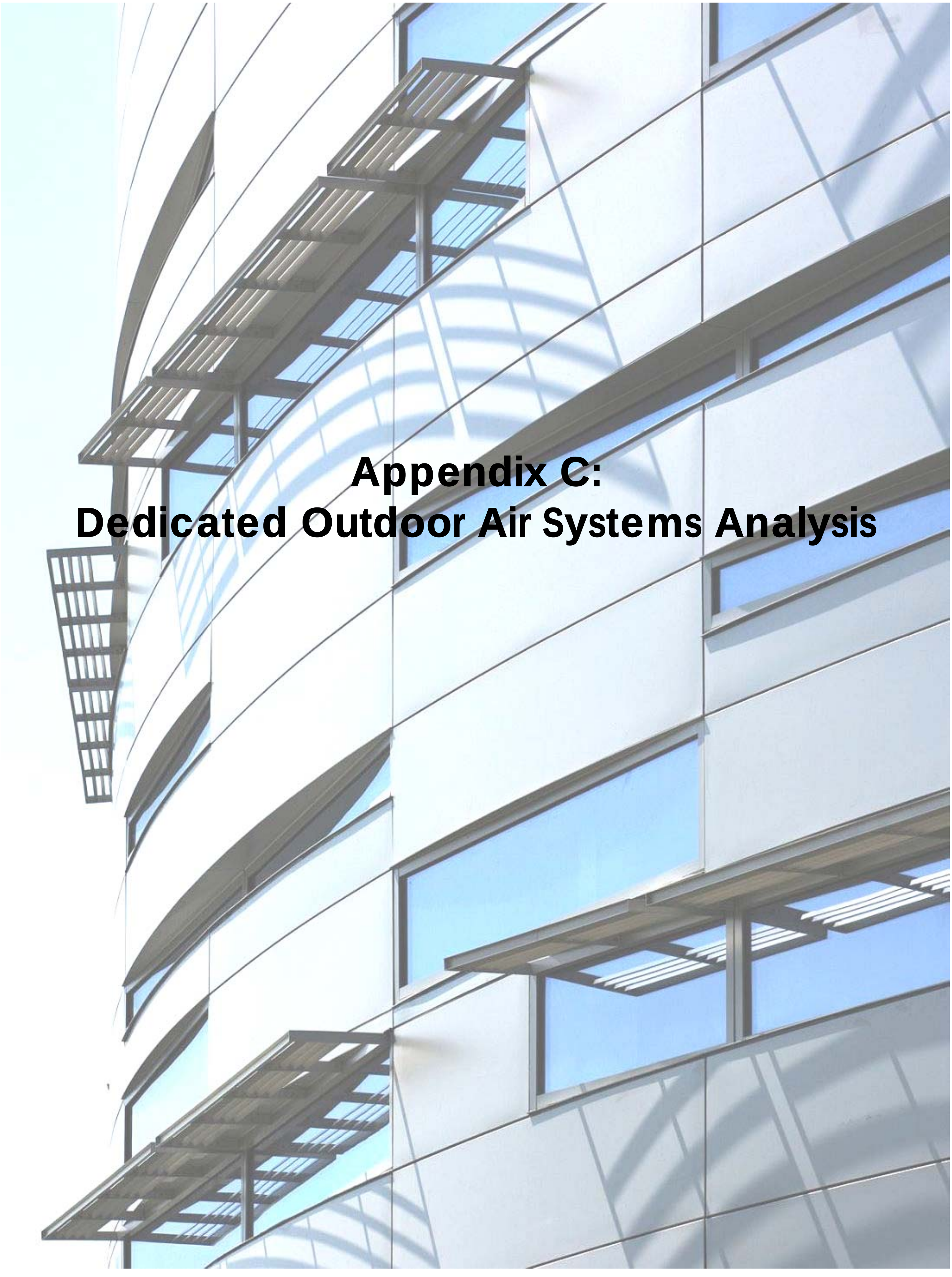
Zone 1 - West Wing, Floors 1-3 Redesign

Room Number	Room Name	Space Discription	Area (sq.ft)	Lamp	Wattage Per Lamp	Lamps per Fixture	Number of Fixtures	Watts	Power Density (W/SqFt)	Required PD (W/sqft)	Std 90.1 Compliant ?
103	Seminar Room	Lecture Room	830	PC1	26	2	0	0	0.00	2.75	Yes
			830	FF2	32	2	12	768	0.93		
			830	PB2	26	2	4	208	0.25		
			830	PB2D	26	2	24	1248	1.50		
104	Lecture Room	Lecture Room	550	PC1	26	2	0	0	0.00	2.75	Yes
			550	FF2	32	2	8	512	0.93		
			550	PB2	26	2	3	156	0.28		
			550	PB2D	26	2	16	832	1.51		
114	Shower/Locker	Restroom	120	PC1	26	2	3	156	1.30	1.2	No
115	Storage	Storage	290	FC1	32	3	4	384	1.32	1.2	No
116	Storage	Storage	490	FR4	32	2	9	576	1.18	1.2	Yes
117	Purchasing	Office	350	FD1	32	4	4	512	1.46	1.1	No
119	Building Facilities	Office	210	FD1	32	4	2	256	1.22	1.1	No
120	Receiving/Storage/Loading	Shipping/Receiving	310	FR4	32	2	4	256	0.83	1	Yes
144	Elevator Machine Room	Mechanical	110	FR4	32	2	2	128	1.16	1.4	Yes
147	Telecommunications	Electrical	225	FR4	32	2	4	256	1.14	1.4	Yes
148	Electrical Room	Electrical	680	FR4	32	2	9	576	0.85	1.4	Yes
150	Elevator Machine Room	Mechanical	130	FR4	32	2	1	64	0.49	1.4	Yes
151	Plumbing	Mechanical	380	FR4	32	2	6	384	1.01	1.4	Yes
152	Generator	Electrical	300	FR6	48	2	6	576	1.92	1.4	No
154	Fan Room	Mechanical	255	FR6	48	2	5	480	1.26	1.4	Yes
202	Lunch Room/Kitchen	Multi-Purpose	1250	PC1	26	2	37	1924	6.41	2.2	No
			1250	PK1	150	1	4	600	2.35		
			1250	FX1	25	1	3	75	0.06		
219	IT Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
220	IT Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
221	Computer/ Visual Room	Computer Lab	270	FN3	39	4	2	312	1.16	2.1	Yes
			270	PL2	50	1	2	100	0.37		
223	Conferemce Room	Conference Room	440	PC2	18	2	2	72	0.16	2.3	Yes
			440	PB2D	26	2	10	520	1.18		
224	Server Room	Computer Room	350	FH3	32	3	4	384	1.10	1.1	Yes
225	Mens Restroom	Restroom	210	PC1	26	2	5	260	1.24	1.9	Yes
			210	FW2	25	1	2	50	0.24		
226	Womens Restroom	Restroom	190	PC1	26	2	5	260	1.37	1.9	Yes
			190	FW2	25	1	2	50	0.26		
227	Corridor	Corridor	780	FN3	39	4	10	1560	2.00	1	No
229	Elevator Vestibule	Corridor	250	PC1	26	2	3	156	0.62	1	Yes
230	Telephone	Office Space	60	FR4	32	2	1	64	1.07	1.1	Yes
231	Electrical	Mechanical Room	140	FR4	32	2	3	192	1.37	1.4	Yes
262	Storage	Storage	60	FA1	32	2	1	64	1.07	1.2	Yes
	Corridor	Corridor	330	PC1	26	2	11	572	1.73	1	No
301	Library	Library	1200	PC1	26	2	30	1560	1.30	1.3	Yes
319	ACA Office	Office Space	120	FN3	28	4	2	224	1.87	1.1	No
320	ACA Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
321	IT Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
322	IT Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
323	IT Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
324	Conferemce Room	Conference Room	440	PC2	18	2	2	72	0.16	2.3	Yes
			440	PB2D	26	2	10	520	1.18		
325	IT Room	Office Space	350	FH3	32	3	4	384	1.10	1.1	Yes
326	Mens Restroom	Restroom	220	PC1	26	2	7	364	1.65	1.9	Yes
			220	FW2	25	1	2	50	0.23		
327	Womens Restroom	Restroom	220	PC1	26	2	8	416	1.89	1.9	No
			220	FW2	25	1	2	50	0.23		
328	Corridor	Corridor	780	FN3	39	4	10	1560	2.00	0.5	No
330	Elevator Vestibule	Corridor	250	PC1	26	2	3	156	0.62	0.5	No
331	Electrical	Mechanical Room	120	FR4	32	2	2	128	1.07	1.4	Yes
331	Telephone	Office Space	80	FR4	32	2	2	128	1.60	1.1	No
262	Storage	Storage	60	FA1	32	2	1	64	1.07	1.2	Yes
	Corridor	Corridor	330	PC1	26	2	11	572	1.73	1	No
100	Parking	Parking	7650	FR5	32	2	46	2944	0.38	0.4	Yes

Zone 2 - South Wing, Floors 1-3 Redesign											
Room Number	Room Name	Space Discription	Area (sq.ft)	Lamp	Wattage Per Lamp	Lamps per Fixture	Number of Fixtures	Watts	Power Density (W/SqFt)	Required PD (W/sqft)	Std 90.1 Compliant ?
AT	Atrium	Atrium	4800	PF3	42	1	25	1050	0.22	1.6	Yes
			4800	PF2	32	1	25	800	0.17		
			4800	PC1	26	2	6	312	0.07		
			4800	PG1	250	1	9	2250	0.47		
			4800	PY2	100	1	14	1400	0.29		
			4800	PY3	70	1	14	980	0.20		
			4800	PP1	32	2	9	576	0.12		
121	Open Office	Office Space	1115	FK1	32	2	15	960	0.86	2.1	Yes
			1115	PF3	42	1	7	294	0.26		
			1115	PC2	18	2	7	252	0.23		
122	Personnel Manager	Office Space	105	FN3	28	2	2	112	1.07	1.1	Yes
123	Accounting	Office Space	110	FN3	28	2	2	112	1.02	1.1	Yes
124	Accounting	Office Space	110	FN3	28	2	2	112	1.02	1.1	Yes
125	Development	Office Space	110	FN3	28	2	2	112	1.02	1.1	Yes
126	Development	Office Space	110	FN3	28	2	2	112	1.02	1.1	Yes
127	Conference	Conference	190	FQ1	150	2	4	1200	6.32	1.3	No
			190	PC1D	26	2	3	156	0.82		
128	Development	Office Space	200	PL2	50	1	2	100	0.5	2.1	Yes
			200	FN3	39	2	1	78	0.39		
			200	FN4	54	2	1	108	0.54		
129	Board Member	Office Space	200	PL2	50	1	2	100	0.5	2.1	Yes
			200	FN3	39	2	1	78	0.39		
			200	FN4	54	2	1	108	0.54		
130	CFO	Office Space	200	PL2	50	1	2	100	0.5	2.1	Yes
			200	FN3	39	2	1	78	0.39		
			200	FN4	54	2	1	108	0.54		
131	Vice President	Office Space	200	PL2	50	1	2	100	0.5	2.1	Yes
			200	FN3	39	2	1	78	0.39		
			200	FN4	54	2	1	108	0.54		
132	President	Office Space	200	PL2	50	1	2	100	0.5	2.1	No
			200	FN3	39	4	1	156	0.78		
			200	FN4	54	4	1	216	1.08		
133	Executive Director	Office Space	200	PL2	50	1	2	100	0.5	2.1	Yes
			200	FN3	39	2	1	78	0.39		
			200	FN4	54	2	1	108	0.54		
134	Board Room	Conference Room	775	PC3	18	2	1	36	0.05	2.1	No
			775	PW2D	26	2	9	468	0.60		
			775	PC1D	26	2	8	416	0.54		
			775	FQ1	150	2	5	1500	1.94		
135	Mens Restroom	Restroom	240	PC1	26	2	7	364	1.52	1.9	Yes
			240	FW2	25	1	2	50	0.21		
136	Womens Restroom	Restroom	240	PC1	26	2	7	364	1.52	1.9	Yes
			240	FW2	25	1	2	50	0.21		
137	Corridor/Kitchenette	Corridor	460	PC1	26	2	34	1768	3.84	1.5	No
			460	FX1	25	1	2	50	0.11		
139	Workroom Storage	Storage	320	FD1	32	4	3	384	1.20	1.2	Yes
140	Graphics	Office Space	340	FH3	32	3	7	672	1.98	1.1	No
145	Telephone Room	Electrical Room	90	FR4	32	2	1	64	0.71	1	Yes
146	Electrical Closet	Electrical Room	30	FR4	32	2	1	64	2.13	0.5	No
143	Reception	Office Space	530	FK1	32	2	5	320	0.60	2.1	Yes
			530	PB2	26	2	4	208	0.39		
			530	FR2	32	2	2	128	0.24		
			530	PF3	42	1	2	84	0.16		
204	Open Office	Office Space	2325	FK1	32	2	37	2368	1.02	2.1	Yes
			2325	PF3	42	1	17	714	0.31		
			2325	PC2	18	2	17	612	0.26		

Zone 2 - South Wing, Floors 1-3 Redesign											
Room Number	Room Name	Space Discription	Area (sq.ft)	Lamp	Wattage Per Lamp	Lamps per Fixture	Number of Fixtures	Watts	Power Density (W/SqFt)	Required PD (W/sqft)	Std 90.1 Compliant ?
205	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
206	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
207	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
208	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
209	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
210	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
211	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
212	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
213	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
214	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
215	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
216	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
217	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
218	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
302	Open Office	Office Space	2325	FK1	32	2	37	2368	1.02	2.1	Yes
			2325	PF3	42	1	17	714	0.31		
			2325	PC2	18	2	17	612	0.26		
305	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
306	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
307	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
308	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
309	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
310	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
311	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
312	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
313	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
314	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
315	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
316	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
317	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes
318	PI Office	Office Space	120	FN3	28	2	2	112	0.93	1.1	Yes

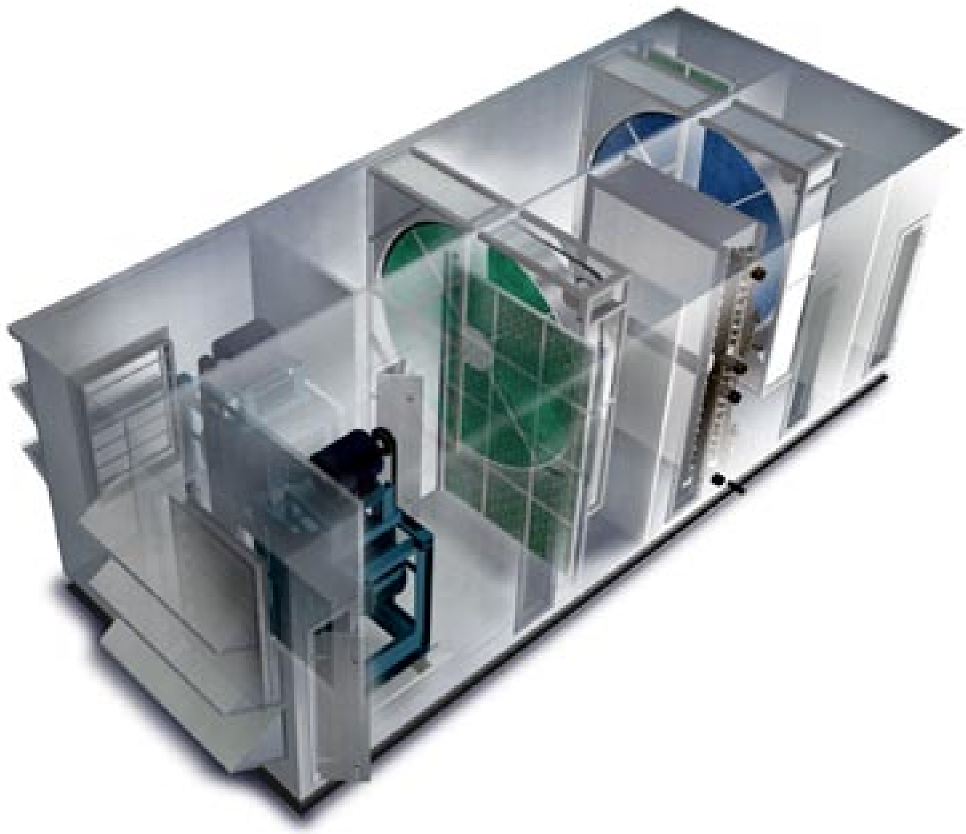
Appendix C:
Dedicated Outdoor Air Systems Analysis



Desiccant Wheel Products

EP Series

Packaged Energy Recovery Systems



Technical Guide

Table of Contents

Designs For Energy Efficiency And Indoor Air Quality

Energy efficient design and indoor air quality are the two challenges facing mechanical engineers today in the field of Heating, Ventilating and Air Conditioning (HVAC). To minimize the loss of energy, building envelopes have been made more energy efficient. This also reduces the cost associated with cooling or heating the building. By tightening the building envelopes, we reduce the amount of outside air entering the building. However, that outside air is needed to remove the air contaminants generated indoors. Flushing these pollutants from the indoors to the outdoors has been the most effective way of reducing the indoor air contaminant to acceptable levels. This ventilation concept is formalized in ASHRAE Standard 62.

What does this mean for an "average" building? First, it will have forms of mechanical ventilation to supply controlled amounts of outside air into the building. To balance the building pressure, a similar amount of air has to be exhausted from the building. This is a waste of energy for the sake of air quality. Imagine a building owner/operator sitting next to the exhaust air discharge and throwing dollar bills into the air stream. The exhaust air stream represents a revenue loss. Meanwhile, the building owner/operator is paying for the ventilation air to be cooled or heated.

Can this waste be stopped? Yes, it can! And that is exactly what total energy recovery will do. The heating or cooling energy contained in the exhaust air stream can be recovered and used to precondition the outdoor air being brought into the building.

Energy recovery systems are easy to apply if you separate the ventilation system from the air-conditioning system. This solution offers several advantages: easy to design, allows use of existing conventional equipment with no modifications and simple to control.

In addition, total energy recovery systems can be directly connected to individual or multiple air-conditioning units to provide a controlled minimum amount of fresh air at all times. This allows the conventional equipment to behave as if it were using re-circulated air year-round.

" ...The air-conditioning system doesn't know if it's summer or winter," stated a building operator. In other words, a building on the humid, muggy Gulf Coast would have the same fresh air intake as a building in Southern California.

Using This Manual

This design manual presents the SEMCO EP and EPD Series of packaged energy recovery systems, which are designed around the EXCLU-SIEVE® total energy (TE) and sensible only (TS) recovery wheels. These systems are designed to provide efficient, large amounts of outdoor air to all types of facilities. They can be applied as precon-ditioners to traditional HVAC equipment or as integrated systems that provide total space conditioning and precise humidity control. This manual explains the benefits provided by the technology, provides a detailed selection procedure and reviews specific guidelines to assure an effective system design. This material should be studied carefully before beginning the design process.

SEMCO also offers a computerized energy savings analysis and energy wheel selection program for frequent users, which simplifies this design process and cost justification.

For additional design support or to answer any technical questions, a list of the SEMCO representatives nearest you is located at SEMCO's website at www.semcoinc.com. You can also call SEMCO Incorporated toll-free at 888-4SEMCOINC.

The SEMCO System

The SEMCO packaged energy recovery system offers the ultimate performance in the transfer of total energy (both latent and sensible). Pre-engineered and factory assembled, the SEMCO system also provides the air handling capability for the building's exhaust and supply air. The system can be selected to precondition outdoor air going to other conventional air handling systems or as an integrated system that provides total space conditioning with the additional heating and cooling options available.

The heart of this system is a technologically advanced EXCLU-SIEVE desiccant wheel. In addition to providing superior performance, the wheel's 3Å molecular sieve-desiccant coating is selective in what it adsorbs from an exhaust air stream. The desiccant rejects airborne contaminants while it transfers water vapor, thus providing total energy transfer from the exhaust to the supply air stream. Selectivity allows EXCLU-SIEVE to be used in critical applications, including recovery from contaminated airstreams. In the past, energy recovery was avoided or limited to sensible-only energy exchange in applications like these.

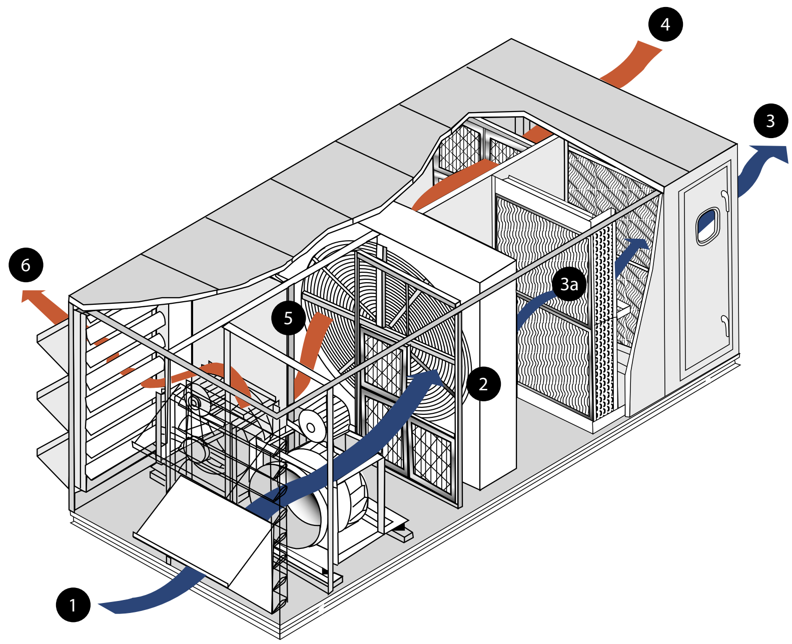
The EXCLU-SIEVE wheel uses a fluted media with an aluminum backbone, which is coated with a fast-acting, adsorbent desiccant surface. As the transfer media slowly rotates between the outdoor and exhaust airstreams, the warmer air surrenders its sensible energy to the aluminum. This energy is then shifted to the cooler air stream during the second half of the revolution.

Just as the temperature is captured and released, so is the moisture. EXCLU-SIEVE's 3Å molecular sieve-desiccant coating has an enormous internal surface area and strong attraction to water vapor. Since the opposing airstreams have different temperatures and moisture contents, the vapor pressure will also be different. This pressure difference is the driving force in the transferring of latent energy.

By using the desiccant coating, EXCLU-SIEVE recovers the moisture from the exhaust air stream to the supply air stream without the airborne pollutants exchanging. This very important and unique feature has been well documented through independent laboratory and field-testing. (A copy of the Georgia Tech Research Institute study is available free of charge.)

Six steps to fresh, cool air during the cooling season:

Step 1
Hot, humid outside air is drawn in.
Step 2
Fresh air is blown in through the slowly rotating EXCLU-SIEVE wheel. The desiccant-coated fluted media captures heat and moisture.
Step 3a
The air can be further cooled or heated to space neutral conditions.
Step 3
The cooled and dehumidified air enters the HVAC system or is delivered directly to the occupied space.
Step 4
Cool, dry return air that is exhausted from the building enters the Total Energy Recovery System.
Step 5
As return air passes through the EXCLU-SIEVE wheel, it removes the heat and humidity captured by the wheel from the fresh air stream.
Step 6
Warm, humidified exhaust air is blown out.



The Product Line

SEMCO Packaged Energy Recovery Systems are available in nine cabinet sizes ranging in airflow capacity from 2,000 scfm to 40,000 scfm. The standard and optional features that are available with this system are discussed below. Equipment summaries are provided on pages 45 and 46. Individual equipment information, as well as, their configurations, complete with typical flow schematics, is presented on pages 6 and 7.

Standard Features

1 The EXCLU-SIEVE® Total Energy Wheel

- Certified total energy recovery performance (sensible and latent) up to 90 percent efficient.
- Patented 3Å molecular sieve-desiccant coating to avoid desiccant cross-contamination.
- Wheel faces are coated to ensure long lasting corrosion protection.
- Sensible-only wheel is polymer coated to avoid oxidation and future transferring of moisture.
- All aluminum, structural spoke system eliminates mechanical fatigue and allows media replacement for wheels greater than size TE3-9.
- Non-wearing labyrinth seals.

2 SEMCO Panel System

- Double-wall panel construction (2 inches thick with 18-gauge outer skin) eliminates exposed insulation and the associated risk of bacterial growth.
- Double-wall removable panels provided for large internal components.
- Gasketed double-wall access doors for all compartments.
- Secondary roof of continuous standing-seam panels standard on units designed for outdoor installation.
- Welded cabinet floor with integrated drain pan.

3 Supply and Exhaust Air Fans

- AMCA rated fans sized for quiet and efficient operation, backward curve(up to 16 inches diameter) and airfoil (18 inches diameter and greater).
- Mounted, balanced, tested and internally isolated for vibration.
- Motors are NEMA frame, high-efficiency with a 1.15 service factor.

4 Filter Sections

- Filters that are 30 percent efficient are provided for the outdoor air and return airstreams.

5 Hoods and Dampers

- Low-leakage motorized fresh air damper and gravity exhaust air damper.
- Outdoor units are provided with an intak and exhaust hood with bird screen.

6 Electrical Package with Single Point Connection

- All motors wired to starters, disconnects and a main start/stop control center.
- Start/stop panel has hand/off/auto positions.
- Control center integrates limit switches on damper motors.
- 208, 240 or 480 volt single-point connections are available.

Optional Features

7 Increased Filter Efficiency

- Sixty-five, 85 or 95 percent cartridge filters can be provided in addition to the standard 30 percent filters.

8 Reheat Options

- Hot water coil.
- Steam coil, non-freeze type.
- Electric coil, wiring and controls for the electric heater to a separate electrical connection point.

9 Cooling Options

- Chilled water or direct expansion coil.

10 Variable Speed Wheel Control Package

- Digital reading of temperatures.
- Proportional heating control.
- Automatic summer/winter changeover.

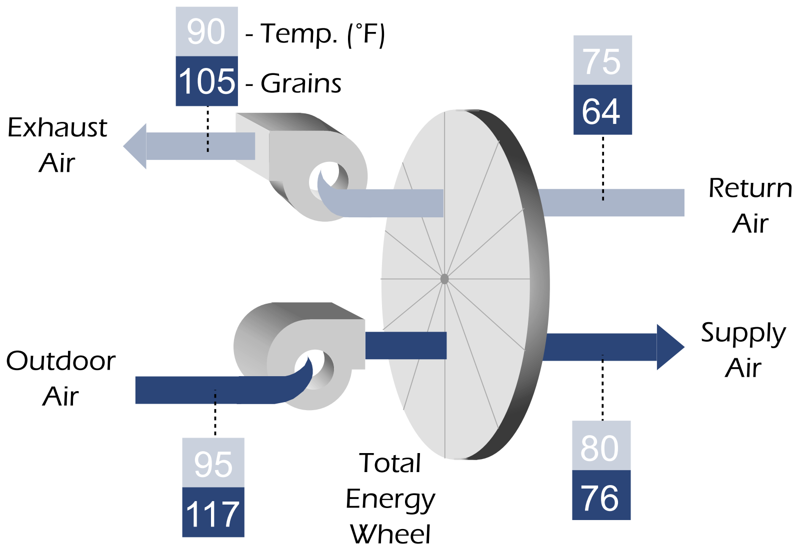
Key Benefits

- Standard, catalogued energy wheel products and wheel systems.
- Independently certified wheel performance in accordance with ASHRAE Standard 84-91 and ARI Standard 1060 with regard to:
  — latent heat transfer efficiency;
  — sensible heat transfer efficiency; and,
  — pressure loss across wheel.
- Equal latent and sensible heat transfer.
- Highest performing wheel on the market.
- Independently certified cross-contamination of less than 0.04 percent.
- Field adjustable purge section.
- Wheel media independently certified to pass NFPA 90A requirements for flame spread and smoke generation based upon ASTM E84 fire test method.
- Reliable operation.
- Minimal maintenance.
- Many successful installations.
- Extended 3 and 5-year service contract available for wheel.
- Highest engineering expertise in the industry.

Available Equipment Configurations

EP

In addition to the SEMCO EXCLU-SIEVE energy recovery wheel, this dual-wall system contains backward curved supply and exhaust fans, outdoor air and return air filtration and an optional, full-electrical package with a single-point electrical connection. All EP family products are designed for either indoor or outdoor mounting.

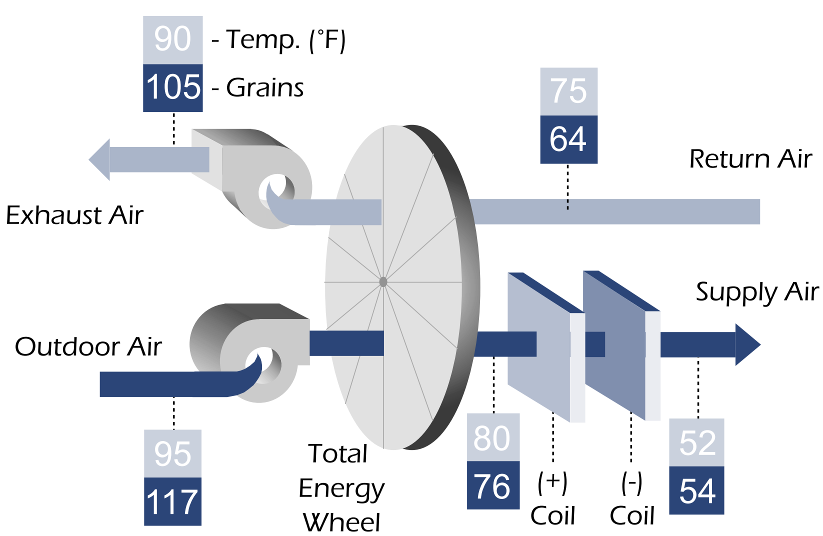


EP Product

- *Suitable for new construction and can be retrofitted to most existing facilities.*
- *Precools and dehumidifies outdoor air during the cooling season.*
- *Preheats and pre-humidifies the outdoor air during the heating season.*
- *Supplies preconditioned outdoor air to conventional HVAC systems, allowing them to effectively increase outdoor air percentages.*
- *Preconditioned outdoor air can be introduced to the return air plenum serving a central HVAC system.*
- *It can also be supplied directly to the conditioned space since the system's recovery efficiency ranges between 74 and 85% (in balanced flow operation).*

EPH, EPC, EPHC

These products build on the EP product mentioned above. However, unlike the EP, they integrate full heating and cooling options. The cooling options include either chilled water or DX cooling coils, with options regarding the number of fins per inch and the number of row options. The heating options include either hot water, steam or electric coils.



EPH, EPC, EPHC Products

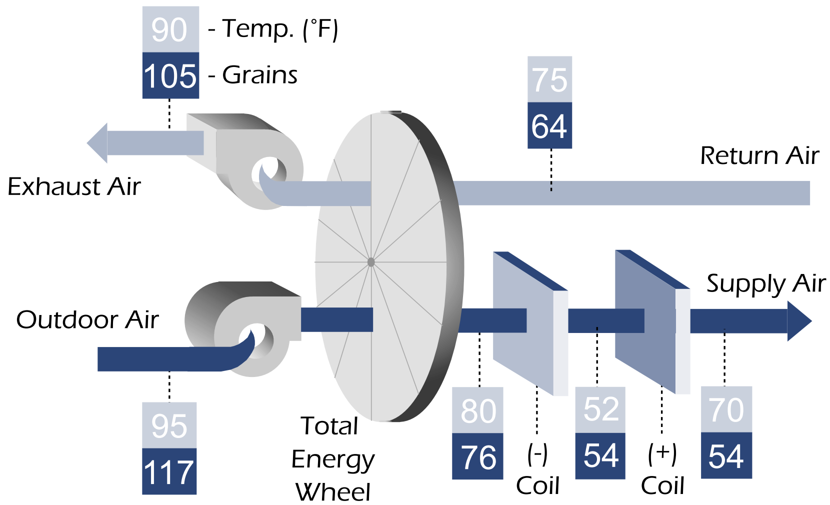
These products are applied to installations where there is a need for 100 percent outdoor air. The SEMCO system is the primary source for temperature and/or humidity control. This includes hospitals, manufacturing areas, laboratories and casinos. These products are also used to precondition buildings where the outdoor air goes directly to the space, but requires additional post heating or cooling to supplement what is being provided by the energy recovery wheel.

EPCH

EPCH Product

Applications for this product include buildings that need high percentages of outdoor air for a humidity controlled environment, where the SEMCO system is the primary source. This product may be the sole source for temperature and humidity control. It also handles primarily latent loads by over-drying the outdoor air with the cooling coil and then reheating to a temperature that is comfortable to the occupants.

This product builds on the basic EP product, but integrates full cooling and reheating. The cooling options include either chilled water or direct expansion (DX) cooling coils, with options regarding the number of fins per inch and the number of row options. The heating options include either hot water, steam or electric coils.

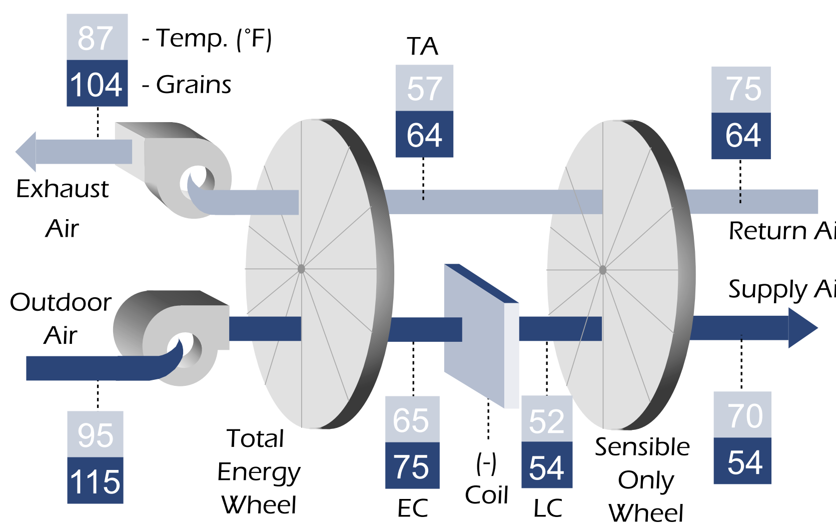


EPD

EPD Product

The applications for this product include buildings that need high percentages of outdoor air for a humidity controlled environment where the SEMCO system provides 45-55 grains of water/pound of dry air and a neutral temperature of 65-70 degrees to the space. This approach allows conventional HVAC systems to operate most efficiently by cycling on and off, while using all recirculated air and handling only sensible loads. Good applications for the EPD systems include classrooms, hotels, dormitories, casinos and laboratories. This approach to ventilation of humidity control is very energy efficient since the EPD system can generate up to 10 tons of latent cooling for every 3 tons input with no cost of reheating.

This product builds on the EP product but integrates full cooling for humidity control and a sensible energy wheel to provide free reheat. This dual-wall system contains an EXCLU-SIEVE energy recovery wheel, a sensible energy wheel, backward curved, supply and exhaust fans, outdoor air and return air filtration, cooling coil, limited capacity reheat coil and an optional full-electrical package including a single-point electrical connection. The cooling options include either chilled water or DX cooling coils, with options regarding the number of fins per inch and the number of row options. The heating options include either hot water, steam or electric coils.



EP Detailed Selection Procedure

1 Select unit size from Table 1 based on the larger supply air (SA) or return air (RA) cfm required. Then select the smallest unit which meets the required task, since it will provide the most cost-effective selection.

ex. *If 7000 cfm SA at 1-inch external static pressure and 6000 cfm RA at .5-inch external static pressure is required, then select size 9 based on 7000 cfm.*

2 Select unit configuration(EP, EPH, EPC, EPCH or EPHC) based on project requirements (see page 6 and 7 for guidance).

ex. *Select EPHC if a year-round controlled SA condition is desired.*

3 Use Table 4 (page 24) to determine the internal static pressures (ISP) for both the SA and RA sides of the unit.

ex. *In an indoor unit, the ISP for the SA side of the EPCH-9 at 7000 cfm is 2.54 inches. The ISP for the RA side of the EP-9 at 6000 cfm is 1.81 inches.*

SA @ 7000 cfm

OA opening	*.11 in.wg.*
SA opening	*.11 in.wg.*
Damper	*.11 in.wg.*
OA filter	*.42 in.wg.*
Wheel	*.82 in.wg.*
CHW coil	*.61 in.wg.*
HW Coil	*.10 in.wg.*
Casing	*.30 in.wg.*
ISP	*2.58 in.wg.*

RA @ 6000 cfm

EA opening	*.15 in.wg.*
RA opening	*.15 in.wg.*
Damper	*.08 in.wg.*
RA filter	*.49 in.wg.*
Wheel	*.67 in.wg.*
Casing	*.30 in.wg.*
ISP	*1.84 in.wg.*

4 Determine fan total static pressure (TSP) by adding the ISP to the required external static pressure.

ex. *SA side TSP is 2.58" + 1" = 3.58"*
RA side TSP is 1.84" + .5" = 2.34"

5 Use Table 4 again to determine purge/seal air volume to be added to each designed airflow to determine total fan airflow.

ex. *EP-9 purge/seal volume is 906 cfm.*

Total SA fan flow = 7906 cfm
Total RA fan flow = 6906 cfm

Table 1. System Capacities and Base Effectiveness

Model	Capacity	%Base Effective- ness
EP-3	Low 2,000 Mid 2,500 High 3,000	78 75 74
EP-5	Low 3,000 Mid 4,000 High 4,500	81 77 76
EP-9	Low 4,500 Mid 6,000 High 8,000	82 78 75
EP-13	Low 6,000 Mid 8,000 High 10,000	84 80 77
EP-18	Low 8,000 Mid 10,000 High 15,000	85 82 76
EP-24	Low 11,000 Mid 14,000 High 18,000	84 81 77
EP-28	Low 15,000 Mid 18,000 High 23,000	82 79 76
EP-35	Low 18,000 Mid 22,000 High 27,000	83 80 77
EP-43	Low 26,000 Mid 30,000 High 40,000	80 78 75

Example 1

Condition	Temp. Dry Bulb	Temp. Wet Bulb	Abs. Humidity gr/lb
Summer OA	95°	78°	117
Summer RA	75°	61.9°	63
Summer SA	81°	62.7°	79
Winter OA	0°	-1°	4
Winter RA	70°	51.4°	27
Winter SA	49°	39.2°	20

Table 2. Supply Air Efficiency Chart

Airstream Flow Ratio	Base Effectiveness in %					
	75	77	79	81	83	85
0.70	81	83	86	88	90	92
0.80	79	81	83	85	87	90
0.90	77	79	81	83	85	87
1.00	75	77	79	81	83	85
1.10	69	71	73	75	77	78
1.25	63	65	67	69	71	72
1.40	57	58	60	61	63	64

Notes:
For SA efficiency use SA cfm/RA cfm.
For RA efficiency use RA cfm/SA cfm.

6 Determine motor horsepower based on the unit's basic fan size, total fan airflow and TSP from the fan data table on pages 26-29. The minimum motor horsepower is the fan brake horsepower plus 10 percent to allow for drive loss and safety factors. An optional extended range fan (shown as size X or XX) is offered for most model sizes. This fan offers horsepower savings depending on exact performance required. However, an increase in unit size is possible.

ex. *Using a size 9 fan, the SA fan brake horsepower is 6.9 based on 7900 cfm at 3.58 in.wg. static pressure. This would require a minimum 10 hp motor. The RA fan brake horsepower is 4.0 based on 6900 cfm at 2.34 in.wg. static pressure. This would require a minimum of 5.0 hp motor.*

7 Find the base wheel effectiveness percentage from Table 1 based on the model selected and the smaller SA or RA cfm.

ex. *Base effectiveness for EP-9 based on 6000 cfm is 78 percent.*

8 Determine SA efficiency from Table 2 and their cfm ratio.

ex. *SA efficiency would be approximately 70 percent interpolating from Table 2 for a base wheel effectiveness of 78 percent and a SA/RA ratio of 7000 cfm/6000 cfm = 1.17.*

9 Determine summer and winter SA conditions, based on design temperatures and SA efficiency by using Equation 1 from Figure 1. (See page 6 for EP configuration.)

Figure 1:

Equation 1:
$X_{SA} = X_{OA} - E_{SA}(X_{OA} - X_{RA})$

Equation 2:
$X_{EA} = X_{RA} + E_{SA}(X_{OA} - X_{RA})$

X = dry bulb temperature (°F) or moisture content (gr/lb) or enthalpy (BTU/lb).

ex. *The following design condition example and a 70 percent SA efficiency are determined below:*

Equation 1 for summer dry bulb:
$SA_{(DB\ TEMP)} = 95° - .70\ (95°-75°) = 81°F$

Equation 1 for summer humidity:
$SA_{(GRAINS)} = 117\ gr - .70\ (117gr - 63\ gr) = 79\ gr$

10 Estimate unit SA conditions using the cooling coil table (page 30) and the heating coil tables (page 33).

11 Determine the need for variable speed option on the wheel.

ex. *If the 7000 cfm EP unit supplies preconditioned outdoor air directly to an air-conditioned space, the unit's full capacity will be required in the cooling season. On cool days, the unit may have the capacity to provide SA conditions above the desired setpoint design, such as 65°F, with a desired 55°F SA setpoint. To provide better control of the unit's SA conditions, the variable speed option should be selected. This option can also be used to provide frost protection for the wheel. (See also the SEMCO Energy Recovery Wheel Technical Guide for a complete discussion of wheel performance and controls.)*

12 Select unit voltage and determine power requirements from the Electrical Data Table on page 37.

ex. *For the EPCH-9, use a 10-hp SA fan, a 7.5-hp RA fan, a variable speed wheel and 240 volt/3 phase/60-cycle power.*

From Electrical Data Table:

Full Load Ampacity	
10-hp SA fan	*28.0 amps*
5-hp RA fan	*15.2 amps*
Wheel VFD	*3.9 amps*
Control power	*0.8 amps*
Total FLA's	**47.9 amps**

Minimum Circuit Ampacity	
FLA from above	*47.9 amps*
25% of largest motor	*7.0 amps*
Total MCA	**54.9 amps**

Maximum Overcurrent Protection(MOCP)	
FLA from above	*47.9 amps*
125% of largest motor	*35.0 amps*
MOCP*	**82.9 amps**

**Select the next smaller sized time delay fuse, per instructions in UL 1995.*

Table 3. System Capacities and Base Effectiveness

Model	Capacity		Effectiveness in %
EPD-3	Low	2,000	78
	Mid	2,250	76
	High	2,500	75
EPD-5	Low	3,000	81
	Mid	3,500	79
	High	4,000	77
EPD-9	Low	4,500	82
	Mid	6,000	78
	High	7,300	76
EPD-13	Low	6,000	84
	Mid	7,500	81
	High	8,800	79
EPD-18	Low	8,000	85
	Mid	10,000	82
	High	14,000	77
EPD-24	Low	11,000	84
	Mid	13,000	82
	High	15,000	80
EPD-28	Low	15,000	82
	Mid	18,500	80
	High	21,000	78
EPD-34	Low	18,000	83
	Mid	21,000	80
	High	24,000	79
EPD-43	Low	26,000	80
	Mid	30,000	78
	High	37,000	76

EPD Detailed Selection Procedure

1. Select unit size from Table 3 based on larger SA or RA cfm required. Then select the smallest unit which meets the required task, since this will provide the most cost-effective selection.

ex. *If 7000 cfm of SA at 1-inch external static pressure and 6000 cfm RA at .5-inch external static pressure is required, then select EP-9 based on 7000 cfm.*

2. Select EPD unit configuration based on project requirements of high latent load and to provide year-round temperature of SA conditions. (See page 7 for EPD configuration.)

3. Use Table 5 (page 25) to determine the ISP for both the SA and RA sides of the unit.

ex. *In an indoor unit, the ISP pressure for the SA side of EPD-9 at 7000 cfm is 3.46 inches. The ISP for the RA side of EPD-9 at 6000 cfm is 2.73 inches.*

SA @ 7000cfm

OA opening	*.04 in.wg.*
SA opening	*.04 in.wg.*
Damper	*.13 in.wg.*
OA Filter	*.55 in.wg.*
E Wheel	*.96 in.wg.*
CHW Coil	*.78 in.wg.*
HW Coil	*.13 in.wg.*
S Wheel	*.82 in.wg.*
Casing	*.30 in.wg.*
ISP	**3.75 in.wg.**

RA @ 6000cfm

EA opening	*.20 in.wg.*
RA opening	*.20 in.wg.*
Damper	*.10 in.wg.*
RA Filter	*.49 in.wg.*
E Wheel	*.80 in.wg.*
S Wheel	*.67 in.wg.*
Casing	*.30 in.wg.*
ISP	**2.76 in.wg.**

4. Determine fan TSP by adding the ISP to the required external static pressure.

ex. *SA side TSP is 3.75” + 1” = 4.75”*
RA side TSP is 2.76” + .5” = 3.26”

5. Use Table 5 again to determine purge/seal air volume to be added to each designed airflow to determine total fan airflow.

ex. *EPD-9 sensible wheel purge/seal volume is 906 cfm and the enthalpy wheel purge/seal volume is 1119 cfm.*

Total SA fan flow = 9025 cfm
Total RA fan flow = 8025 cfm

6 Determine motor horsepower based on the unit's basic fan size, total fan airflow and TSP from the fan performance tables (pages 26-29). The minimum motor horsepower is the fan brake horsepower listed in the chart plus 10 percent to allow for drive loss and safety factors. An optional extended range fan (shown as size X or XX) is offered for most model sizes. This fan offers horsepower savings depending on the exact performance required. However, an increase in unit size is possible.

ex. *Using a size 9 fan, the SA fan brake horsepower is 10.2 based on 9025 cfm at 4.75-inches static pressure. This would require a minimum 15 hp motor. The RA fan brake horsepower is 6.4 based on 8025 cfm at 3.26-inches static pressure. This would require a minimum 7.5 hp motor.*

7 Find the base wheel effectiveness from Table 3 (page 11) based on the model selected and using the smaller of the SA or RA cfm.

ex. *The base wheel effectiveness for EPD-9 based on 6000 cfm is 78 percent.*

8 Determine SA and RA efficiency from Table 3 and their cfm ratio.

ex. *SA efficiency would be approximately 70 percent interpolating from Table 4 for a base wheel effectiveness of 78 percent and a SA/RA ratio of 7000 cfm/6000 cfm =1.17. The RA efficiency would be approximately 81 percent using 6000 cfm/7000 cfm.*

9 Determine summer and winter SA conditions, based on design temperature and SA and RA efficiencies using equations 3 to 5 from Figure 2. (See page 7 for EPD configuration.)

Figure 2:

Equation 3: Enthalpy Wheel
$X_{EC} = X_{OA} - E_{SA} (X_{OA} - X_{TA})$

Equation 4A: Sensible Wheel (SA Side)
$T_{SA} = T_{LC} - E_{SA} (T_{LC} - T_{RA})$

Equation 4B: Sensible Wheel (SA Side)
$W_{SA}[gr/lb] = W_{LC}[gr/lb]$

Equation 5A: Sensible Wheel (RA Side)
$T_{TA} = T_{RA} - E_{SA} (T_{LC} - T_{RA})$

Equation 5B: Sensible Wheel (RA Side)
$W_{TA}[gr/lb] = W_{RA}[gr/lb]$

EC = entering coil condition

LC = leaving coil condition

TA = sensible wheel leaving EA condition

T = dry bulb temperature (°F)

W= humidity (gr/lb)
X = dry bulb temperature (°F) or, moisture content (gr/lb) or, enthaply (Btu/lb)

ex. *By using Equation 4A with the design conditions shown in Example 2 and a 70 percent SA efficiency, the following leaving coil condition (LC) is determined.*

Equation 4A for summer DB:
$SA(_{DB\ TEMP}) = 53°F - .70(53°F - 75°F) = 68.4°F$

Equation 4B for Summer Humidity:
$SA(_{GRAINS}) = LC(_{GRAINS}) = 56\ gr$

The summer coil entering conditions can be calculated by using the remaining equations and working backwards through the exhaust air (EA) side of the unit. This will allow verification that the coil has adequate capacity to achieve the assumed LC condition.

When the temperature drops below 25°F, the sensible wheel and cooling coil will shut off to prevent frosting. In this mode, Equation 3 will yield the SA conditions for the unit.

Example 2

Condition	TDB	TWB	rh%	Grains
Summer OA	95.0°	78.0°	47	117
Summer RA	75.0°	62.3°	63	63
Summer LC	53.0°	52.1°	94	56
Summer TA	57.2°	55.5°	90	63
Summer EC	68.5°	63.2°	75	79
Summer SA	68.4°	58.0°	54	56
Winter OA	0.0°	-1.0°	70	4
Winter RA	70.0°	51.4°	25	27
Winter SA	49.0°	39.2°	38	20

10 Determine the need for variable speed option on the sensible wheel.

ex. *If the EPD system is the only source for space-conditioning, a sensor located in the supply airstream can be used to vary the speed of the sensible wheel in order to control the SA temperature leaving the system.*

In the cooling mode, the EPD's LC temperature is set to control the desired humidity level. However, by reducing the speed of the sensible wheel, the amount of reheat is altered. This allows the system to provide more or less sensible cooling. (Note: If the variable speed control option is used, the reduced sensible wheel efficiency must be taken into account when determining the tonnage for the EPD system.)

In the heating mode, the sensible wheel speed is controlled to provide the desired SA condition. In rare cases, the supplemental heating is required if the two wheels in series are inefficient and cannot satisfy the load of the conditioned space. When the air temperature outside falls below 25°F, the sensible wheel is turned off to avoid condensation.

11 Select unit voltage and determine power requirements from the Electrical Data table on page 37.

ex. *For the EPD-9, use a 15-hp SA fan, a 10-hp RA fan, 2 constant speed wheels and 240 volt/3 phase/60-cycle power:*

From Electrical Data Table:

Full Load Ampacity	
15-hp SA fan	*42.0 amps*
7.5-hp RA fan	*22.0 amps*
Wheels	*4.4 amps*
Control power	*0.8 amps*
Total FLA's	**69.2 amps**

Minimum Circuit Ampacity	
FLA from above	*69.2 amps*
25% of largest motor	*10.5 amps*
Total MCA	**79.7 amps**

Maximum Overcurrent Protection(MOCP)	
FLA from above	*69.2 amps*
125% of largest motor	*52.5 amps*
MOCP*	**121.7 amps**

**Select the next smaller sized time delay fuse, per instructions in UL 1995.*

Basic cooling coil performance is given in the Cooling Coil Tables on pages 30-32. The amount of dehumidification capacity is related to the LC air temperature. To calculate the amount of cooling capacity required, use the following equations:

Equation 6:
$BTU/H = 4.5 \times cfm \ (EC_{ENTHALPY} - LC_{ENTHALPY})$

Equation 7A:
$BTU/H_{SENSIBLE} = 1.08 \times cfm \ (EC_{DB\ TEMP} - LC_{DB\ TEMP})$

Equation 7B:
$BTU/H_{LATENT} = .68 \times cfm \ (EC_{GRAINS} - LC_{GRAINS})$

ex. *For the 7000 cfm EPD unit, calculate the cooling capacity with and without the EPD unit at the outside air condition of 95°F DB and 78°F WB and with a 53°F DB and 52°F WB leaving coil condition. Use a psychrometric chart to obtain either the enthalpies or the humidity in grains at each condition:*

For the cooling capacity without the EPD unit, use equation 6:

BTU/H = 4.5 x 7000 x (41.3 - 21.4) = 626,850 BTU/H or 626,850/12,000 = 52.2 tons of cooling

Example 2 (Continued)

Condition	Dry Bulb	Wet Bulb	Humidity	Enthalpy
OA	95.0°	78.0°	117gr	41.3
EC	68.5°	63.2°	79gr	28.8
LC	53.0°	52.1°	56gr	21.4

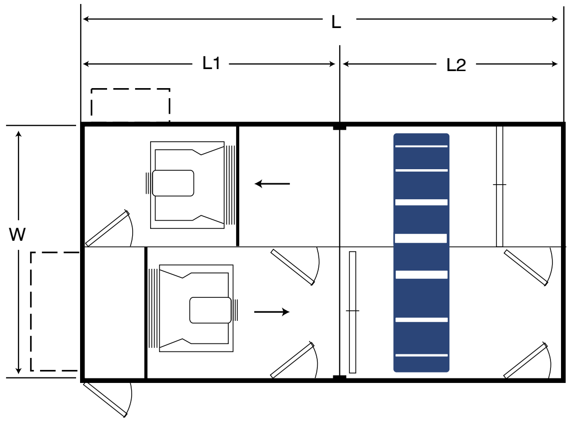
Use equations 7A and 7B for the cooling capacity with the EPD unit:

$BTU/H_{SENSIBLE} = 1.08 \times 7000 \times (68.5 - 53) = 117{,}180\ BTU/H$

$BTU/H_{LATENT} = .68 \times 7000 \times (79 - 56) = 109{,}480\ BTU/H$

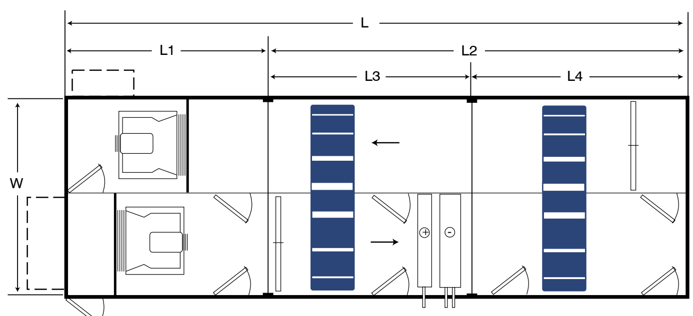
$BTU/H = 117{,}180 + 109{,}480 = 226{,}660\ BTU/H$ *or* $226{,}660/12{,}000 =$ *18.9 tons of cooling*

Unit Weights and Dimensions



EP

Model	W (in.)	L (in.)	L1 (in.)	L2 (in.)	H (in.)	Weight Mod#1 (lbs)	Weight Mod#2 (lbs)	Notes
EP-3	86	163	-	-	48	4,950	-	5
EP-5	86	167	-	-	60	5,750	-	5
EP-9	98	171	-	-	72	7,350	-	2,4
EP-13	98	182	-	-	86	9,400	-	2,4
EP-18	122	190	-	-	98	12,150	-	2,4
EP-24	122	204	-	-	110	14,250	-	2,4
EP-28	146	215	119	96	122	10,100	7,750	2,4
EP-35	146	231	129	102	134	11,700	8,650	2,4
EP-43	182	245	137	108	146	15,100	10,500	3



EPD

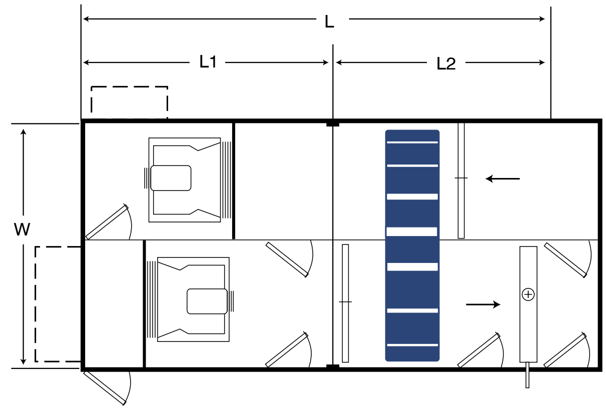
Model	W (in.)	L (in.)	L1 (in.)	L2 (in.)	L3 (in.)	L4 (in.)	H (in.)	Weight Mod#1 (lbs)	Weight Mod#2 (lbs)	Weight Mod#3 (lbs)	Weight Mod#4 (lbs)	Notes
EPD-3	86	263	-	-	-	-	48	7,100	-	-	-	1,5
EPD-5	86	267	-	-	-	-	60	8,300	-	-	-	1,5
EPD-9	98	271	-	-	-	-	72	10,450	-	-	-	1,4
EPD-13	98	295	-	-	-	-	86	13,700	-	-	-	1,4
EPD-18	122	308	108	200	-	-	98	7,150	10,000	-	-	1,4
EPD-24	122	321	115	206	-	-	110	8,450	11,450	-	-	1,4
EPD-28	146	334	119	-	113	102	122	10,100	-	7,800	7,750	1,4
EPD-35	146	350	129	-	113	108	134	11,700	-	8,500	8,650	1,4
EPD-43	182	364	137	-	113	113	146	15,100	-	10,150	10,500	1

FOR ALL EP MODELS

Notes:

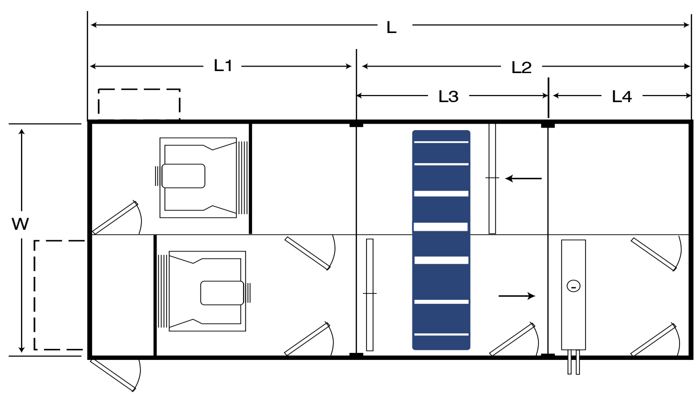
1. Electric heating coil will add 12” to unit length.
2. 12” wider EA side available for increased capacity.
3. 24” wider EA side available for increased capacity.
4. Add 12” to width for X and XX size EA fan.
5. Add 18” to unit length for X and XX size SA or EA fan.
6. Right handed units shown. For left hand unit, mirror down centerline.

EPH

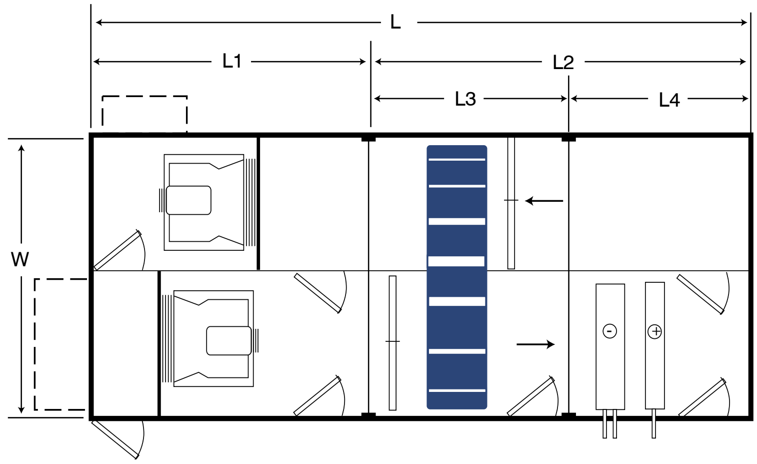


Model	W	L	L1	L2	H	Weight Mod#1	Weight Mod#2	Notes
	(in.)	(in.)	(in.)	(in.)	(in.)	(lbs)	(lbs)	
EPH-3	86	182	-	-	48	5,300	-	1,5
EPH-5	86	186	-	-	60	6,150	-	1,5
EPH-9	98	190	-	-	72	7,850	-	1,4
EPH-13	98	208	-	-	86	10,150	-	1,4
EPH-18	122	216	-	-	98	13,000	-	1,4
EPH-24	122	230	-	-	110	15,200	-	1,4
EPH-28	146	241	119	121	122	10,100	8,750	1,4
EPH-35	146	256	129	127	134	11,700	9,750	1,4
EPH-43	182	270	137	133	146	15,100	11,850	1

EPC

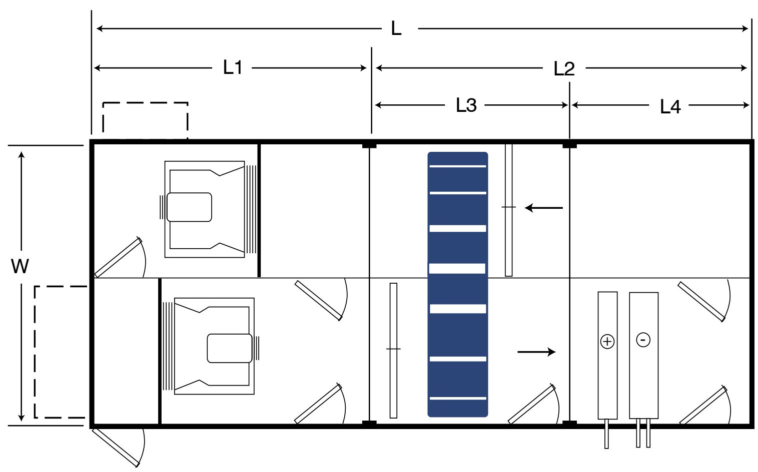


Model	W	L	L1	L2	L3	L4	H	Weight Mod#1	Weight Mod#2	Weight Mod#3	Weight Mod#4	Notes
	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)	(lbs)	(lbs)	(lbs)	(lbs)	
EPC-3	86	198	-	-	-	-	48	5,650	-	-	-	5
EPC-5	86	202	-	-	-	-	60	6,600	-	-	-	5
EPC-9	98	206	-	-	-	-	72	8,350	-	-	-	4
EPC-13	98	224	-	-	-	-	86	10,800	-	-	-	4
EPC-18	122	232	-	-	-	-	98	13,900	-	-	-	4
EPC-24	122	250	115	135	-	-	110	8,450	7,700	-	-	4
EPC-28	146	256	119	137	-	-	122	10,100	9,950	-	-	4
EPC-35	146	272	129	143	-	-	134	11,700	11,050	-	-	4
EPC-43	182	291	137	-	74	80	146	15,100	-	6,750	7,350	1



EPCH

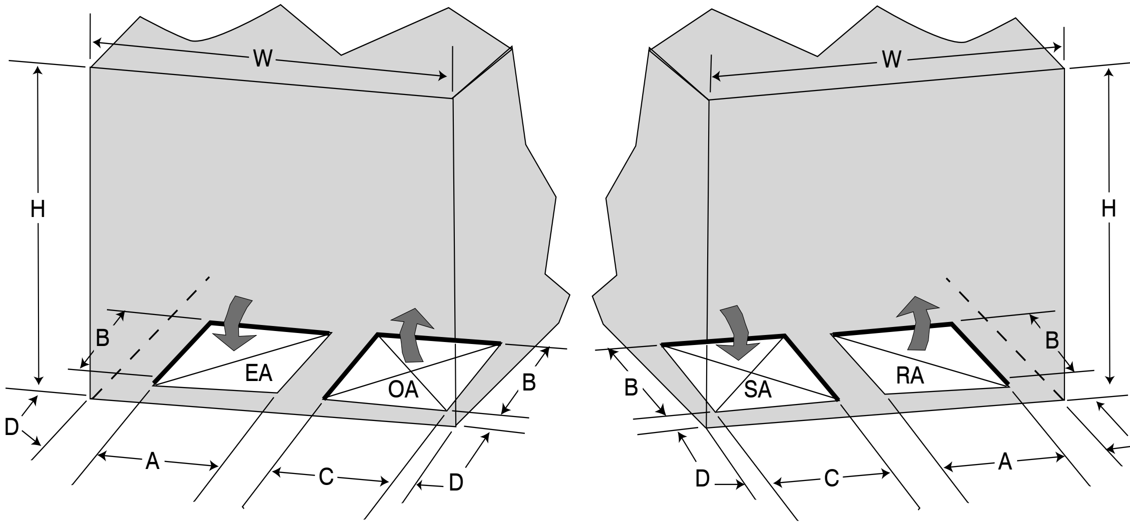
Model	W	L	L1	L2	L3	L4	H	Weight Mod#1	Weight Mod#2	Weight Mod#3	Weight Mod#4	Notes
	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)	(lbs)	(lbs)	(lbs)	(lbs)	
EPCH-3	86	210	-	-	-	-	48	5,850	-	-	-	1,5
EPCH-5	86	214	-	-	-	-	60	6,850	-	-	-	1,5
EPCH-9	98	218	-	-	-	-	72	8,700	-	-	-	1,4
EPCH-13	98	236	-	-	-	-	86	11,200	-	-	-	1,4
EPCH-18	122	243	-	-	-	-	98	14,400	-	-	-	1,4
EPCH-24	122	262	115	147	-	-	110	8,450	8,200	-	-	1,4
EPCH-28	146	273	119	-	74	80	122	10,100	-	5,400	5,600	1,4
EPCH-35	146	289	129	-	74	86	134	11,700	-	5,900	6,200	1,4
EPCH-43	182	303	137	-	74	92	146	15,100	-	6,750	8,150	1



EPHC

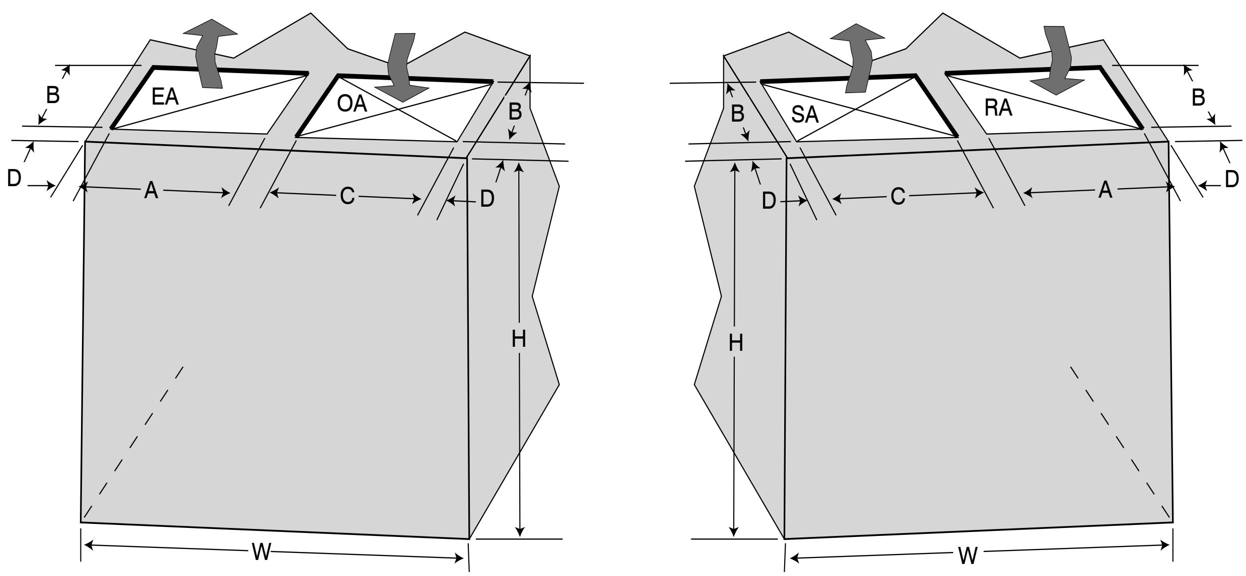
Model	W	L	L1	L2	L3	L4	H	Weight Mod#1	Weight Mod#2	Weight Mod#3	Weight Mod#4	Notes
	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)	(in.)	(lbs)	(lbs)	(lbs)	(lbs)	
EPHC-3	86	210	-	-	-	-	48	5,850	-	-	-	1,5
EPHC-5	86	214	-	-	-	-	60	6,850	-	-	-	1,5
EPHC-9	98	218	-	-	-	-	72	8,700	-	-	-	1,4
EPHC-13	98	236	-	-	-	-	86	11,200	-	-	-	1,4
EPHC-18	122	243	-	-	-	-	98	14,400	-	-	-	1,4
EPHC-24	122	262	115	147	-	-	110	8,450	8,200	-	-	1,4
EPHC-28	146	273	119	-	74	80	122	10,100	-	5,400	5,600	1,4
EPHC-35	146	289	129	-	74	86	134	11,700	-	5,900	6,200	1,4
EPHC-43	182	303	137	-	74	92	146	15,100	-	6,750	8,150	1

Standard Roof & Floor Openings



Standard Floor Openings

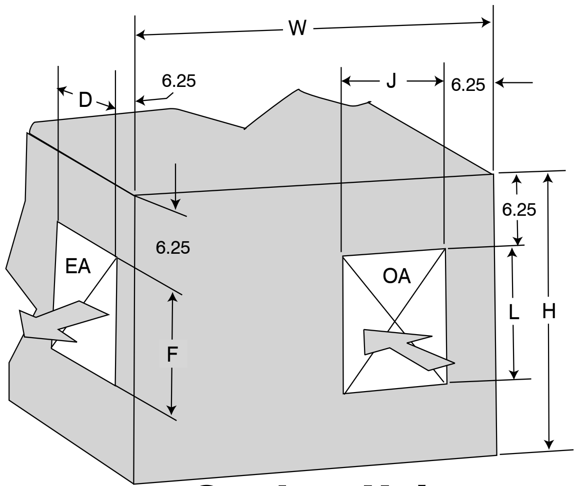
SIZE	H	W	A	B	C	D
3	48.25	86.25	24	20	24	6.25
5	60.25	86.25	24	20	34	6.25
9	72.25	98.25	34	20	46	6.25
13	86.25	98.25	34	26	46	6.25
18	98.25	122.25	46	26	58	6.25
24	110.25	122.25	46	32	58	6.25
28	122.25	146.25	58	32	70	6.25
35	134.25	146.25	58	37	70	6.25
43	146.25	182.25	70	44	94	6.25



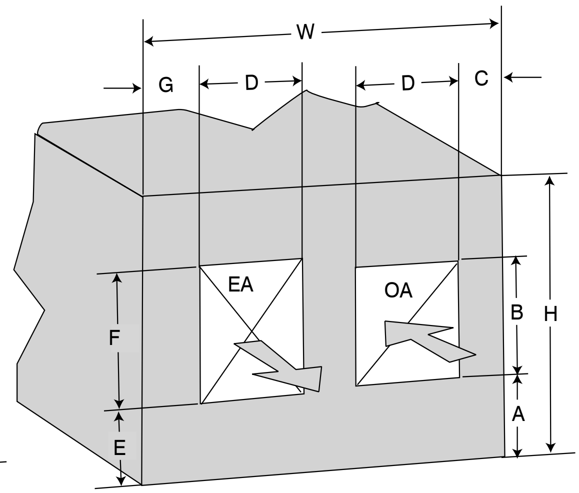
Standard Roof Openings

Notes:
1. All dimensions are in inches.
2. Height includes structural steel base.
3. Roof openings only available on interior units.

Standard End Wall and Side Wall Openings



Outdoor Unit

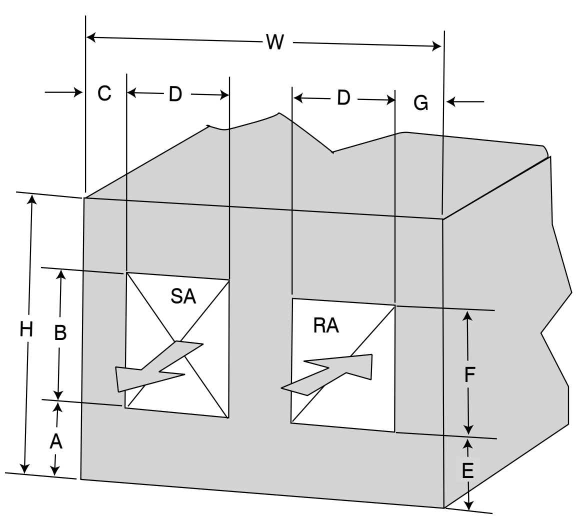


Indoor Unit

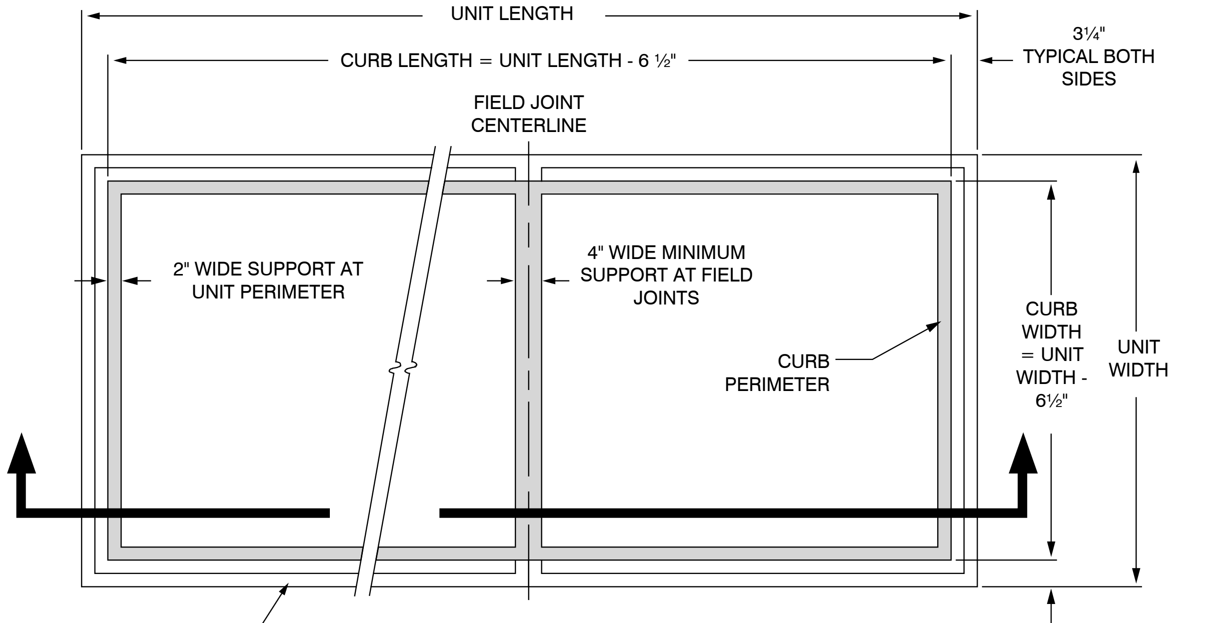
Standard OA/EA Openings

Size	H	W	A	B	C	D	E	F	G	J	L
3	48.25	86.25	14.25	24	12.25	20	14.25	24	12.25	24	24
5	60.25	86.25	15.25	34	14.25	20	20.25	24	14.25	24	42
9	72.25	98.25	15.25	46	20.25	20	21.25	34	14.25	36	48
13	86.25	98.25	23.25	46	17.25	26	29.25	34	11.25	36	60
18	98.25	122.25	23.25	58	23.25	26	29.25	46	17.25	48	72
24	110.25	122.25	29.25	58	20.25	32	35.25	46	14.25	48	72
28	122.25	146.25	29.25	70	26.25	32	35.25	58	20.25	54	96
35	134.25	146.25	35.25	70	22.75	37	41.25	58	16.75	60	96
43	146.25	182.25	29.25	94	32.25	44	41.25	70	20.25	84	96

Notes:
1. All dimensions are in inches.
2. Height includes structural steel base.

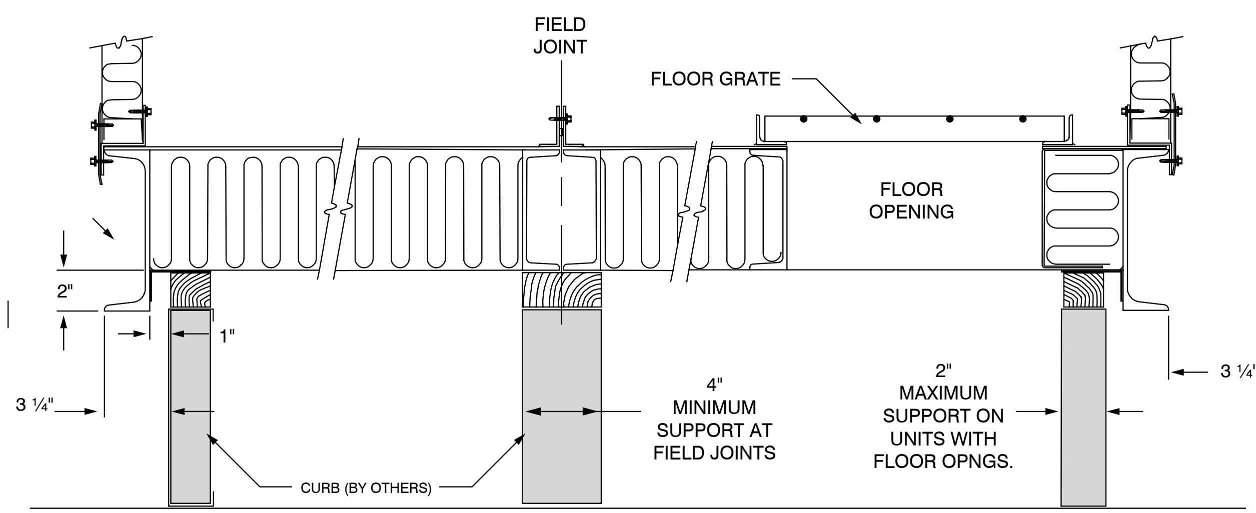


Standard SA/RA Openings



PLAN VIEW

TYPICAL UNIT WITH CURB SUPPORT

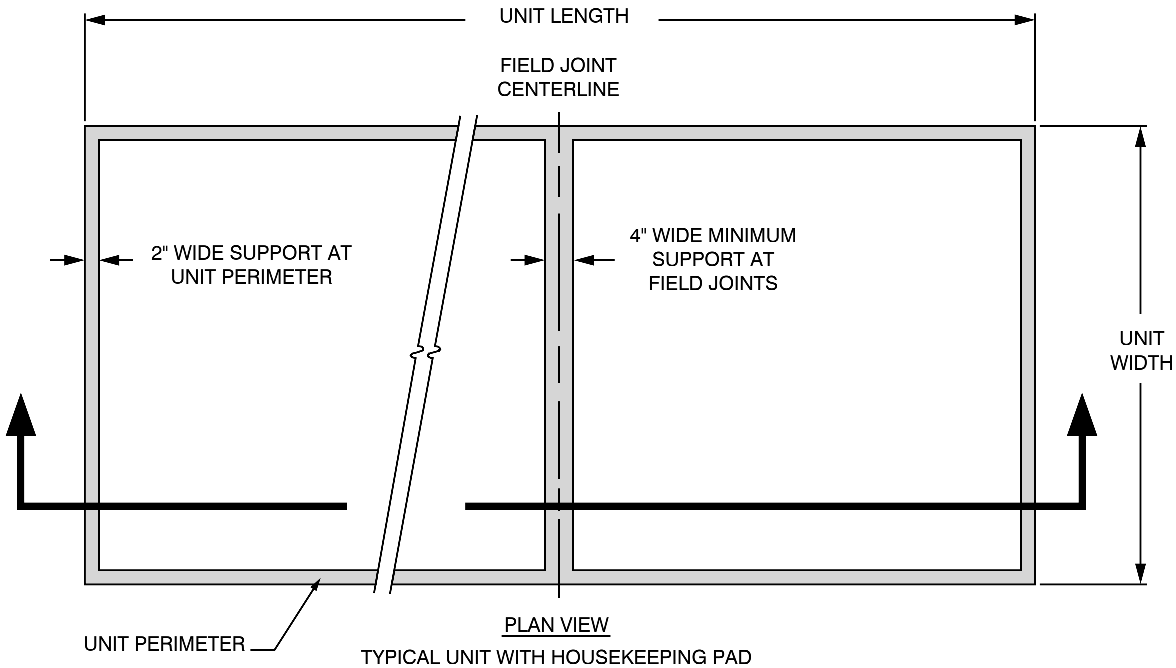


SECTION

SELF FLASHING UNIT BASE
SHOWING CURB SUPPORT REQUIREMENTS

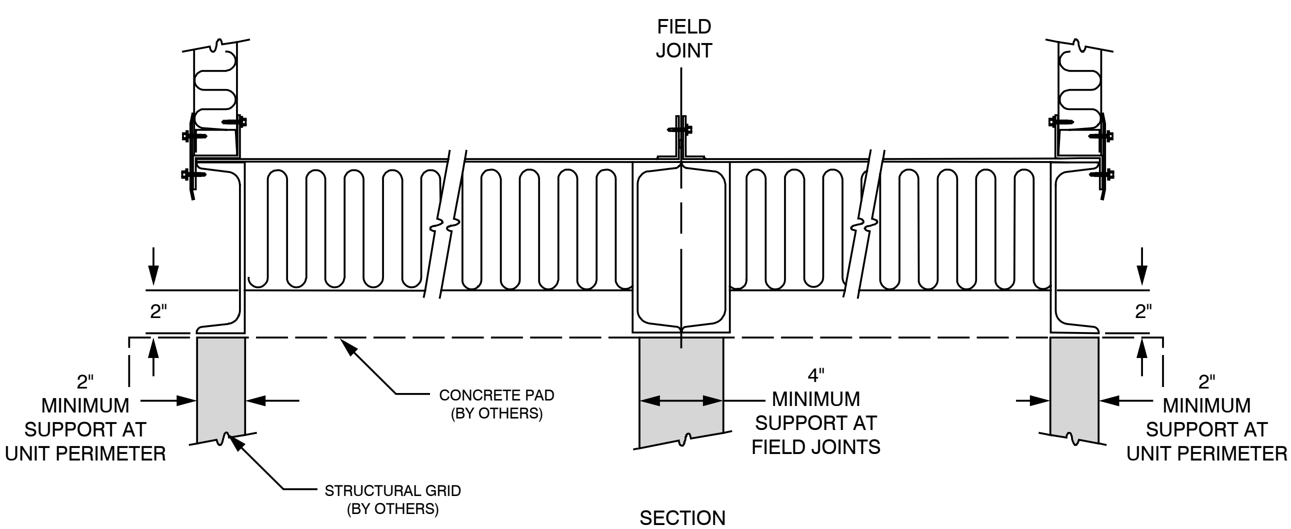
NOTES
1. ROOF CURB SHOULD BE SIZED TO ALLOW UNIT TO HANG OVER CURB.
2. CURB SIZE:
   WIDTH = UNIT WIDTH - 6.5"
   LENGTH = UNIT LENGTH -6.5"
3. UNIT SUPPORT IS REQUIRED AROUND THE ENTIRE PERIMETER AND ALONG BOTH SIDES OF ANY FIELD JOINTS.
4. WHEN UNITS REQUIRE FIELD JOINTS, SUPPORT SHOULD BE LEVEL TO 1/16" BETWEEN FIELD JOINTS.

Mounting Details, Grid or Pad Support



PLAN VIEW

TYPICAL UNIT WITH HOUSEKEEPING PAD
OR STRUCTURAL GRID SUPPORT



SECTION

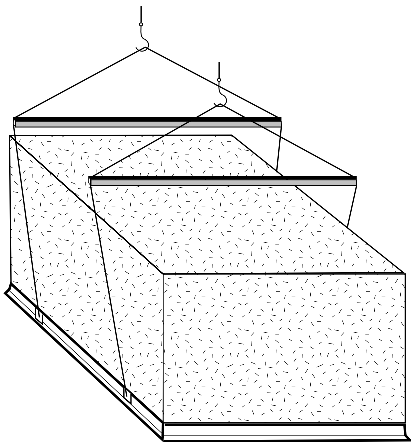
UNIT BASE WHEN MOUNTING
ON PAD OR STRUCTURAL GRID

NOTES

1. UNIT SUPPORT IS REQUIRED AROUND THE ENTIRE PERIMETER AND ALONG BOTH SIDES OF ANY FIELD JOINTS.

2. WHEN UNITS REQUIRE FIELD JOINTS, SUPPORT SHOULD BE LEVEL TO 1/16" BETWEEN FIELD JOINTS.

Lifting and Rigging



The units are designed to be lifted from lifting eyes attached to the unit base structure. Spreader bars must be used to hoist sections to avoid damaging the enclosure. The unit must not be lifted with a forklift.

Field Joints

Units may be split into multiple shipping modules, if size or weight dictates. These units will include factory matched field joints for reassembly at the site. All fasteners, gaskets and caulk are included with the unit.

Coil Piping

Hot water coils and chilled water coils have supply and return connections extended through the casing wall to the unit exterior. Drain and vent connections are not extended.

DX refrigerant coils have liquid lines extended to the unit exterior. Suction line connections are inside the unit.

Steam coils have supply and condensate connection extended through the casing wall to the unit exterior. The condensate connection for the lower steam coil is approximately at floor level. Accommodations for the drip leg will need to be made to the exterior of the unit.

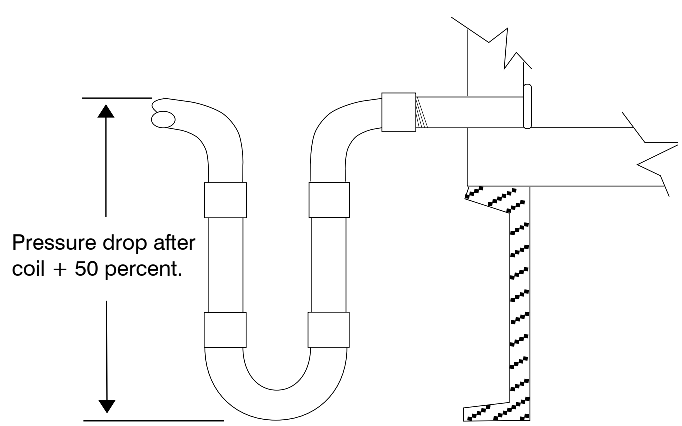
Cooling Coil Condensate Connections

The centerline of the connections is 8.75 inches above the bottom of the base steel. The connections are 1.5 inches MPT.

The plenum containing the condensate pan will be subject to a positive pressure drop on the downstream side of the cooling coil, including the external losses.

The height of water in the trap should be about 50 percent greater than the downstream air pressure drop to prevent air from being blown through the trap.

The unit must be mounted at a sufficient height above the floor or roof to permit installation of the required height P-trap.



Component Pressure Drop Tables

Table 4: Single Wheel Unit Pressure Drops

Size	EP-3			EP-5			EP-9			EP-13			EP-18	
CFM	2000	2500	3000	3000	4000	4500	4500	6000	8000	6000	8000	10000	8000	10000
Enth. wheel purge	513	543	513	695	695	695	906	906	906	1168	1168	1168	1440	1440
Fan cfm	2513	3013	3513	3695	4695	5195	5406	6906	8906	7168	9168	11168	9440	11440
OA opening (w/hood)	0.02	0.04	0.05	0.02	0.03	0.03	0.01	0.02	0.03	0.01	0.02	0.30	0.01	0.01
EA opening (w/hood)	0.04	0.05	0.07	0.08	0.12	0.15	0.07	0.12	0.20	0.08	0.12	0.18	0.07	0.11
RA or EA opening	0.10	0.14	0.19	0.09	0.15	0.19	0.09	0.15	0.24	0.09	0.15	0.22	0.09	0.13
SA or OA opening	0.06	0.10	0.14	0.06	0.11	0.14	0.05	0.08	0.14	0.05	0.08	0.13	0.04	0.06
Damper	0.07	0.10	0.14	0.05	0.08	0.09	0.05	0.08	0.13	0.06	0.09	0.14	0.04	0.07
OA filter	0.26	0.38	0.51	0.25	0.41	0.50	0.19	0.32	0.53	0.24	0.39	0.58	0.19	0.28
RA filter	0.17	0.26	0.37	0.17	0.30	0.37	0.27	0.49	0.87	0.30	0.52	0.82	0.22	0.34
Enth. wheel	0.69	0.92	1.18	0.52	0.74	0.86	0.48	0.67	0.97	0.42	0.57	0.75	0.47	0.51
Cooling coil	0.26	0.40	0.58	0.31	0.56	0.70	0.25	0.44	0.79	0.30	0.53	0.82	0.23	0.36
Heating coil	0.04	0.07	0.09	0.05	0.09	0.11	0.04	0.07	0.13	0.05	0.09	0.13	0.04	0.06
Casing losses	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Int. static pressure														
Ext. static pressure														
Total static pressure														

Size	EP-18	EP-24			EP-28			EP-35			EP-43		
CFM	15000	11000	14000	18000	15000	18500	23000	18000	22500	27000	26000	30000	40000
Enth. wheel purge	1440	1735	1735	1735	1961	1961	1961	2297	2297	2297	2662	2662	2662
Fan cfm	16440	12735	15735	19735	16961	20461	24961	20297	24797	29297	28662	32662	42662
OA opening (w/hood)	0.03	0.20	0.02	0.04	0.01	0.02	0.03	02	0.02	0.03	0.02	0.02	0.04
EA opening (w/hood)	0.22	0.09	0.14	0.21	0.10	0.15	0.22	0.11	0.16	0.23	0.11	0.14	0.23
RA or EA opening	0.26	0.16	0.24	0.38	0.11	0.17	0.25	0.11	0.17	0.24	0.12	0.15	0.26
SA or OA opening	0.14	0.05	0.08	0.13	0.06	0.09	0.15	0.06	0.10	0.14	0.06	0.08	0.14
Damper	0.14	0.06	0.09	0.13	0.07	0.10	0.14	0.06	0.10	0.13	0.09	0.11	0.19
OA filter	0.59	0.27	0.41	0.65	0.26	0.38	0.57	0.30	0.45	0.63	0.28	0.37	0.62
RA filter	0.76	0.31	0.50	0.84	0.30	0.45	0.69	0.34	0.54	0.77	0.41	0.55	0.98
Enth. wheel	0.83	0.42	0.55	0.74	0.49	0.62	0.81	0.47	0.60	0.75	0.56	0.67	0.98
Cooling coil	0.80	0.32	0.53	0.87	0.33	0.51	0.78	0.38	0.60	0.86	0.35	0.47	0.83
Heating coil	0.13	0.05	0.09	0.14	0.05	0.08	0.13	0.06	0.10	0.14	0.06	0.08	0.13
Casing losses	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Int. static pressure													
Ext. static pressure													
Total static pressure													

Notes:

1. Filter pressure drops based on 2 inches thick, 30% efficient Class II filters.
2. Cooling coil pressure drops based on 6 row, 10 fins per inch single-circuited coil.
3. Heating coil pressure drops based on 1 row, 6 fins per inch.
4. Purge volumes based on 4 inches P_{OA}-P_{RA} for wheel.
5. Casing losses include fan inlet losses.

Table 5: Dual Wheel Unit Pressure Drops

Size	EPD-3			EPD-5			EPD-9			EPD-13			EPD-18	
CFM	2000	2250	2500	3000	4000	4500	4500	6000	8000	6000	8000	10000	8000	10000
Sens. wheel purge	513	513	513	695	695	695	906	906	906	1168	1168	1168	1440	1440
Enth. wheel purge	663	663	663	877	877	877	1119	1119	1119	1415	1415	1415	1718	1718
Fan cfm	3176	3676	4176	4572	5572	6072	6525	8025	10025	8583	10583	12583	11158	13158
OA opening (w/hood)	0.04	0.05	0.07	0.03	0.04	0.05	0.02	0.03	0.04	0.02	0.03	0.04	0.01	0.02
EA opening (w/hood)	0.06	0.07	0.10	0.12	0.17	0.21	0.11	0.16	0.25	0.11	0.17	0.23	0.03	0.04
RA or EA opening	0.16	0.21	0.27	0.14	0.22	0.26	0.13	0.20	0.31	0.13	0.19	0.27	0.12	0.17
SA or OA opening	0.06	0.10	0.14	0.06	0.11	0.14	0.05	0.08	0.14	0.05	0.08	0.13	0.04	0.06
Damper	0.11	0.15	0.19	0.07	0.11	0.13	0.07	0.10	0.16	0.08	0.12	0.17	0.06	0.09
OA filter	0.42	0.56	0.72	0.39	0.57	0.68	0.28	0.43	0.67	0.34	0.52	0.73	0.27	0.38
RA filter	0.17	0.26	0.37	0.17	0.30	0.37	0.27	0.49	0.87	0.30	0.52	0.82	0.22	0.34
Enth. wheel	0.93	1.19	1.46	0.67	0.91	1.05	0.59	0.80	1.13	0.50	0.67	0.86	0.48	0.59
Sens. wheel	0.69	0.92	1.18	0.52	0.74	0.86	0.48	0.67	0.97	0.42	0.57	0.75	0.41	0.51
Cooling coil	0.41	0.59	0.80	0.47	0.77	0.94	0.36	0.59	0.98	0.42	0.69	1.03	0.32	0.47
Heating coil	0.07	0.10	0.13	0.08	0.13	0.15	0.06	0.110	0.16	0.07	0.11	0.17	0.05	0.08
Casing losses	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Int. static pressure														
Ext. static pressure														
Total static pressure														

Size	EPD-18	EPD-24			EPD-28			EPD-35			EPD-43		
CFM	15000	11000	14000	18000	15000	18500	23000	18000	22500	27000	26000	30000	40000
Sens. wheel purge	1440	1735	1735	1735	1961	1961	1961	2297	2297	2297	2662	2662	2662
Enth. wheel purge	1718	2044	2044	2044	2291	2291	2291	2657	2657	2657	3052	3052	3052
Fan cfm	18158	14779	17779	21779	19252	22752	27252	22954	27454	31954	31714	35714	45714
OA opening (w/hood)	0.04	0.02	0.03	0.04	0.02	0.02	0.04	0.02	0.03	0.04	0.02	0.03	0.04
EA opening (w/hood)	0.07	0.12	0.17	0.26	0.13	0.18	0.26	0.14	0.20	0.27	0.13	0.16	0.27
RA or EA opening	0.32	0.21	0.31	0.46	0.15	0.21	0.30	0.15	0.21	0.28	0.14	0.18	0.30
SA or OA opening	0.14	0.05	0.08	0.13	0.06	0.09	0.50	0.06	0.10	0.14	0.06	0.08	0.14
Damper	0.17	0.08	0.11	0.16	0.08	0.12	0.17	0.08	0.12	0.16	0.10	0.13	0.22
OA filter	0.71	0.36	0.52	0.79	0.34	0.47	0.68	0.39	0.56	0.75	0.34	0.44	0.74
RA filter	0.76	0.31	0.51	0.84	0.30	0.45	0.69	0.34	0.54	0.77	0.41	0.55	0.98
Enth. wheel	0.94	0.49	0.63	0.83	0.56	0.70	0.91	0.53	0.68	0.84	0.63	0.74	1.07
Sens. wheel	0.83	0.42	0.55	0.74	0.49	0.62	0.81	0.47	0.60	0.75	0.56	0.67	0.98
Cooling coil	0.97	0.43	0.66	1.04	0.43	0.62	0.92	0.49	0.73	1.01	0.42	0.55	0.94
Heating coil	0.16	0.07	0.11	0.17	0.07	0.10	0.15	0.08	0.12	0.17	0.07	0.09	0.15
Casing losses	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Int. static pressure													
Ext. static pressure													
Total static pressure													

Notes:

1. Filter pressure drops based on 2 inches thick, 30% efficient Class II filter.
2. Cooling coil pressure drops based on 6 row, 10 fins per inch single-circuited coil.
3. Heating coil pressure drops based on 1 row, 6 fins per inch.
4. Purge volumes based on 4 inches P_{OA}-P_{RA} for enthalpy wheel and 7 inches for sensible wheel.
5. Casing losses include fan inlet losses.

Fan Data

Max motor size assumes the motor is mounted on top of the fan. A larger motor may be provided by mounting the motor and the fan on a common base. This will add length to the unit.

SIZE 3

Maximum 5 hp Motor

	STATIC PRESSURE IN INCHES OF WATER																			
	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		9" SP		10" SP	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
1200	1464	.32																		
1400	1563	.38	1933	.74																
1600	1670	.45	2025	.86	2323	1.28														
1800	1786	.52	2120	.97	2406	1.44	2667	1.92												
2200	2029	.71	2327	1.21	2594	1.78	2835	2.36	3051	2.93	3265	3.53								
2600	2285	.96	2558	1.53	2799	2.14	3025	2.81	3235	3.50	3427	4.17	3608	4.48	3789	5.54				
3000	2548	1.27	2801	1.90	3024	2.57	3231	3.29	3428	4.05	3615	4.85	3792	5.65						
3400	2818	1.65	3052	2.36	3262	3.09	3455	3.86	3637	4.67	3813	5.53								
3800	3092	2.10	3311	2.90	3508	3.70	3691	4.53	3862	5.40										
4200	3370	2.65	3576	3.53	3761	4.40														
4600	3650	3.28	3844	4.25																
5000																				

Class I = Max. 3006 RPM Class II = Max. 3909 RPM EPF150

SIZE 5

Maximum 10 hp Motor

	STATIC PRESSURE IN INCHES OF WATER																			
	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		9" SP		10" SP	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
2500	1101	.59	1420	1.20																
2800	1157	.68	1449	1.32	1721	2.06														
3100	1217	.77	1487	1.45	1742	2.22														
3400	1281	.88	1534	1.60	1772	2.40	1998	3.29												
4000	1416	1.14	1644	1.94	1852	2.81	2054	3.76	2249	4.78	2436	5.88								
4600	1551	1.43	1767	2.34	1956	3.29	2135	4.31	2312	5.39	2484	6.53	2650	7.74	2811	9.02				
5200	1689	1.78	1899	2.81	2073	3.85	2238	4.94	2396	6.09	2553	7.30	2707	8.56	2858	9.88	3004	11.27	3147	12.71
5800	1833	2.20	2034	3.35	2200	4.48	2353	5.66	2500	6.89	2642	8.17	2783	9.51	2922	10.88	3059	12.30	3194	13.79
7000	2135	3.28	2306	4.61	2468	6.00	2607	7.37	2735	8.75	2861	10.20	2983	11.68	3102	13.21	3219	14.77	3335	16.38
8200	2448	4.74	2592	6.22	2739	7.83	2876	9.46	2998	11.07	3110	12.67	3219	14.30	3327	16.00	3432	17.72	3535	19.48
9400			2892	8.28	3019	10.04	3147	11.90	3268	13.78	3378	15.63	3479	17.45	3277	19.31	3672	21.18	3766	23.10
10600			3201	10.84	3312	12.76	3426	14.78	3539	16.88	3648	19.00	3749	21.10						

Class I = Max. 2302 RPM Class II = Max. 2930 RPM Class III = Max. 3767 RPM EPF182

SIZE 5X

Maximum 10 hp Motor

	STATIC PRESSURE IN INCHES OF WATER																			
	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		9" SP		10" SP	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
3000	1004	.71	1295	1.44																
3400	1061	.82	1326	1.60	1572	2.50														
3800	1123	.96	1366	1.78	1595	2.71	1810	3.76												
4200	1189	1.11	1415	1.98	1627	2.96	1829	4.03	2021	5.21										
4600	1257	1.27	1470	2.20	1667	3.23	1858	4.34	2040	5.55	2214	6.85								
5400	1394	1.66	1592	2.72	1767	3.84	1934	5.06	2098	6.34	2258	7.70	2411	9.14	2560	10.67				
6200	1533	2.11	1725	3.34	1885	4.58	2036	5.88	2181	7.26	2325	8.71	2467	10.22	2604	11.79	2738	13.45	2869	15.17
7000	1679	2.67	1862	4.05	2013	5.42	2152	6.84	2286	8.32	2415	9.86	2543	11.47	2670	13.13	2794	14.83	2917	16.62
7800	1831	3.34	1999	4.85	2148	6.39	2278	7.93	2402	9.51	2523	11.17	2639	12.86	2754	14.61	2869	16.43	2982	18.28
9400	2144	5.09	2282	6.81	2422	8.68	2548	10.54	2659	12.37	2765	14.23	2868	16.14	2970	18.12	3068	20.12	3164	22.15
11000			2583	9.40	2703	11.48	2822	13.67	2933	15.86	3033	18.02	3126	20.15	3216	22.32	3305	24.55	3393	26.82
12600			2895	12.71	2998	15.00	3102	17.40	3207	19.91	3307	22.44	3399	24.93						

Class I = Max. 2101 RPM Class II = Max. 2674 RPM Class III = Max. 3438 RPM EPF200

Legend:
Class I = First white section
Class II = Blue shaded section
Class III = White section after blue section
Underlined figures indicate Maximum Static Efficiency

SIZE 9, 5XX

Maximum 20 hp Motor

	STATIC PRESSURE IN INCHES OF WATER																			
	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		9" SP		10" SP	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
3500	868	.79	1130	1.61																
4000	912	.92	1156	1.82																
4500	962	1.06	1191	2.03	1393	3.09														
5000	1016	1.22	1231	2.26	1422	3.40	1600	4.61												
6000	1133	1.60	1324	2.79	1498	4.07	1657	5.43	1809	6.86	1954	8.31								
7000	1256	2.07	1429	3.40	1587	4.83	1735	6.33	1874	7.91	2006	9.53	2135	11.22	2259	12.90				
8000	1383	2.64	1544	4.13	1688	5.70	1825	7.34	1955	9.06	2078	10.83	2196	12.65	2311	14.54	**2424**	**16.47**	**2533**	**18.38**
9000	1514	3.33	1665	4.98	1798	6.69	1924	8.48	2046	10.34	2162	12.25	2274	14.23	2381	16.25	**2485**	**18.31**	**2587**	**20.43**
10000	1647	4.14	1788	5.95	1915	7.83	2032	9.76	2145	11.76	2254	13.81	2360	15.93	**2463**	**18.11**	**2562**	**20.33**	**2657**	**22.56**
12000	1917	6.20	2046	8.37	2159	10.55	2266	12.81	2365	15.09	**2461**	**17.43**	**2555**	**19.83**	**2648**	**22.30**	**2737**	**24.78**	**2825**	**27.32**
14000	2192	8.92	2310	11.46	**2415**	**14.00**	**2511**	**16.54**	**2604**	**19.16**	**2692**	**21.82**	**2776**	**24.50**	**2858**	**27.23**	**2939**	**30.02**	**3019**	**32.85**
16000			**2579**	**15.34**	**2677**	**18.24**	**2767**	**21.14**	**2852**	**24.06**	**2934**	**27.02**	**3013**	**30.03**	**3088**	**33.04**				

Class I = Max. 1888 RPM Class II = Max. 2403 RPM Class III = Max. 3090 RPM EPF222

SIZE 13, 9X

Maximum 20 hp Motor

	STATIC PRESSURE IN INCHES OF WATER																			
	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		9" SP		10" SP	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
4400	804	.99																		
5000	849	1.15	1057	2.20																
5600	898	1.34	1094	2.49	1270	3.71														
6200	950	1.55	1135	2.79	1299	4.10														
7400	1058	2.05	1227	3.45	1376	4.98	1515	6.55	1647	8.15										
8600	1171	2.64	1328	4.26	1466	5.94	1593	7.73	1714	9.55	1828	11.35	1942	13.28						
9800	1289	3.36	1436	5.22	1564	7.05	1683	9.00	1794	11.04	1902	13.12	2004	15.16	2104	17.25	**2204**	**19.45**		
11000	1409	4.22	1546	6.30	1668	8.36	1780	10.45	1885	12.64	1985	14.93	2081	17.23	2175	19.55	**2266**	**21.87**	**2355**	**24.21**
12200	1533	5.27	1660	7.52	1776	9.83	1882	12.11	1981	14.43	2077	16.88	2167	19.37	**2255**	**21.93**	**2342**	**24.53**	**2426**	**27.10**
14600	1787	7.94	1896	10.51	2001	13.28	2098	16.05	**2189**	**18.77**	**2275**	**21.49**	**2358**	**24.28**	**2439**	**27.18**	**2516**	**30.11**	**2592**	**33.15**
17000			2142	14.43	**2234**	**17.50**	**2324**	**20.74**	**2408**	**23.96**	**2489**	**27.18**	**2565**	**30.32**	**2639**	**33.49**	**2711**	**36.72**	**2781**	**40.01**
19400			**2394**	**19.40**	**2477**	**22.81**	**2557**	**26.35**	**2636**	**30.05**	**2711**	**33.74**	**2783**	**37.40**						

Class I = Max. 1715 RPM Class II = Max. 2183 RPM Class III = Max. 2806 RPM EPF245

SIZE 13X, 9XX

Maximum 30 hp Motor

	STATIC PRESSURE IN INCHES OF WATER																			
	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		9" SP		10" SP	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
5000	716	1.13	943	2.37																
5800	756	1.33	961	2.65																
6600	803	1.56	991	2.98	1163	4.59														
7400	854	1.82	1028	3.34	1187	5.04	1338	6.91												
8200	909	2.12	1070	3.76	1219	5.55	1358	7.48	1495	9.60										
9000	966	2.47	1115	4.20	1256	6.10	1388	8.14	1514	10.31	1638	12.63								
10600	1082	3.28	1217	5.24	1341	7.35	1460	9.58	1574	11.95	1683	14.41	1789	16.99	1895	19.72	**1999**	**22.55**		
12200	1203	4.30	1328	6.50	1439	8.83	1547	11.29	1651	13.85	1751	16.51	1848	19.27	1942	22.12	**2034**	**25.07**	**2126**	**28.16**
13800	1326	5.54	1443	7.99	1547	10.56	1643	13.21	1738	15.99	1831	18.87	1921	21.83	**2009**	**24.90**	**2094**	**28.03**	**2177**	**31.24**
17000	1576	8.74	1682	11.81	1774	14.83	1861	17.98	1941	21.17	**2019**	**24.47**	**2096**	**27.86**	**2173**	**31.36**	**2248**	**34.90**	**2321**	**38.49**
20200	1831	13.12	1928	16.84	**2013**	**20.45**	**2090**	**24.01**	**2165**	**27.72**	**2235**	**31.46**	**2303**	**35.31**	**2368**	**39.18**	**2433**	**43.15**	**2499**	**47.26**
23400			**2178**	**23.25**	**2258**	**27.52**	**2330**	**31.67**	**2397**	**35.79**	**2462**	**40.00**	**2526**	**44.34**						

Class I = Max. 1556 RPM Class II = Max. 1981 RPM Class I = Max. 2546 RPM EPF270

Legend:
Class I = First white section
Class II = Blue shaded section
Class III = White section after blue section
Underlined figures indicate Maximum Static Efficiency

SIZE 18, 13XX

Maximum 50 hp Motor

STATIC PRESSURE IN INCHES OF WATER																				
	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		9" SP		10" SP	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
6000	639	1.33																		
7000	675	1.56	860	3.20																
8000	717	1.84	888	3.58	1041	5.56														
9000	761	2.14	921	3.99	1064	6.11	1198	8.40												
10000	809	2.50	959	4.48	1094	6.69	1219	9.13	1339	11.70										
11000	858	2.89	1000	5.02	1128	7.33	1246	9.87	1358	12.57	14.67	15.41								
13000	960	3.89	1090	6.26	1205	8.83	1313	11.55	1415	14.48	1512	17.58	1607	20.83	1699	24.14	1790	27.60		
15000	1066	5.15	1186	7.73	1292	10.60	1391	13.58	1485	16.69	1575	19.97	1662	23.45	1746	27.07	1828	30.78	1909	34.60
17000	1174	6.66	1287	9.53	1386	12.63	1477	15.90	1565	19.30	1649	22.80	1730	26.44	1808	30.22	1884	34.16	1958	38.22
21000	1399	10.60	1496	14.27	1585	17.77	1667	21.52	1744	25.50	1817	29.55	1889	33.72	1959	37.98	2026	42.26	2092	46.69
25000	1629	15.97	1714	20.50	1794	24.77	1869	28.93	1940	33.30	2007	37.89	2071	42.62	2133	47.44	2194	52.36	2254	57.33
29000			1938	28.38	2010	33.57	2078	38.45	2143	43.24	2206	48.20	2266	53.37						

Class I = Max. 1401 RPM Class II = Max. 1783 RPM Class III = Max. 2291 RPM EPF300

SIZE 24, 18X

Maximum 50 hp Motor

STATIC PRESSURE IN INCHES OF WATER																				
	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		9" SP		10" SP	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
7000	574	1.56																		
8000	600	1.77	774	3.70																
9000	630	2.03	792	4.06	939	6.39														
11000	696	2.63	841	4.89	969	7.44	1091	10.26												
13000	769	3.38	899	5.89	1017	8.66	1126	11.71	1230	14.96	1330	18.33								
15000	845	4.31	965	7.09	1073	10.09	1174	13.32	1269	16.80	1360	20.46	1449	24.27	1536	28.22				
17000	923	5.47	1036	8.46	1136	11.77	1230	15.23	1319	18.88	1403	22.73	1485	26.82	1565	31.06	1643	35.38	1720	39.84
19000	1003	6.83	1110	10.07	1204	13.65	1291	17.37	1375	21.27	1455	25.33	1532	29.61	1606	34.05	1678	38.63	1749	43.35
23000	1169	10.25	1264	14.18	1350	18.17	1428	22.46	1502	26.94	1573	31.47	1642	36.15	1709	40.97	1774	45.93	1838	51.13
27000	1340	14.75	1424	19.53	1502	24.01	1575	28.71	1643	33.71	1707	38.84	1769	44.08	1831	49.51	1890	54.92	1948	60.46
31000	1514	20.52	1589	26.12	1661	31.48	1728	36.61	1792	41.97	1852	47.59	1909	53.36	1965	59.34	2019	65.36	2073	71.52
35000			1758	34.14	1823	40.36	1886	46.32	1945	52.09	2002	58.05	2057	64.35						

Class I = Max. 1273 RPM Class II = Max. 1620 RPM Class III = Max. 2083 RPM EPF330

SIZE 28, 24X, 18XX

Maximum 50 hp Motor

STATIC PRESSURE IN INCHES OF WATER																				
	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		9" SP		10" SP	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
8000	496	1.73																		
9200	518	2.00																		
10400	541	2.28	689	4.55																
11600	568	2.60	707	5.04																
14000	628	3.34	751	6.11	862	9.11	968	12.42												
16400	693	4.25	803	7.35	906	10.73	999	14.21	1089	17.97										
18800	762	5.37	862	8.78	954	12.45	1043	16.36	1126	20.42	1203	24.51	1282	29.02						
23600	906	8.32	992	12.37	1070	16.67	1145	21.24	1218	25.98	1289	30.90	1357	35.95	1421	41.00	1483	46.15	1544	51.45
28400	1053	12.27	1131	17.14	1201	22.10	1266	27.23	1329	32.63	1390	38.13	1451	43.85	1511	49.74	1569	55.72	1625	61.76
33200	1204	17.52	1275	23.22	1339	28.93	1398	34.70	1455	40.71	1509	46.84	1562	53.14	1615	59.66	1667	66.25	1719	73.06
38000	1357	24.22	1423	30.84	1482	37.35	1536	43.81	1588	50.43	1638	57.19	1687	64.19	1734	71.26	1780	78.45	1826	85.81
42800			1572	40.05	1627	47.40	1678	54.70	1726	61.99	1773	69.48	1818	77.02	1862	84.75				

Class I = Max. 1151 RPM Class II = Max. 1465 RPM Class I = Max. 1884 RPM EPF365

Legend:
Class I = First white section
Class II = Blue shaded section
Class III = White section after blue section
Underlined figures indicate Maximum Static Efficiency

SIZE 35, 28X, 24XX

Maximum 50 hp Motor

	STATIC PRESSURE IN INCHES OF WATER																			
	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		9" SP		10" SP	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
10000	454	2.18																		
11500	474	2.50																		
13000	497	2.87	628	5.66																
16000	549	3.71	667	6.98	770	10.45														
19000	609	4.78	712	8.42	808	12.38	895	16.52	981	21.07										
22000	672	6.09	765	10.13	852	14.51	934	19.13	1010	23.89	1083	28.87								
25000	738	7.70	824	12.15	901	16.85	978	21.97	1050	27.21	1118	32.59	1182	38.01	1247	43.87	1314	50.25		
28000	805	9.59	885	14.45	957	19.60	1026	25.03	1094	30.75	1159	36.61	1221	42.62	1279	48.57	1337	54.86	1394	61.32
34000	943	14.45	1014	20.26	1078	26.20	1138	32.43	1195	38.84	1251	45.45	1307	52.33	1362	59.43	1415	66.61	1466	73.87
40000	1083	20.84	1148	27.73	1206	34.58	1260	41.56	1312	48.83	1361	56.20	1410	63.90	1458	71.71	1506	79.75	1553	87.90
46000	1226	29.16	1285	37.08	1339	44.99	1388	52.80	1436	60.90	1481	69.04	1525	77.44	1568	86.05	1610	94.77	1652	103.72
52000			1425	48.66	1475	57.61	1521	66.45	1564	75.24	1607	84.39	1648	93.58	1688	103.00				

Class I = Max. 1044 RPM Class II = Max. 1329 RPM Class III = Max. 1708 RPM EPF402

SIZE 43, 35X, 28XX

Maximum 50 hp Motor (up to 75 hp motor on C-III fan)

	STATIC PRESSURE IN INCHES OF WATER																			
	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		9" SP		10" SP	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
12000	408	2.60																		
13800	426	3.00																		
15600	446	3.44	566	6.82																
17400	468	3.91	581	7.54																
21000	518	5.03	618	9.17	709	13.67	794	18.53												
24600	572	6.41	661	11.02	745	16.07	822	21.35	894	26.84										
28200	629	8.11	710	13.18	786	18.73	859	24.63	926	30.63	989	36.75	1053	43.45						
35400	748	12.57	819	18.69	883	25.16	943	31.90	1003	39.04	1061	46.42	1116	53.90	1168	61.40	1219	69.16	1269	77.13
42600	871	18.66	934	25.91	991	33.33	1044	41.01	1095	49.03	1145	57.30	1195	65.91	1244	74.74	1291	83.61	1337	92.71
49800	996	26.65	1054	35.22	1105	43.65	1154	52.40	1200	61.32	1244	70.47	1287	79.88	1330	89.59	1373	99.58	1415	109.67
57000	1122	36.80	1176	46.74	1224	56.49	1268	66.17	1310	76.00	1352	86.34	1391	96.62	1429	107.13	1467	117.99	1505	129.14
64200			1300	60.84	1345	71.91	1386	82.76	1425	93.66	1463	104.8	1500	116.15	1536	127.73				

Class I = Max. 944 RPM Class II = Max. 1202 RPM Class III = Max. 1545 RPM EPF445

SIZE 43X, 35XX

Maximum 50 hp Motor

	STATIC PRESSURE IN INCHES OF WATER																			
	1" SP		2" SP		3" SP		4" SP		5" SP		6" SP		7" SP		8" SP		9" SP		10" SP	
CFM	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP	RPM	BHP
16000	381	3.47																		
18000	397	3.93	510	7.95																
20000	414	4.42	520	8.67																
24000	454	5.59	550	10.46	634	15.65														
28000	499	7.05	583	12.37	663	18.29	734	24.33	805	31.07										
32000	545	8.75	622	14.63	695	21.09	763	27.86	825	34.71	887	42.18								
36000	593	10.79	665	17.24	730	24.10	794	31.48	855	39.21	910	46.79	965	54.94	1020	63.59				
44000	693	16.04	756	23.59	813	31.53	867	39.90	920	48.64	972	57.75	1022	67.09	1069	76.42	1114	85.81	1159	95.68
52000	795	22.92	853	31.88	904	40.86	952	50.22	998	59.97	1043	70.02	1088	80.46	1132	91.14	1175	102.05	1217	113.23
60000	899	31.77	952	42.11	999	52.33	1043	62.77	1086	73.74	1126	84.77	1165	96.07	1204	107.73	1243	119.72	1282	132.10
68000	1005	42.97	1054	54.77	1098	66.40	1138	77.89	1177	89.76	1215	102.02	1251	114.41	1286	127.04	1321	140.08	1355	153.12
76000			1156	69.75	1198	82.94	1236	95.83	1272	108.78	1307	122.01	1341	135.50	1374	149.26				

Class I = Max. 857 RPM Class II = Max. 1091 RPM Class I = Max. 1403 RPM EPF490

Legend:
Class I = First white section
Class II = Blue shaded section
Class III = White section after blue section
Underlined figures indicate Maximum Static Efficiency

Coil Data Tables

Standard EPC, EPCH, EPHC Chilled Water Coils

Model	Capacity (cfm)	Finned Height	Finned Width	Face Velocity (fpm)	Standard Chilled Water Coils				
					Model	Water Pressure Drop, ft.	GPM	Leaving Air Temp. °F db/wb	Connection Size MPT
EP-3	Low 2000 Med 2500 High 3000	33 in	30 in	291 364 436	5WQ1006B	9.3 13.4 18.8	17 21 26	51.6 / 51.3 52.4 / 52 53.1 / 52.6	1.5 “
EP-5	Low 3000 Med 4000 High 4500	45 in	30 in	320 427 480	5WQ1006B	10.8 17.7 21.5	26 34 38	51.9 / 51.6 52.9 / 52.5 53.5 / 52.9	2 “
EP-9	Low 4500 Med 6000 High 8000	54 in	42 in	286 381 508	5WH1006B	3.8 6.5 10.9	38 51 68	52.1 / 51.8 52.9 / 52.6 54.1 / 53.5	1.5 “
EP-13	Low 6000 Med 8000 High 10000	66 in	42 in	312 416 519	5WH1006B	5 8.3 12.4	51 68 85	52.3 / 52 53.3 / 52.8 54.2 / 53.5	1.5 “
EP-18	Low 8000 Med 10000 High 15000	78 in	54 in	274 342 513	5WH1006B	6 8.9 18.2	68 85 128	51.4 / 51.2 52.2 / 51.8 53.8 / 53.1	2 “
EP-24	Low 11000 Med 14000 High 18000	90 in	54 in	326 415 533	5WH1006B	8.5 13 20.3	94 119 153	52 / 51.7 52.9 / 52.5 53.9 / 53.3	2 “
EP-28	Low 15000 Med 18500 High 23000	99 in	66 in	331 408 507	5WL1006B	4.9 7.1 10.5	128 158 196	52.4 / 52.1 53.1 / 52.7 53.9 / 53.3	2.5 “
EP-35	Low 18000 Med 22500 High 27000	111 in	66 in	354 442 531	5WL1006B	5.5 8.2 11.6	153 191 232	52.6 / 52.3 53.5 / 53 54.2 / 53.5	2.5 “
EP-43	Low 26000 Med 30000 High 40000	123 in	90 in	338 390 520	5WS1006B	5.9 7.7 13	221 256 341	52.5 / 52.1 53 / 52.6 54.1 / 53.4	2.5 “

Design basis: Entering air temperature: 73°Fdb/66°F wb; entering water temperature: 45°F; water temperature rise: 11°±2°F.

Standard EPC, EPCH, EPHC DX Coils

Model	Capacity (cfm)	Finned Height	Finned Width	Face Velocity (fpm)	Standard Chilled Water Coils			
					Model	Leaving Air Temp. °F db / wb	Suction Line Connection Size MPT	Liquid Line Connection Size MPT
EP-3	Low 2000 Med 2500 High 3000	33 in	30 in	291 364 436	5EN1006B	53.2 / 53.2 54.4 / 54.3 55.2 / 55	(1) 1-5/8 (1) 1-5/8 (1) 1-5/8	(1) 1-3/8 (1) 1-3/8 (1) 1-3/8
EP-5	Low 3000 Med 4000 High 4500	45 in	30 in	320 427 480	5EN1006B	53.6 / 53.5 55.2 / 54.9 55.6 / 55.3	(1) 1-5/8 (1) 1-5/8 (1) 1-5/8	(1) 1-3/8 (1) 1-3/8 (1) 1-3/8
EP-9	Low 4500 Med 6000 High 8000	54 in	42 in	286 381 508	5EN1006B	51.7 / 51.7 53.4 / 53.2 54.8 / 54.6	(2) 1-5/8 (2) 1-5/8 (2) 1-5/8	(2) 1-1/8 (2) 1-1/8 (2) 1-1/8
EP-13	Low 6000 Med 8000 High 10000	66 in	42 in	312 416 519	5EN1006B	52.2 / 52.2 53.5 / 53.5 54.8 / 54.6	(2) 1-5/8 (2) 1-5/8 (2) 1-5/8	(2) 1-3/8 (2) 1-3/8 (2) 1-3/8
EP-18	Low 8000 Med 10000 High 15000	78 in	54 in	274 342 513	5EN1006B	51.1 / 51.1 52.1 / 52.1 54.6 / 54.2	(2) 2-1/8 (2) 2-1/8 (2) 2-1/8	(2) 1-3/8 (2) 1-3/8 (2) 1-3/8
EP-24	Low 11000 Med 14000 High 18000	90 in	54 in	326 415 533	5EN1006B	51.7 / 51.7 53.1 / 53.1 54.7 / 54.6	(2) 2-1/8 (2) 2-1/8 (2) 2-1/8	(2) 1-3/8 (2) 1-3/8 (2) 1-3/8
EP-28	Low 15000 Med 18500 High 23000	99 in	66 in	331 408 507	5EN1006B	52.1 / 51.8 53.1 / 53.1 54.7 / 54.2	(3) 2-1/8 (3) 2-1/8 (3) 2-1/8	(3) 1-3/8 (3) 1-3/8 (3) 1-3/8
EP-35	Low 18000 Med 22500 High 27000	111 in	66 in	354 442 531	5EN1006B	52.3 / 52.2 53.9 / 53.5 54.9 / 54.6	(3) 2-1/8 (3) 2-1/8 (3) 2-1/8	(3) 1-3/8 (3) 1-3/8 (3) 1-3/8
EP-43	Low 26000 Med 30000 High 40000	123 in	90 in	338 390 520	5EN1006B	52 / 51.8 52.7 / 52.5 54.4 / 54.2	(3) 2-5/8 (3) 2-5/8 (3) 2-5/8	(3) 1-5/8 (3) 1-5/8 (3) 1-5/8

Design basis standard: Entering air temperature: 73°Fdb/66°Fwb; entering water temperature: 45°F; water temperature rise: 11°±2°F. DX coil suction temp.: 45°F; refrigerant: R-22.

Increased Capacity EPC, EPCH, EPHC Chilled Water Coils

Model	Capacity (cfm)	Finned Height	Finned Width	Face Velocity (fpm)	Standard Chilled Water Coils				
					Model	Water Pressure Drop, ft.	GPM	Leaving Air Temp. °F db/wb	Connection Size MPT
EP-3	Low 2000 Med 2500 High 3000	33 in	30 in	291 364 436	5WH0808B	9.1 13.7 18.8	35 44 52	51.9 / 51.8 53.1 / 52.9 54.3 / 53.9	1.5 "
EP-5	Low 3000 Med 4000 High 4500	45 in	30 in	320 427 480	5WH1008B	9.6 16 19.7	52 70 78	50.8 / 50.7 52.3 / 52.2 53 / 52.8	2 "
EP-9	Low 4500 Med 6000 High 8000	54 in	42 in	286 381 508	5WL1008B	6.1 10.2 17	78 105 139	50.4 / 50.3 51.7 / 51.6 53.4 / 53.2	2 "
EP-13	Low 6000 Med 8000 High 10000	66 in	42 in	312 416 519	5WL1008B	7 11.7 17.4	105 139 174	50.8 / 50.7 52.2 / 52.1 53.5 / 53.3	2.5 "
EP-18	Low 8000 Med 10000 High 15000	78 in	54 in	274 342 513	5WS1008B	5.4 8.1 16.9	139 174 261	50.4 / 50.3 51.4 / 51.3 53.6 / 53.4	2.5 "
EP-24	Low 11000 Med 14000 High 18000	90 in	54 in	326 415 533	5WS1008B	6.9 10.7 16.9	192 244 314	51.2 / 51.1 52.4 / 52.2 53.8 / 53.6	3 "
EP-28	Low 15000 Med 18500 High 23000	99 in	66 in	331 408 507	5WM1008B	5.3 7.8 11.7	261 322 401	51.8 / 51.7 52.9 / 52.7 54.1 / 53.9	2.5 "
EP-35	Low 18000 Med 22500 High 27000	111 in	66 in	354 442 531	5WM1008B	6.6 10 14.1	313 392 470	52.2 / 52.1 53.4 / 53.2 54.4 / 54.1	2.5 "
EP-43	Low 26000 Med 30000 High 40000	123 in	90 in	338 390 520	5WT1006B	6.4 8.5 14.8	453 523 697	56.9 / 56.5 57.7 / 57.3 59.4 / 58.7	3 "

Design basis: Entering air temperature: 95°Fdb/78°Fwb; entering water temperature: 45°F; water temperature rise: 11°±2°F.

Increased Capacity EPC, EPCH, EPHC DX Coils

Model	Capacity (cfm)	Finned Height	Finned Width	Face Velocity (fpm)	Standard Chilled Water Coils			
					Model	Leaving Air Temp. °F db / wb	Suction Line Connection Size MPT	Liquid Line Connection Size MPT
EP-3	Low 2000 Med 2500 High 3000	33 in	30 in	291 364 436	5EN1008B	51.5 / 51.5 52.2 / 52.2 54.3 / 54.3	(1) 1-5/8 (1) 2-1/8 (1) 2-1/8	(1) 1-3/8 (1) 1-3/8 (1) 1-3/8
EP-5	Low 3000 Med 4000 High 4500	45 in	30 in	320 427 480	5EN1008B	52.1 / 52.1 54.2 / 54.2 55 / 55	(1) 2-1/8 (1) 2-1/8 (1) 2-5/8	(1) 1-3/8 (1) 1-3/8 (1) 1-3/8
EP-9	Low 4500 Med 6000 High 8000	54 in	42 in	286 381 508	5EN1008B	51.3 / 51.3 53.4 / 53.4 56.3 / 56.3	(2) 2-1/8 (2) 2-1/8 (2) 2-1/8	(2) 1-3/8 (2) 1-3/8 (2) 1-3/8
EP-13	Low 6000 Med 8000 High 10000	66 in	42 in	312 416 519	5EN1008B	52.1 / 52.1 54.3 / 54.3 56.5 / 56.5	(2) 2-1/8 (2) 2-1/8 (2) 2-5/8	(2) 1-3/8 (2) 1-3/8 (2) 1-3/8
EP-18	Low 8000 Med 10000 High 15000	78 in	54 in	274 342 513	5EN1008B	51.6 / 51.6 52.9 / 52.9 55.8 / 55.8	(2) 2-1/8 (2) 2-5/8 (2) 2-5/8	(2) 1-5/8 (2) 1-5/8 (2) 1-5/8
EP-24	Low 11000 Med 14000 High 18000	90 in	54 in	326 415 533	5EN1008B	52.3 / 52.3 54.1 / 54.1 56.1 / 56	(2) 2-5/8 (2) 2-5/8 (2) 2-1/8	(2) 1-5/8 (2) 1-5/8 (2) 1-5/8
EP-28	Low 15000 Med 18500 High 23000	99 in	66 in	331 408 507	5EN1008B	52.1 / 52.1 53.5 / 53.5 55.4 / 55.4	(3) 2-5/8 (3) 2-5/8 (3) 2-5/8	(3) 1-5/8 (3) 1-5/8 (3) 1-5/8
EP-35	Low 18000 Med 22500 High 27000	111 in	66 in	354 442 531	5EN1008B	52.5 / 52.5 54.2 / 54.2 55.8 / 55.8	(3) 2-5/8 (3) 2-5/8 (3) 2-5/8	(3) 1-5/8 (3) 1-5/8 (3) 1-5/8
EP-43	Low 26000 Med 30000 High 40000	123 in	90 in	338 390 520	5EN1008B	52.6 / 52.6 53.7 / 53.7 56.5 / 56.5	* (3) 2-5/8 (3) 2-5/8	(3) 1-5/8 (3) 1-5/8 (3) 1-5/8

Design basis: Entering air temperature: 95°Fdb/78°Fwb; entering water temperature: 45°F; water temperature rise: 11°±2°F. DX coil suction temperature: 45°F; refrigerant: R-22. *(2) 2-5/8 & (1) 2-1/8

Standard EPD Chilled Water Coils

						Standard Chilled Water Coils				
Model	Capacity (cfm)		Finned Height	Finned Width	Face Velocity (fpm)	Model	Water Pressure Drop, ft.	GPM	Leaving Air Temp. °F db/wb	Connection Size MPT
EPD-3	Low	2,513	33 in	30 in	366	5WQ1006B	10.9	19	52.9 / 52.7	1.5 ”
	Med	2,763			402		12.8	21	53.2 / 52.9	
	High	3,013			438		14.9	22	53.5 / 53.2	
EPD-5	Low	3,695	45 in	30 in	394	5WQ1006B	13.9	30	52.8 / 52.6	2 ”
	Med	4,695			501		16.4	33	54.2 / 54.0	
	High	5,195			554		19.5	36	54.5 / 54.2	
EPD-9	Low	5,406	54 in	42 in	343	5WH1006B	5.5	46	53.5 / 52.3	1.5 ”
	Med	6,906			438		8.5	59	53.3 / 53.0	
	High	8,906			565		11.5	70	54.5 / 54.2	
EPD-13	Low	7,168	66 in	42 in	372	5WH1006B	5.1	52	53.5 / 53.3	1.5 ”
	Med	9,168			476		8.0	66	54.3 / 54.0	
	High	11,168			580		13.8	88	54.6 / 54.3	
EPD-18	Low	9,440	78 in	54 in	323	5WH1006B	7.0	74	52.3 / 52.1	2 ”
	Med	11,440			391		9.8	90	52.9 / 52.7	
	High	16,440			562		18.5	129	54.1 / 53.8	
EPD-24	Low	12,735	90 in	54 in	377	5WH1006B	11.1	109	52.4 / 52.2	2 ”
	Med	15,735			466		16.2	134	53.1 / 52.8	
	High	19,735			585		17.9	143	54.6 / 54.2	
EPD-28	Low	16,961	99 in	66 in	374	5WH1006B	10.6	103	52.0 / 51.4	1.5 ”
	Med	20,461			451		14.8	125	52.5 / 51.8	
	High	24,961			550		18.3	141	53.4 / 52.5	
EPD-35	Low	20,297	111 in	66 in	399	5WL1006B	6.5	170	52.9 / 52.7	2.5 ”
	Med	24,797			487		9.3	206	53.6 / 53.3	
	High	29,297			576		10.7	224	54.5 / 54.2	
EPD-43	Low	28,662	123 in	90 in	373	5WL1006B	10.8	230	52.6 / 52.4	2.5 ”
	Med	32,662			425		16.0	287	52.6 / 52.4	
	High	42,662			555		19.0	317	54.3 / 53.9	

Design basis: Entering air temperature: 73°Fdb/66°Fwb; entering water temperature: 45°F; water temperature rise: 11°±2°F.
Note 1: CFM capacity includes typical values for sensible wheel purge volume.

Standard EPD DX Coils

						Standard Chilled Water Coils			
Model	Capacity (cfm)		Finned Height	Finned Width	Face Velocity (fpm)	Model	Leaving Air Temp. °F db / wb	Suction Line Connection Size MPT	Liquid Line Connection Size MPT
EPD-3	Low	2,513	33 in	30 in	366	5EN1006B	54.5 / 54.4	(1) 1-5/8	(1) 1-3/8
	Med	2,763			402		54.9 / 54.9	(1) 1-5/8	(1) 1-3/8
	High	3,013			438		55.3 / 55.2	(1) 1-5/8	(1) 1-3/8
EPD-5	Low	3,695	45 in	30 in	394	5EN1006B	54.9 / 54.8	(1) 1-5/8	(1) 1-3/8
	Med	4,695			501		55.9 / 55.8	(1) 1-5/8	(1) 1-3/8
	High	5,195			554		56.4 / 56.2	(1) 1-5/8	(1) 1-3/8
EPD-9	Low	5,406	54 in	42 in	343	5EN1006B	52.7 / 52.7	(2) 1-5/8	(2) 1-1/8
	Med	6,906			438		53.9 / 53.8	(2) 1-5/8	(2) 1-1/8
	High	8,906			565		55.2 / 55.0	(2) 1-5/8	(2) 1-1/8
EPD-13	Low	7,168	66 in	42 in	372	5EN1006B	53.1 / 53.1	(2) 1-5/8	(2) 1-3/8
	Med	9,168			476		54.5 / 54.2	(2) 1-5/8	(2) 1-3/8
	High	11,168			580		55.4 / 55.2	(2) 1-5/8	(2) 1-3/8
EPD-18	Low	9,440	78 in	54 in	323	5EN1006B	51.8 / 51.8	(2) 2-1/8	(2) 1-3/8
	Med	11,440			391		52.8 / 52.8	(2) 2-1/8	(2) 1-3/8
	High	16,440			562		54.8 / 54.7	(2) 2-1/8	(2) 1-3/8
EPD-24	Low	12,735	90 in	54 in	377	5EN1006B	52.6 / 52.6	(2) 2-1/8	(2) 1-3/8
	Med	15,735			466		53.8 / 53.7	(2) 2-1/8	(2) 1-3/8
	High	19,735			585		55.1 / 54.9	(2) 2-1/8	(2) 1-3/8
EPD-28	Low	16,961	99 in	66 in	374	5EN1006B	52.6 / 52.6	(3) 2-1/8	(3) 1-3/8
	Med	20,461			451		53.7 / 53.6	(3) 2-1/8	(3) 1-3/8
	High	24,961			550		54.9 / 54.7	(3) 2-1/8	(3) 1-3/8
EPD-35	Low	20,297	111 in	66 in	399	5EN1006B	52.9 / 52.9	(3) 2-1/8	(3) 1-3/8
	Med	24,797			487		54.1 / 54.0	(3) 2-1/8	(3) 1-3/8
	High	29,297			576		55.2 / 55.0	(3) 2-1/8	(3) 1-3/8
EPD-43	Low	28,662	123 in	90 in	373	5EN1006B	52.4 / 52.4	(3) 2-5/8	(3) 1-5/8
	Med	32,662			425		53.2 / 53.1	(3) 2-5/8	(3) 1-5/8
	High	42,662			555		54.7 / 54.6	(3) 2-5/8	(3) 1-5/8

Design Basis: Entering air temperature: 73°Fdb/66°Fwb; DX coil suction temperature: 45°F; refrigerant: R-22.
Note 1: CFM capacity includes typical values for sensible wheel purge volume.

Standard EPH, EPCH, EPHC Hot Water Coils

Model	Capacity (cfm)	Finned Height	Finned Width	Face Velocity (fpm)	Standard Chilled Water Coils				
					Model	Water Pressure Drop, ft.	GPM	Leaving Air Temp. °F db/wb	Connection Size MPT
EP-3	Low 2000 Med 2250 High 2500	33 in	30 in	291 327 364	5MH0601B	0.2 0.2 0.3	8 9 10	66.7 65.3 64	1.5 ”
EP-5	Low 3000 Med 4000 High 4500	45 in	30 in	320 427 480	5MH0601B	0.1 0.2 0.3	12 16 17	65.6 62.1 60	2 ”
EP-9	Low 4500 Med 6000 High 8000	54 in	42 in	286 381 508	5MH0601B	0.3 0.5 0.9	17 23 31	68.4 65 61	1.5 ”
EP-13	Low 6000 Med 8000 High 10000	66 in	42 in	312 416 519	5MH0601B	0.4 0.7 1.1	23 31 39	67.4 64 61	1.5 ”
EP-18	Low 8000 Med 10000 High 15000	78 in	54 in	274 342 513	5MH0601B	0.6 1 2.2	31 39 58	70.1 67 61.5	1.5 ”
EP-24	Low 11000 Med 14000 High 18000	90 in	54 in	326 415 533	5MH0601B	0.5 0.8 1.3	43 54 70	68 64.2 61	2 ”
EP-28	Low 15000 Med 18500 High 23000	99 in	66 in	331 408 507	5MH0601B	1.3 1.9 2.9	58 72 89	68 65.4 32.1	1.5 ”
EP-35	Low 18000 Med 22500 High 27000	111 in	66 in	354 442 531	5MH0601B	1.6 2.5 3.6	70 87 105	67.1 63.9 61.5	1.5 ”
EP-43	Low 26000 Med 30000 High 40000	123 in	90 in	338 390 520	5MH0601B	3.1 4.1 7.3	101 116 155	68.4 66.3 62.3	1.5 ”

Design Basis: Entering air temperature: 30°Fwb; entering water temperature: 180°F; leaving water temperature: 160±3°F.

Increased Capacity EPH, EPCH, EPHC Hot Water Coils

Model	Capacity (cfm)	Finned Height	Finned Width	Face Velocity (fpm)	Standard Chilled Water Coils				
					Model	Water Pressure Drop, ft.	GPM	Leaving Air Temp. °F db/wb	Connection Size MPT
EP-3	Low 2000 Med 2250 High 2500	33 in	30 in	291 327 364	5MH0702B	0.7 0.9 1.2	14 16 18	76.6 73.6 71	1.5 ”
EP-5	Low 3000 Med 4000 High 4500	45 in	30 in	320 427 480	5MH0702B	0.6 1 1.3	22 29 32	74.3 67.1 64	2 ”
EP-9	Low 4500 Med 6000 High 8000	54 in	42 in	286 381 508	5MH0702B	1.3 2.3 4.1	32 43 58	78.7 71.1 64	1.5 ”
EP-13	Low 6000 Med 8000 High 10000	66 in	42 in	312 416 519	5MH0702B	1.8 3.2 4.9	43 58 72	76.4 69 63.1	1.5 ”
EP-18	Low 8000 Med 10000 High 15000	78 in	54 in	274 342 513	5MH0702B	1.6 2.4 5.2	58 72 108	81 74.8 64.1	2 ”
EP-24	Low 11000 Med 14000 High 18000	90 in	54 in	326 415 533	5MH0702B	2.4 3.8 6	79 101 130	76.1 69.6 63	2 ”
EP-28	Low 15000 Med 18500 High 23000	99 in	66 in	331 408 507	5MH0702B	5.5 8.3 12.7	108 134 166	76.3 70.6 64.8	1.5 ”
EP-35	Low 18000 Med 22500 High 27000	111 in	66 in	354 442 531	5MH0702B	5.8 8.9 12.7	130 162 195	74.5 68.4 64	2 ”
EP-43	Low 26000 Med 30000 High 40000	123 in	90 in	338 390 520	5MS0802B	2.6 3.5 6.2	188 216 289	80.6 76.6 68.7	2.5 ”

Design Basis: Entering air temperature: 0°F; entering water temperature: 180°F; leaving water temperature: 160±3°F.

Standard EPD Hot Water Coils

Model	Capacity (cfm)	Finned Height	Finned Width	Face Velocity (fpm)	Standard Chilled Water Coils				
					Model	Water Pressure Drop, ft.	GPM	Leaving Air Temp. °F db	Connection Size MPT
EPD-3	Low 2,513 Med 2,763 High 3,013	33 in	30 in	366 402 438	5MQ0601B	0.39 0.57 0.57	8 10 10	62.3 61.9 60.5	1.5 “
EPD-5	Low 3,695 Med 4,695 High 5,195	45 in	30 in	394 501 554	5MQ0601B	0.52 0.87 0.97	12 16 17	61.6 59.0 57.9	1.5 “
EPD-9	Low 5,406 Med 6,906 High 8,906	54 in	42 in	343 438 565	5MH0601B	0.34 0.58 0.99	17 23 31	62.2 59.8 57.3	1.5 “
EPD-13	Low 7,168 Med 9,168 High 11,168	66 in	42 in	372 476 580	5MH0601B	0.67 0.90 1.00	28 33 35	62.4 59.3 56.6	1.5 “
EPD-18	Low 9,440 Med 11,440 High 16,440	78 in	54 in	323 391 562	5MH0601B	0.87 1.06 2.18	35 39 58	65.1 61.9 58.0	1.5 “
EPD-24	Low 12,735 Med 15,735 High 19,735	90 in	54 in	377 466 585	5MH0601B	0.61 0.92 1.28	43 54 65	62.2 59.9 57.3	2 “
EPD-28	Low 16,961 Med 20,461 High 24,961	99 in	66 in	374 451 550	5MH0601B	1.31 1.93 2.83	58 72 89	62.9 60.7 58.6	1.5 “
EPD-35	Low 20,297 Med 24,797 High 29,297	111 in	66 in	399 487 576	5MH0601B	2.24 2.62 2.78	83 90 93	62.9 60.2 60.3	1.5 “
EPD-43	Low 28,662 Med 32,662 High 42,662	123 in	90 in	373 425 555	5MH0601B	3.55 3.99 4.94	113 120 135	64.0 62.2 58.5	1.5 “

Design Basis: Entering air temperature: 0°F; entering water temperature: 180°F; leaving water temperature: 160±3°F.
Note 1: CFM capacity includes typical values for sensible wheel purge volume.

Increased Capacity EPD Hot Water Coils

Model	Capacity (cfm)	Finned Height	Finned Width	Face Velocity (fpm)	Standard Chilled Water Coils				
					Model	Water Pressure Drop, ft.	GPM	Leaving Air Temp. °F db	Connection Size MPT
EPD-3	Low 2,513 Med 2,763 High 3,013	33 in	30 in	366 402 438	5MH0702B	1.43 1.70 1.99	20 22 24	74.1 72.0 70.1	1.5 “
EPD-5	Low 3,695 Med 4,695 High 5,195	45 in	30 in	394 501 554	5MH0702B	1.87 2.48 2.74	30 35 37	72.6 66.7 64.3	2 “
EPD-9	Low 5,406 Med 6,906 High 8,906	54 in	42 in	343 438 565	5MH0702B	2.54 3.50 4.73	46 55 65	77.4 71.4 65.2	1.5 “
EPD-13	Low 7,168 Med 9,168 High 11,168	66 in	42 in	372 476 580	5MH0702B	3.12 4.24 5.39	59 70 80	75.3 69.2 64.5	1.5 “
EPD-18	Low 9,440 Med 11,440 High 16,440	78 in	54 in	323 391 562	5MH0702B	4.67 6.38 8.86	84 100 120	79.9 75.3 66.1	2 “
EPD-24	Low 12,735 Med 15,735 High 19,735	90 in	54 in	377 466 585	5MH0702B	6.38 8.03 9.85	110 125 140	76.1 70.7 65.0	2 “
EPD-28	Low 16,961 Med 20,461 High 24,961	99 in	66 in	374 451 550	5MH0702B	8.06 10.24 13.27	140 160 185	76.5 71.9 67.1	1.5 “
EPD-35	Low 20,297 Med 24,797 High 29,297	111 in	66 in	399 487 576	5MH0702B	10.51 12.21 14.97	173 188 210	75.4 70.1 66.1	1.5 “
EPD-43	Low 28,662 Med 32,662 High 42,662	123 in	90 in	373 425 555	5MS0702B	2.65 3.27 4.69	240 270 330	75.4 72.4 66.0	2.5 “

Design Basis: Entering air temperature: 0°F; entering water temperature: 180°F; leaving water temperature: 160±3°F.
Note 1: CFM capacity includes typical values for sensible wheel purge volume.

Standard EPH, EPCH, EPHC Electric Coils

Model	Capacity (cfm)	Electric Heater kW	Nominal Temp Rise at Rated Capacity	FLA @ 208 Volts 3Ø / 60 hz	FLA @ 240 Volts 3Ø / 60 hz	FLA @ 480 Volts 3Ø / 60 hz
EPH-3	Low 2000 Med 2250 High 3000	10	15.8 14.0 12.6	27.8	24.1	12.0
EPH-5	Low 3000 Med 4000 High 4500	15	15.8 11.9 10.5	41.6	36.1	18.0
EPH-9	Low 4500 Med 6000 High 8000	20	14.0 10.5 7.9	55.5	48.1	24.1
EPH-13	Low 6000 Med 8000 High 10000	25	13.2 9.9 7.9	69.4	60.1	30.1
EPH-18	Low 8000 Med 10000 High 15000	35	13.8 11.1 7.4	97.2	84.2	42.1
EPH-24	Low 11000 Med 14000 High 18000	45	12.9 10.2 7.9	124.9	108.3	54.1
EPH-28	Low 15000 Med 18500 High 23000	60	12.6 10.2 8.2	-	-	72.2
EPH-35	Low 18000 Med 22500 High 27000	75	13.2 10.5 8.8	-	-	90.2
EPH-43	Low 26000 Med 30000 High 40000	100	12.2 10.5 7.9	-	-	120.3

Increased Capacity EPH, EPCH, EPHC Electric Coils

Model	Capacity (cfm)	Electric Heater kW	Nominal Temp Rise at Rated Capacity	FLA @ 208 Volts 3Ø / 60 hz	FLA @ 240 Volts 3Ø / 60 hz	FLA @ 480 Volts 3Ø / 60 hz
EPH-3	Low 2000 Med 2250 High 3000	30	47.4 42.1 37.9	83.3	72.2	36.1
EPH-5	Low 3000 Med 4000 High 4500	45	47.4 35.6 31.6	124.9	108.3	54.1
EPH-9	Low 4500 Med 6000 High 8000	60	42.1 31.6 23.7	166.5	144.3	72.2
EPH-13	Low 6000 Med 8000 High 10000	75	39.5 29.6 23.7	208.2	180.4	90.2
EPH-18	Low 8000 Med 10000 High 15000	105	41.5 33.2 22.1	291.5	252.6	126.3
EPH-24	Low 11000 Med 14000 High 18000	135	38.8 30.5 23.7	374.7	324.8	162.4
EPH-28	Low 15000 Med 18500 High 23000	180	37.9 30.7 24.7	-	-	216.5
EPH-35	Low 18000 Med 22500 High 27000	225	39.5 31.6 26.3	-	-	270.6
EPH-43	Low 26000 Med 30000 High 40000	300	36.5 31.6 23.7	-	-	360.8

Note 1: Electric heating coils require a separate power connection.
Note 2: To determine Minimum Ampacity use 125% of the listed full load amps.
Note 3: Fuse Recommendation: Use 125% of the listed full load amps and select the next larger size Dual-Element Time-Delay Fuses.
Note 4: $kw = \frac{cfm \times \Delta T}{360}$

Standard EPD Electric Coils

Model	Capacity (cfm)	Electric Heater kW	Nominal Temp Rise at Rated Capacity	FLA @ 208 Volts 3Ø / 60 hz	FLA @ 240 Volts 3Ø / 60 hz	FLA @ 480 Volts 3Ø / 60 hz
EPD-3	Low 2,513 Med 2,763 High 3,013	10	15.8 14.0 12.6	27.8	24.1	12.0
EPD-5	Low 3,695 Med 4,695 High 5,195	15	15.8 11.9 10.5	41.6	36.1	18.0
EPD-9	Low 5,406 Med 6,906 High 8,906	20	14.0 10.5 7.9	55.5	48.1	24.1
EPD-13	Low 7,168 Med 9,168 High 11,168	25	13.2 9.9 7.9	69.4	60.1	30.1
EPD-18	Low 9,440 Med 11,440 High 16,440	35	13.8 11.1 7.4	97.2	84.2	42.1
EPD-24	Low 12,735 Med 15,735 High 19,735	45	12.9 10.2 7.9	124.9	108.3	54.1
EPD-28	Low 16,961 Med 20,461 High 24,961	60	12.6 10.2 8.2	-	-	72.2
EPD-35	Low 20,297 Med 24,797 High 29,297	75	13.2 10.5 8.8	-	-	90.2
EPD-43	Low 28,662 Med 32,662 High 42,662	100	12.2 10.5 7.9	-	-	120.3

Increased Capacity EPD Electric Coils

Model	Capacity (cfm)	Electric Heater kW	Nominal Temp Rise at Rated Capacity	FLA @ 208 Volts 3Ø / 60 hz	FLA @ 240 Volts 3Ø / 60 hz	FLA @ 480 Volts 3Ø / 60 hz
EPD-3	Low 2,513 Med 2,763 High 3,013	30	37.7 34.3 31.5	83.3	72.2	36.1
EPD-5	Low 3,695 Med 4,695 High 5,195	45	38.5 30.3 27.4	124.9	108.3	54.1
EPD-9	Low 5,406 Med 6,906 High 8,906	60	35.1 27.5 21.3	166.5	144.3	72.2
EPD-13	Low 7,168 Med 9,168 High 11,168	75	33.1 25.9 21.2	208.2	180.4	90.2
EPD-18	Low 9,440 Med 11,440 High 16,440	105	35.1 29.0 20.2	291.5	252.6	126.3
EPD-24	Low 12,735 Med 15,735 High 19,735	135	33.5 27.1 21.6	374.7	324.8	162.4
EPD-28	Low 16,967 Med 20,461 High 24,961	180	33.5 27.8 22.8	-	-	216.5
EPD-35	Low 20,297 Med 24,797 High 29,297	225	35.0 28.7 24.3	-	-	270.6
EPD-43	Low 28,662 Med 32,662 High 42,662	300	33.1 29.0 22.2	-	-	360.8

Note 1: Electric heating coils require a separate power connection.
Note 2: To determine Minimum Ampacity use 125% of the listed full load amps.
Note 3: Fuse Recommendation: Use 125% of the listed full load amps and select the next larger size Dual-Element Time-Delay Fuses.
Note 4: CFM capacity includes typical values for sensible wheel purge volume.
Note 5: $kw = \frac{cfm \times \Delta T}{360}$

<table>
<tr><th rowspan="2">HP</th><th colspan="3">3 Phase Full Load Amps</th><th rowspan="2">Minimum Efficiency Std. Motors</th><th rowspan="2">Minimum Efficiency High Eff. Motors</th></tr>
<tr><th>208V</th><th>240V</th><th>480V</th></tr>
<tr><td>1/6</td><td>0.6</td><td>0.6</td><td>0.3</td><td>-</td><td>-</td></tr>
<tr><td>1/4</td><td>1.0</td><td>1.0</td><td>0.5</td><td>-</td><td>-</td></tr>
<tr><td>1/2</td><td>2.4</td><td>2.2</td><td>1.1</td><td>-</td><td>-</td></tr>
<tr><td>3/4</td><td>3.5</td><td>3.2</td><td>1.6</td><td>73</td><td>-</td></tr>
<tr><td>1</td><td>4.6</td><td>4.2</td><td>2.1</td><td>76.6</td><td>82.5</td></tr>
<tr><td>1-1/2</td><td>6.6</td><td>6.0</td><td>3.0</td><td>80</td><td>84</td></tr>
<tr><td>2</td><td>7.5</td><td>6.8</td><td>3.4</td><td>79.9</td><td>84</td></tr>
<tr><td>3</td><td>10.6</td><td>9.6</td><td>4.8</td><td>83.1</td><td>86.5</td></tr>
<tr><td>5</td><td>16.7</td><td>15.2</td><td>7.6</td><td>83.4</td><td>87.5</td></tr>
<tr><td>7-1/2</td><td>24.2</td><td>22</td><td>11</td><td>86.6</td><td>88.5</td></tr>
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<tr><td>15</td><td>46.2</td><td>42</td><td>21</td><td>89.3</td><td>90.2</td></tr>
<tr><td>20</td><td>59.4</td><td>54</td><td>27</td><td>90.4</td><td>91</td></tr>
<tr><td>25</td><td>74.8</td><td>68</td><td>34</td><td>90.5</td><td>92.4</td></tr>
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<tr><td>40</td><td>114</td><td>104</td><td>52</td><td>90</td><td>93</td></tr>
<tr><td>50</td><td>-</td><td>130</td><td>65</td><td>91.2</td><td>94.1</td></tr>
<tr><td>60</td><td>-</td><td>-</td><td>77</td><td>92</td><td>93.6</td></tr>
<tr><td>75</td><td>-</td><td>-</td><td>96</td><td>92.4</td><td>94.1</td></tr>
<tr><td>100</td><td>-</td><td>-</td><td>124</td><td>92.5</td><td>94.1</td></tr>
<tr><th>HP</th><th colspan="3">3Ø Variable Frequency Drive (VFD)</th><th colspan="2">Yaskawa Model #</th></tr>
<tr><td>1/2</td><td>3.9</td><td>3.9</td><td>-</td><td colspan="2">CIMR-V7AM20P4</td></tr>
<tr><td>1/2</td><td>-</td><td>-</td><td>1.6</td><td colspan="2">CIMR-V7AM40P2</td></tr>
<tr><td>1</td><td>6.4</td><td>6.4</td><td>-</td><td colspan="2">CIMR-V7AM20P7</td></tr>
<tr><td>1</td><td>-</td><td>-</td><td>4.7</td><td colspan="2" rowspan="5">CIMR-V7AM40P7</td></tr>
<tr><th></th><th colspan="3">Control Power Transformer (CPT)</th></tr>
<tr><td>150 VA</td><td>0.7</td><td>0.6</td><td>0.4</td></tr>
<tr><td>500 VA</td><td>2.4</td><td>2.0</td><td>1.0</td></tr>
<tr><td>3 KVA</td><td>14.4</td><td>13.0</td><td>6.25</td></tr>
</table>

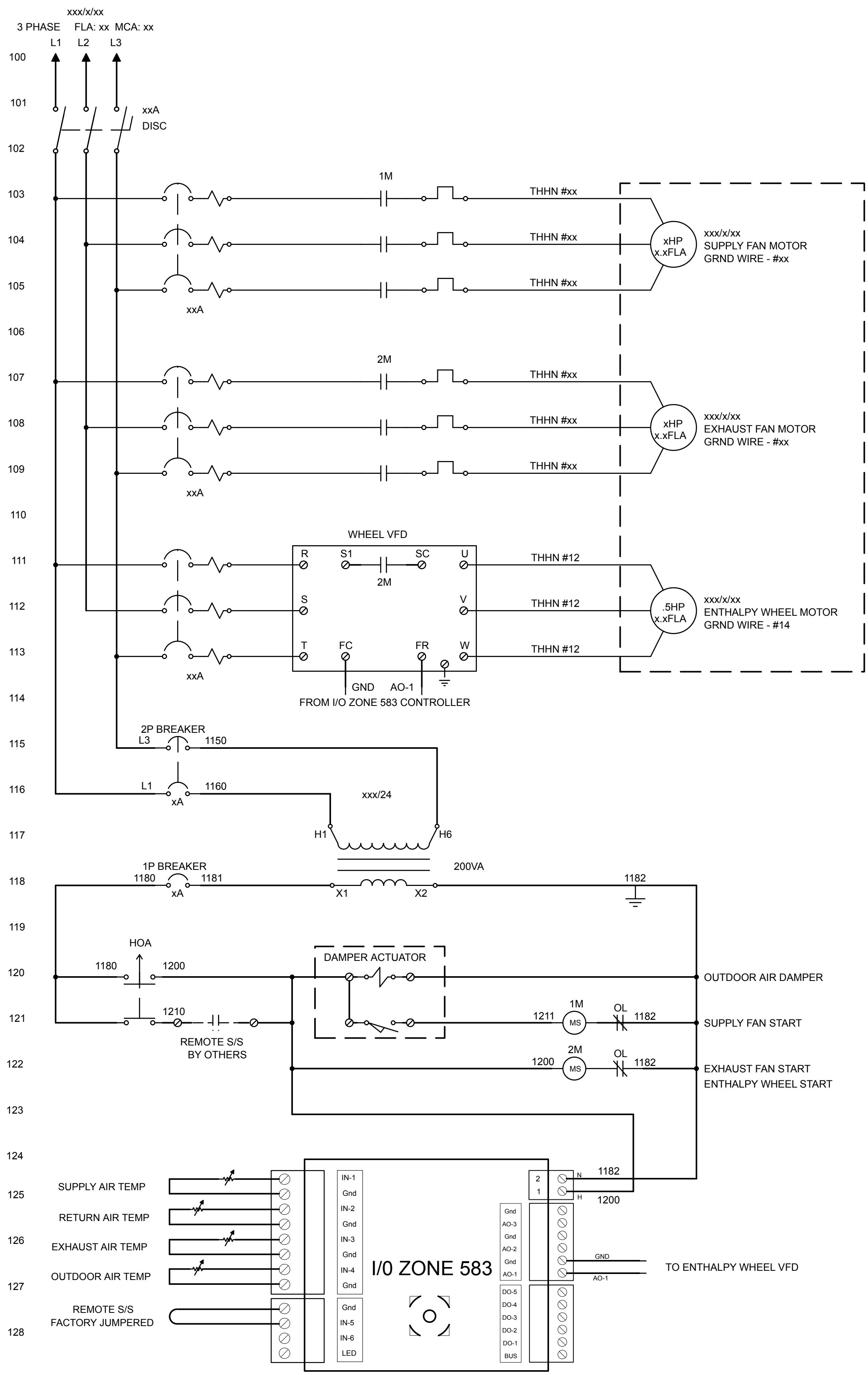
Note 1: To determine Minimum Circuit Ampacity, add the FLA's for each fan motor, the FLA of the constant speed wheel motor or the Variable Frequency Drive. Then add the CPT amps and 25 percent of the largest motor FLA.

Note 2: Maximum Overcurrent Protection(MOCP) is 125% of largest motor plus FLA, per instructions in UL 1995.

Note 3: Use a 3KVA transformer for units with 120 volt lights. Usa a 500 VA transformer if controls are included, otherwise use 180 VA transformer.

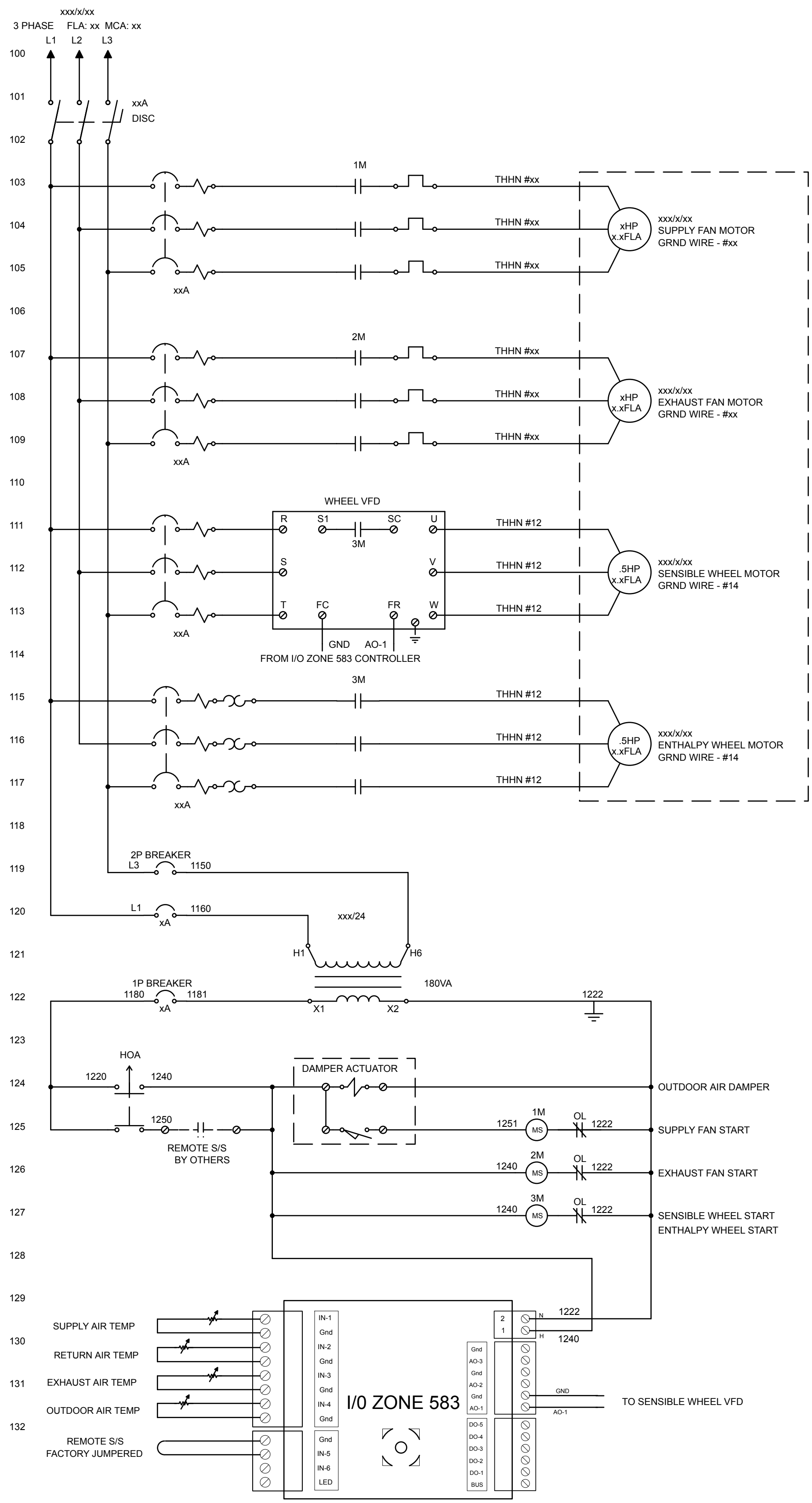
Single Wheel Electrical Schematic

Typical EP Series Unit with Variable Speed Wheel



Dual Wheel Electrical Schematic

Typical EPD Series Unit with Variable Speed Wheel



Sample Specifications

Energy recovery units shall be SEMCO standard 'EP' series with components as follows:

A. Casing - Wall and roof panels shall consist of 2 inch thick dual wall 18 gauge galvanized solid exterior skins and 22 gauge galvanized steel solid interior skins enclosing 2 inch thick 3 pcf mineral wool insulation. The housing shall be supported by a painted structural steel base. The base includes a solid welded floor with mineral wool insulation. The bottom face of the insulation shall be protected with a 22 gauge galvanized steel cover. The base shall be self-flashing when set on a properly sized curb. Floor openings shall have perimeter lips turned up into unit and be covered by a protective grate. Lifting lugs shall be welded to the structural base.

Access - Access shall be provided through large hinged, tightly sealed doors or removable access panels. Access doors shall be constructed of the same materials as the unit casing. Each door shall be provided with two cam type handles and two heavy duty hinges to achieve maximum sealing. Handles shall be internal and external for opening from the inside or outside of the unit. All doors shall open against the air pressure. Removable panels shall be provided for heating and cooling coils.

Outdoor Installation - Units shall have a factory-installed, 22 gauge galvanized steel standing seam sheet metal roof. All roof field joints shall have U-clips. The U-clips shall be shipped with the unit for field installation. Outdoor air intake and exhaust air discharge openings shall have galvanized steel sheet metal hoods with openings covered with bird screen. Hoods may ship loose for field installation depending on shipping width restrictions.

B. Fans - Fans shall be centrifugal plenum type. Fans shall incorporate a wheel, heavy gauge reinforced steel inlet plate with removable spun inlet cone, structural steel frame, and shaft and bearings in the AMCA Arrangement 3 configuration to form a heavy duty integral unit. All fan wheels shall be tapered spun wheel cones or shrouds providing stable flow and high rigidity. The wheels shall be non-overloading type. The blades shall be securely welded, die-formed backward curved (16" and smaller) or airfoil (18" and larger) type. Fan wheels shall be statically and dynamically balanced. Fan shafts shall be sized for first critical speed of at least 1.43 times the maximum speed for the class. Fan wheel bearings shall be heavy duty, grease lubricated, anti-friction ball or roller, self-aligning, pillow block type and selected for minimum average bearing life (AFBMA L-50) in excess of 200,000 hours at the maximum class RPM. Fan ratings shall be based on tests made in accordance with AMCA Standard 210 and shall bear the AMCA Seal.

Motors, Drives and Guards - Fan motors shall be standard NEMA frame, high efficiency, with 1.15 service factor and open drip-proof enclosures. Belt drives shall be designed for a minimum 1.4 service factor. Drives shall be fixed pitch. Rotating fan and drive parts shall be enclosed by protective guards.

Fan Vibration Isolation - Fans assemblies shall have adjustable motor bases, motors and V-belt drives mounted with the assembly mounted on 1-inch deflection spring isolators with flexible connections between fan and fan wall.

C. Enthalpy Recovery Wheel - The rotor media shall be made of aluminum, which is coated to prohibit corrosion. All media surfaces shall be coated with a non-migrating solid adsorbent layer prior to being formed into the honeycomb media structure to ensure that all surfaces are coated and that adequate latent capacity is provided. The media shall have a flame spread of less than 25 and a smoke developed of less than 50 when rated in accordance with ASTM E87. In addition to the desiccant coating that is applied to the surfaces of the aluminum substrate, the two faces of the total energy recovery wheel shall be covered and sealed with a two part polymer heavy duty coating specifically chosen for chemical resistance.

The desiccant shall be inorganic and specifically developed for the selective adsorption of water vapor. The desiccant shall utilize a 3A molecular sieve certified by the manufacturer to have an internal pore diameter distribution which limits adsorption to materials not larger than the critical diameter of a water molecule (2.8 angstroms).

Submit certification by a qualified independent organization - documenting equal sensible and latent recovery efficiencies conducted in accordance with ASHRAE 84-78P and the results presented in accordance with ARI 1060 standards.

An independent wheel test from a credible test laboratory shall document that the desiccant material utilized does not transfer pollutants typically encountered in the indoor air environment. The cross-contamination and performance certification reports shall be provided upon written request for engineering review.

Sensible Recovery Wheel (For EPD only)- The rotor media shall be made of aluminum, which is coated to prohibit corrosion. The media shall have a flame spread of less than 25 and a smoke developed of less than 50 when rated in accordance with ASTM E-87.

Media Cleaning - The media shall be cleanable with low-pressure steam (less than 5 PSI), hot water or light detergent, without degrading the latent recovery. Dry particles up to 800 microns shall pass freely through the media.

Purge Sector - The unit shall be provided with a factory set, field adjustable purge sector designed to limit cross-contamination to less than .04 percent of that of the exhaust air stream concentration when operated under appropriate conditions.
Rotor Seals - The rotor shall be supplied with labyrinth seals only, which at no time shall make contact with any rotating surface of the exchanger rotor face. These multi-pass seals shall utilize four labyrinth stages for optimum performance.

Rotor Support System - The rotor media shall be provided in segmented fashion to allow for field erection or replacement of one section at a time without requiring side access. The media shall be rigidly held in place by a structural spoke system made of extruded aluminum.

Rotor Housing - The rotor housing shall be a structural framework which limits the deflection of the rotor due to air pressure loss to less than 1/32 inch. The housing is made of galvanized steel to prevent corrosion. The rotor is supported by two pillow block bearings which can be maintained or replaced without the removal of the rotor from its casing or the media from its spoke system.

Temperature Control Panel - Variable speed control shall be accomplished by the use of an A/C inverter. The inverter shall include all digital programming with a manual speed adjustment on the front of the inverter. The drive system shall allow for a turndown ratio of 80:1 (20 rpm to 1/4 rpm). The control system shall include four linearized thermistor sensors as follows:
(1) Proportional temperature controller mounted in the supply air stream;
(2) Differential summer/winter changeover sensors mounted in the outdoor and return air streams;
(3) Frost prevention sensor located in the exhaust air stream; and, (4) Digital readout of the temperature readings recorded by these sensors and control set points is displayed by the control panel.

Digital Performance Display Module - Digital read out confirming the effectiveness of the energy wheel via temperature readings recorded by these sensors and control set points shall be displayed by the control panel.

D. Chilled Water, DX and Hot Water Coils - Primary surface shall be round seamless 5/8 inch O.D. by .020 inch thick copper tube on 1.5 inch centers, staggered in the direction of airflow. All joints shall be brazed.

Secondary surface shall consist of .006 (.0075 for heating coils) inch rippled aluminum plate fins for higher capacity and structural strength. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Bare copper tube shall not be visible between fins and the fins shall have no openings punched in them to prevent the accumulation of lint and dirt. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates.

Casings shall be constructed of continuous galvanized steel. Coil side plates shall be of reinforced flange type.

Coils shall have equal pressure drop through all circuits. Coils shall be circuited for counter flow heat transfer to provide the maximum heat transfer rates.

Headers on coils shall be seamless copper tubing. The headers shall have intruded tube holes to provide a large brazing surface for maximum strength and inherent flexibility. Supply and return connections on water coils shall be steel with male pipe threads. DX coils shall have copper sweat connections.

The complete coil core shall be tested with 315 psig air pressure under warm water and be suitable for operation at 250 psig working pressures.

Individual tube tests and core tests before installation of headers shall not be considered satisfactory. Water cooling coils shall be circuited for drainability. Use of internal restrictive devices to obtain turbulent flow shall not be acceptable. Vents and drains shall be furnished on all water coils. Coils shall be rated in accordance with ARI.

Coils shall be mounted in galvanized holding racks. Water coil supply and return connections shall be extended to the unit exterior. Water coil drain and vent connections are accessible from the interior of the unit and are not extended. Cooling coils shall be mounted in an insulated pitched 304 stainless steel condensate pan.

Optional Electric Heating Coil - Where scheduled, heater shall be the finned tubular or open coil electric resistance type. Heater shall include, door interlocking non-fused disconnect switch, magnetic de-energizing contactors, control circuit transformer, pressure type air flow interlock switch and manual and auto reset thermal cutout over current protection. The electric heater shall require a separate power feeder connection in addition to the power connection to the main unit electrical panel.

E. Pre-Filters (Return & Outside Air) - Filters shall be Farr type 30/30 or approved equal. Air filters shall be 2" thick, pleated, disposable type. Each filter shall consist of a non-woven cotton and synthetic fabric media, media support grid and enclosing frame. Filter media shall be a cotton and synthetic blend with at least 15 pleats per linear foot. A welded wire grid, spot-welded on one-inch centers and treated for corrosion resistance is bonded to the downstream side of the media to maintain the radial pleat and prevent media oscillation. The filter media shall have a Minimum Efficiency Reporting Value of MERV 7 when evaluated under guidelines of ASHRAE Standard 52.2-1999 and an average dust spot efficiency of 25-30% when evaluated under ASHRAE Standard 52.1-1992. The filter shall be listed by Underwriters' Laboratories as Class 2. A bank of galvanized universal holding frames shall be arranged for upstream access. Provisions shall be made on the downstream side of the frames to prevent filter blowout from moisture or overloading.

Optional Secondary High Efficiency Filters (65%, 85%, 95%) - Mounted in the same filter bank with the Pre-filters shall be 12" deep high performance filters, which shall be high lofted supported media disposable type. The media blanket shall be formed into uniform tapered radial pleats and bonded to a welded wire media support grid, which is spot-welded on one-inch centers, and treated for corrosion resistance. Media support contour stabilizers shall be mechanically fastened to diagonal support members of the same construction to create a rigid and durable filter enclosure. There shall be a minimum of four contour stabilizers on the air entering side and six on the air exiting side. The media shall have a Minimum Efficiency Reporting Value of MERV 14 when evaluated under guidelines of ASHRAE Standard 52.2-1999 and an average dust spot efficiency of either 60-65%, 80-85%, or 90-95% when evaluated under ASHRAE Standard 52.1-1992. The filter is listed by Underwriters' Laboratories as Class 2.

F. Outdoor Air Dampers - Dampers shall have galvanized steel frames and blades, with blade and jamb seals for low leakage performance. Dampers shall have two-position electric actuators with an integral limit switch. The limit switch shall be wired through the supply fan coil.

G. Exhaust Air Dampers - Dampers shall be gravity operated back draft type. Dampers shall have aluminum frames and blades, with blade seals for low leakage performance.

H. Electrical - Unit shall require a 480, 240 or 208 volt (as scheduled), 3 phase, 60 cycle power connection at the main electrical panel. The electrical panel shall be NEMA 3R rated and mounted on the unit exterior as shown on the General Arrangement drawings. The electric panel shall consist of a non-fused disconnect, fused IEC full voltage starters for each fan and constant speed wheel, control power transformer and HOA switch for the unit. Electrical panels shall bear an ETL label.

All wiring 120 volt and higher and wire size #8 and smaller shall be run in MC cable. All wire size #6 and larger shall be run in EMT. Fan motors requiring wire run in EMT shall have a 2' length of seal tight at the motor junction box. Low voltage wiring shall use plenum cable, installed external to the conduit. Starter coils shall be 24 volt AC for contactors rated 75 amps or less and 120-volt AC for contactors rated greater than 75 amps.

Optional Lights & GFI Receptacle - Vapor tight lights shall be provided in access compartments as shown on the General Arrangement drawing. Lights shall be wired to a single switch on the unit exterior. A GFI receptacle shall be mounted next to the light switch. A separate 120-volt power connection shall be required at the GFI receptacle to provide power for the lights and receptacle.

I. Warranty - The unit manufacturer shall warrant to the Buyer, for a period of eighteen months from the date of shipment, that goods delivered to the Buyer should in all respects be free from defects in material and workmanship when used in a proper and normal manner. In the event of equipment failure, prompt notification during the Warranty Period must first be made by the Buyer, in addition to there being confirmation to the unit manufacturer's satisfaction that the goods have been stored, installed, operated and maintained properly and in accordance with standard industry practice. If such confirmation is granted and it is established that the equipment failed to be free from defects within the eighteen months of shipment, the unit manufacturer shall correct the nonconformity at the unit manufacturer's option of either: (1) repairing any defective part or parts, or (2) making available at the unit manufacturer's plant a repaired or replacement part.

Model Size	3	5	9	13	18	24	28	35	43
Width	86.25	86.25	98.25	98.25	122.25	122.25	146.25	146.25	182.25
Height	48.25	60.25	72.25	86.25	98.25	110.25	122.25	134.25	146.25
Supply Air CFM Range [1] Return Air CFM Range [1]	2,000-3,000	3,000-4,500	4,500-8,000	6,000-10,000	8,000-15,000	11,000-18,000	15,000-23,000	18,000-27,000	26,000-40,000
Fan size (standard)	EPF 150	EPF 182	EPF 222	EPF 245	EPF 300	EPF 330	EPF 365	EPF 402	EPF 445
Fan size (option X)	-	EPF 200	EPF 245	EPF 270	EPF 330	EPF 365	EPF 402	EPF 445	EPF 490
Fan size (option XX)	-	EPF 222	EPF 270	EPF 300	EPF 365	EPF 402	EPF 445	EPF 490	-
Purge volume (single wheel) [3]	513	695	906	1168	1440	1735	1961	2297	2662
Heat/cool coil total fin height	33 in	45 in	54 in	66 in	78 in	90 in	99 in	111 in	123 in
Heat/cool coil total fin length	30 in	30 in	42 in	42 in	54 in	54 in	66 in	66 in	90 in
Number of stacked coils (height)	(1) 33 in	(1) 45 in	(2) 27 in	(2) 33 in	(2) 39 n	(2) 45 in	(3) 33 in	(2) 36 in	(2) 42 in
	-	-	-	-	-	-	-	(1) 39 in	(1) 39 in
Supply filter	(1) 24x24	(2) 24x24	(4) 24 x 24	(6) 24x24	(3) 20x24	(12) 20x24	(12) 24x24	(15) 24x24	(20) 24x24
	(2) 12x24	(2) 12x24	(2) 12 x 24	-	(9) 20x20	-	(3) 12x24	-	(4) 12x24
Return filter	(1) 24x24	(2) 24x24	(2) 24x24	(3) 24x24	(6) 24x24	(8) 24x24	(6) 20x24	(15) 20x24	(15) 24x24
	(2) 12x24	(2) 12x24	(3) 12x24	(3) 12x24	(2) 12x24	-	(9) 20x20	-	(3) 12x24
Door size (inches)	13x31	13x43	13x55	18x66	18x66	18x66	18x66	18x66	18x66

Notes:
1. Maximum airflow limitations vary. Consult SEMCO before laying out unit with velocities greater than 525 fpm on 2” filters, 525 fpm on cooling coils, and 1100 fpm on wheels.
2. For optional wide RA side, RA side components will be the same as the SA side components.
3. Single wheel purge volume based on 4” P_{OA}-P_{RA}.

Model Size	3	5	9	13	18	24	28	35	43
Width	86.25	86.25	98.25	98.25	122.25	122.25	146.25	146.25	182.25
Height	48.25	60.25	72.25	86.25	98.25	110.25	122.25	134.25	146.25
Supply Air CFM Range [1] Return Air CFM Range [1]	2,000-3,000	3,000-4,500	4,500-8,000	6,000-10,000	8,000-15,000	11,000-18,000	15,000-23,000	18,000-27,000	26,000-40,000
Fan size (standard)	EPF 150	EPF 182	EPF 222	EPF 245	EPF 300	EPF 330	EPF 365	EPF 402	EPF 445
Fan size (option X)	-	EPF 200	EPF 245	EPF 270	EPF 330	EPF 365	EPF 402	EPF 445	EPF 490
Fan size (option XX)	-	EPF 222	EPF 270	EPF 300	EPF 365	EPF 402	EPF 445	EPF 490	-
Purge volume (dual wheel) [3]	1176	1572	2025	2583	3158	3779	4252	4954	5714
Heat/cool coil total fin height	33 in	45 in	54 in	66 in	78 in	90 in	99 in	111 in	123 in
Heat/cool coil total fin length	30 in	30 in	42 in	42 in	54 in	54 in	66 in	66 in	90 in
Number of stacked coils (height)	(1) 33 in	(1) 45 in	(2) 27 in	(2) 33 in	(2) 39 n	(2) 45 in	(3) 33 in	(2) 36 in	(2) 42 in
	-	-	-	-	-	-	-	(1) 39 in	(1) 39 in
Supply filter	(1) 24x24	(2) 24x24	(4) 24x24	(6) 24x24	(3) 20x24	(12) 20x24	(12) 24x24	(15) 24x24	(20) 24x24
	(2) 12x24	(2) 12x24	(2) 12x24	-	(9) 20x20	-	(3) 12x24	-	(4) 12x24
Return filter	(1) 24x24	(2) 24x24	(2) 24x24	(3) 24x24	(6) 24x24	(8) 24x24	(6) 20x24	(15) 20x24	(15) 24x24
	(2) 12x24	(2) 12x24	(3) 12x24	(3) 12x24	(2) 12x24	-	(9) 20x20	-	(3) 12x24
RA evaporative cooler area	5	7.5	10	12.5	21	24.5	33.8	38.3	52.3
SA evaporative cooler area	5	7.5	14	17.5	27	31.5	41.3	46.8	71.3
Door size (inches)	13x31	13x43	13x55	18x66	18x66	18x66	18x66	18x66	18x66

Notes:
1. Maximum airflow limitations vary. Consult SEMCO before laying out unit with velocities greater than 525 fpm on 2” filters, 525 fpm on cooling coils, and 1100 fpm on wheels.
2. For optional wide RA side, RA side components will be the same as the SA side components.
3. Dual wheel purge volume based on 7” P_{OA}-P_{RA} on Enthalpy wheel, 4” P_{OA}-P_{RA} on Sensible wheel.

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Y AB 010.10 0406 (supersedes Y AB 010.9 0105)
0406 1K G

20/CPA/3500/0606/EN

CPA

Passive Chilled Beam

- Modular convector for mounting flush or below ceiling plane
- Quiet operation
- No moving parts
- Long maintenance interval and low cost
- Individual/multiple beam control
- Suitable for offices, conference rooms, retail, hotels and healthcare environments
- Can be delivered with 2- or 3-port valve
- Standard height 130 mm with optional coil configuration output
- Customized perforation and multi-service solutions on request

Accessories & product options

- Pipe connection in the end (WD=S)
- Pipe connection at the top (WD=U)
- Factory-fitted 2- or 3-port valve
- Flexible connection pipes

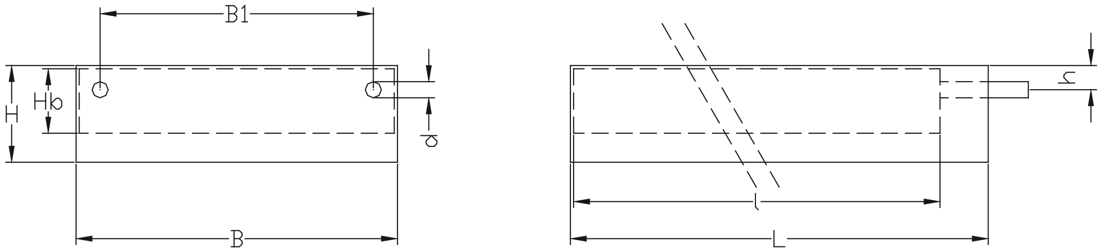
Material and finishing

CPA has side flanges made from extruded aluminum profiles. The modular perforated screen (holes 10 mm / 50% free area) is produced in pre-painted sheet metal, RAL 9010. The outer mounted end cap is produced in ABS-material, RAL 9010. The coil is made from Ø15 mm copper pipes bonded to aluminum fins. Internal distance between fins is 8 mm.

PART	MATERIAL	FINISHING	NOTE
Side flanges	Extruded aluminium	White RAL 9010	Pre-painted
Perforated screen	Sheet metal	White RAL 9010	Pre-painted Hole 10 mm / 50% free area
End cap	ABS-material	White RAL 9010	
Coiling fins	Aluminium		Distance between fins: 8 mm
Cooling pipes	Copper		Diameter 15 mm

DIMENSIONS

B	H	Hb	h	d	B1	l	L
315	130	75	40	15	225	1000 – 4000	l + 200
465	130	75	40	15	375	1000 – 4000	l + 200
615	130	75	40	15	525	1000 – 4000	l + 200
315	130	100	30	15	225	1000 – 4000	l + 200
465	130	100	30	15	375	1000 – 4000	l + 200
615	130	100	30	15	525	1000 – 4000	l + 200



Cooling capacity

Cooling capacities (Pw) [W] are presented for water flow rate qmw= 0.08 kg/s.

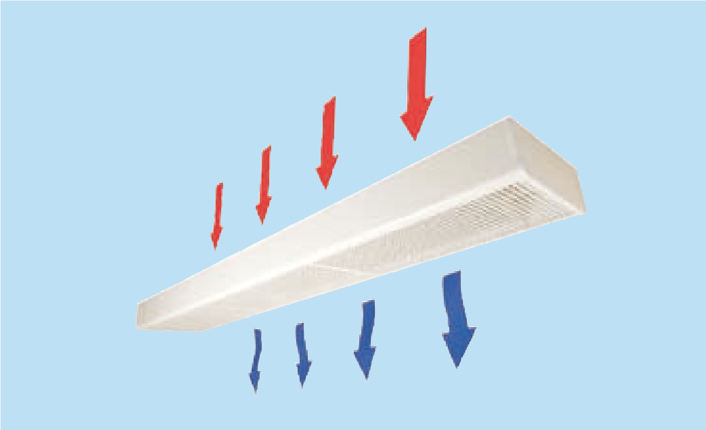
	Pw(W/m) ΔT (°C) 6	7	8	8,5	9	9,5	10	11
CPA-130/075-315	86	107	131	144	157	170	183	212
CPA-130/075-465	136	170	207	228	248	269	290	335
CPA-130/075-615	180	226	276	294	312	349	386	446
CPA-130/100-315	102	126	153	167	181	196	209	242
CPA-130/100-465	168	208	252	276	300	323	345	400
CPA-130/100-615	214	266	322	352	382	411	440	510

ΔT = temperature difference Tr-(Tw1+Tw2)/2, °C

Correction factor for alternative flow rate

qmv (kg/s)	kc
0.015	0.79
0.02	0.83
0.025	0.86
0.03	0.88
0.035	0.91
0.04	0.92
0.045	0.94
0.05	0.96
0.055	0.97
0.06	0.98
0.08	1.0

Cooling capacity according to EN 14518.

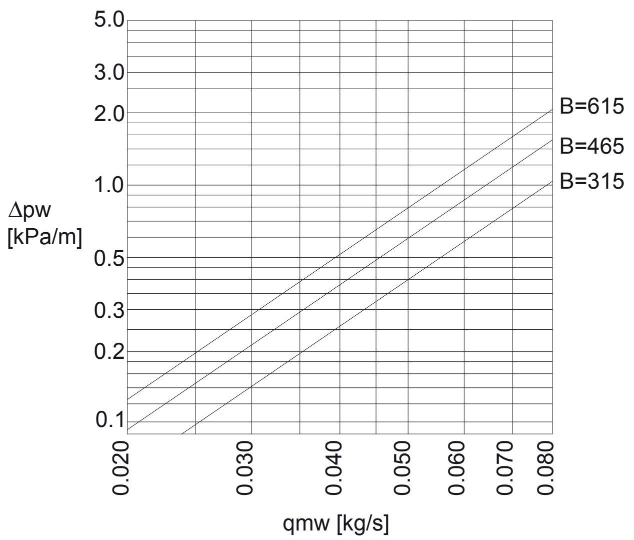


Function

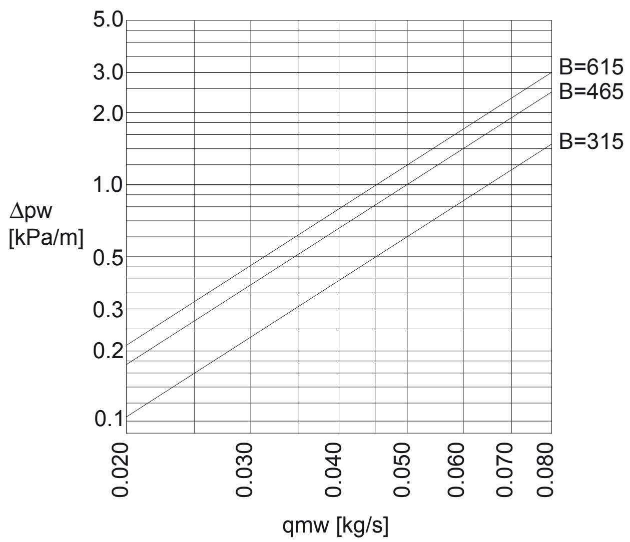
The beam operates by natural convection, removing the heat load from the room and replacing it with a cooling airflow. The convective airflow (output) increases or decreases in proportion with the heat load within the occupied zone, securing an optimal thermal comfort. Varying sensible cooling output requirements are met by regulating the flow of chilled water through the beam heat exchanger. This is controlled by a combination of room thermostat and 2 or 3-port valve. Operating at elevated chilled water temperatures (to avoid latent cooling), the opportunities for "free-cooling" are significant.

Pressure drop of water flow

CPA-130/75



CPA-130/100



ΔT	temperature difference Tr- (Tw1+Tw2) /2, °C
Tr	room temperature, °C
Tw1	water flow temperature, °C
Tw2	return water temperature, °C
P'w	cooling capacity per unit length, W/m

qmw	water mass flow rate, kg/s
kc	correction factor for water flow rate
Δpw	pressure drop of water flow per unit length,
kPa	

$$q_{mv} = \frac{P'w \times L}{C_v \times \Delta T} = kg/s$$

Halton
CARE FOR INDOOR AIR

Water loops - slings

When the pressure drop is high, you need to have 2 parallel water loops (= 2 slings) in the coil. A coil with 2 slings has a connection pipe Ø22mm. Recommended operation pressure for 1 sling, max 15 kPa.

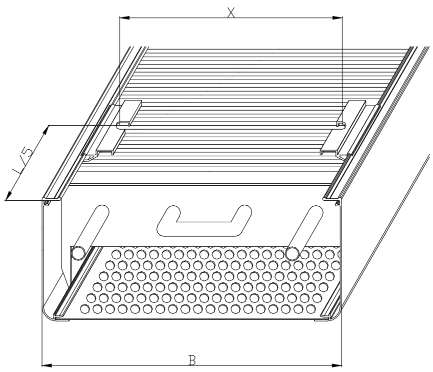
	L	Δt=7,5°C	Δt=8,0°C	Δt=8,5°C	Δt=9,0°C	Δt=9,5°C
CPA-130/075-315-L	1200	1	1	1	1	1
	1800	1	1	1	1	1
	2400	1	1	1	1	1
	3000	1	1	1	1	1
	3600	1	1	1	1	1
	4200	1	1	1	1	1
CPA-130/075-465-L	1200	1	1	1	1	1
	1800	1	1	1	1	1
	2400	1	1	1	1	1
	3000	1	1	1	1	1
	3600	1	1	1	1	1
	4200	1	1	1	1	1
CPA-130/075-615-L	1200	1	1	1	1	1
	1800	1	1	1	1	1
	2400	1	1	1	1	1
	3000	1	1	1	1	1
	3600	1	1	1	1	1
	4200	1	1	1	2	2
CPA-130/100-315-L	1200	1	1	1	1	1
	1800	1	1	1	1	1
	2400	1	1	1	1	1
	3000	1	1	1	1	1
	3600	1	1	1	1	1
	4200	1	1	1	1	1
CPA-130/100-465-L	1200	1	1	1	1	1
	1800	1	1	1	1	1
	2400	1	1	1	1	1
	3000	1	1	1	1	1
	3600	1	1	1	1	1
	4200	1	1	1	2	2
CPA-130/100-615-L	1200	1	1	1	1	1
	1800	1	1	1	1	1
	2400	1	1	1	1	1
	3000	1	1	1	1	1
	3600	1	2	2	2	2
	4200	2	2	2	2	2

Installation

The chilled beam CPA is installed fully exposed below a ceiling or suspended ceiling.
In order to ensure effective convection, the beam should be mounted at a minimum distance from the ceiling (H1) equal to 0.25 x the width of the beam, when installed away from wall surfaces, or 0.5 x beam width when installed close to partition walls.

Each chilled beam is fixed to the ceiling with expansion anchors and threaded drop rods (not included in the delivery). Four assembly brackets are fixed one fifth of the unit length (L/5) away from the end of the beam.
The exact positions of the brackets are adjusted according to the rod position.

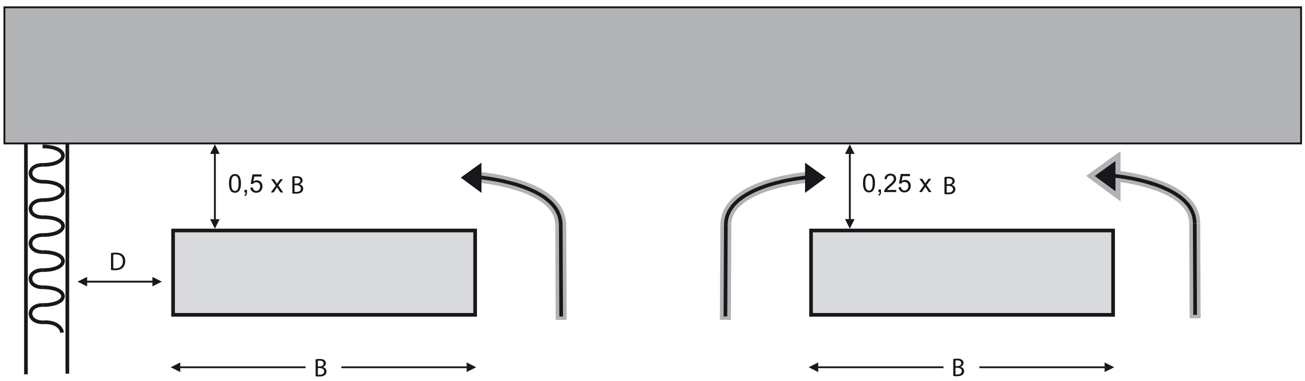
The chilled beam position can be easily adjusted both horizontally and vertically. Assembly brackets are supplied as standard in the package.



B	X
315	223
465	373
615	523

20/CPA/3500/0606/EN

Distance from the ceiling



D = distance wall; up to 1,5 x W

20/CPA/3500/0606/EN

Commissioning

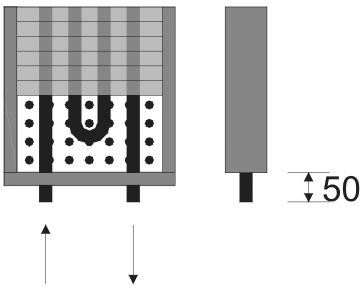
Commissioning of the chilled beam system is carried out following standard practice:

- Fill up and flush the main pipelines
- Fill up and vent the beam circuits
- Adjust the flow water temperature set point
- Adjust water flow rates with the balancing valves in all main pipelines to the correct value

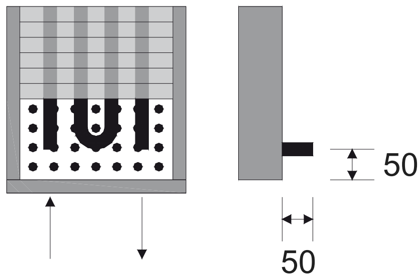
Adjust water flows in all chilled beams to the correct value

Pipe connections

Pipe connection in the end



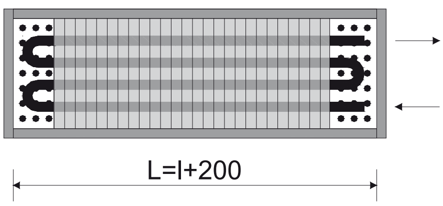
Pipe connection at the top



Coil length with or without factory-fitted control valves

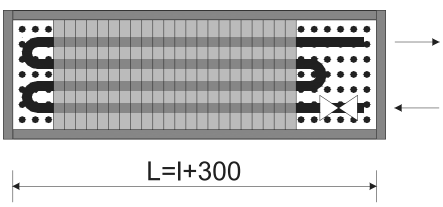
Standard length

Without valve

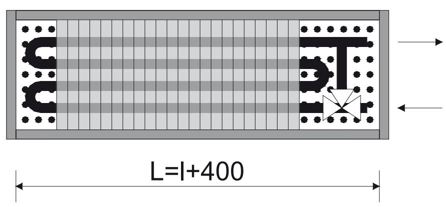


Optional

With 2-port valve



With 3-port valve



Servicing

The CPA chilled beam requires little maintenance. It may be necessary to clean the cooling coils every three to five years, depending on room conditions and air quality. The casing may be cleaned with a damp cloth. The cooling coil can be cleaned using a vacuum cleaner.

Specification

Output/capacity:	80 – 500 W/m
Standard length:	1200, 1800, 2400, 3000, 3600 and 4200 mm
Width:	315, 465 and 615 mm
Casing height:	130 mm
Coil height:	75 and 100 mm

The heat exchanger shall be constructed from aluminium fins and copper pipes with a nominal outside diameter of 15 mm.
The maximum chilled water pipe work operating pressure is 1.0 MPa. All joints shall be fully soldered and factory pressure tested.

Product code

CPA-H/CH-W-L-NW

H = Casing height
130

CH = Coil height
075,100

W = Width
315,465,615

L = Length
1200, 1800, 2400, 3000, 3600, 4200

NW = Number of water loops
CH=075 and W=315: 1
CH=100 and W=315: 1
CH=075 and W=465: 1
CH=100 and W=465: 1,2
CH=075 and W=615: 1,2
CH=100 and W=615: 1,2

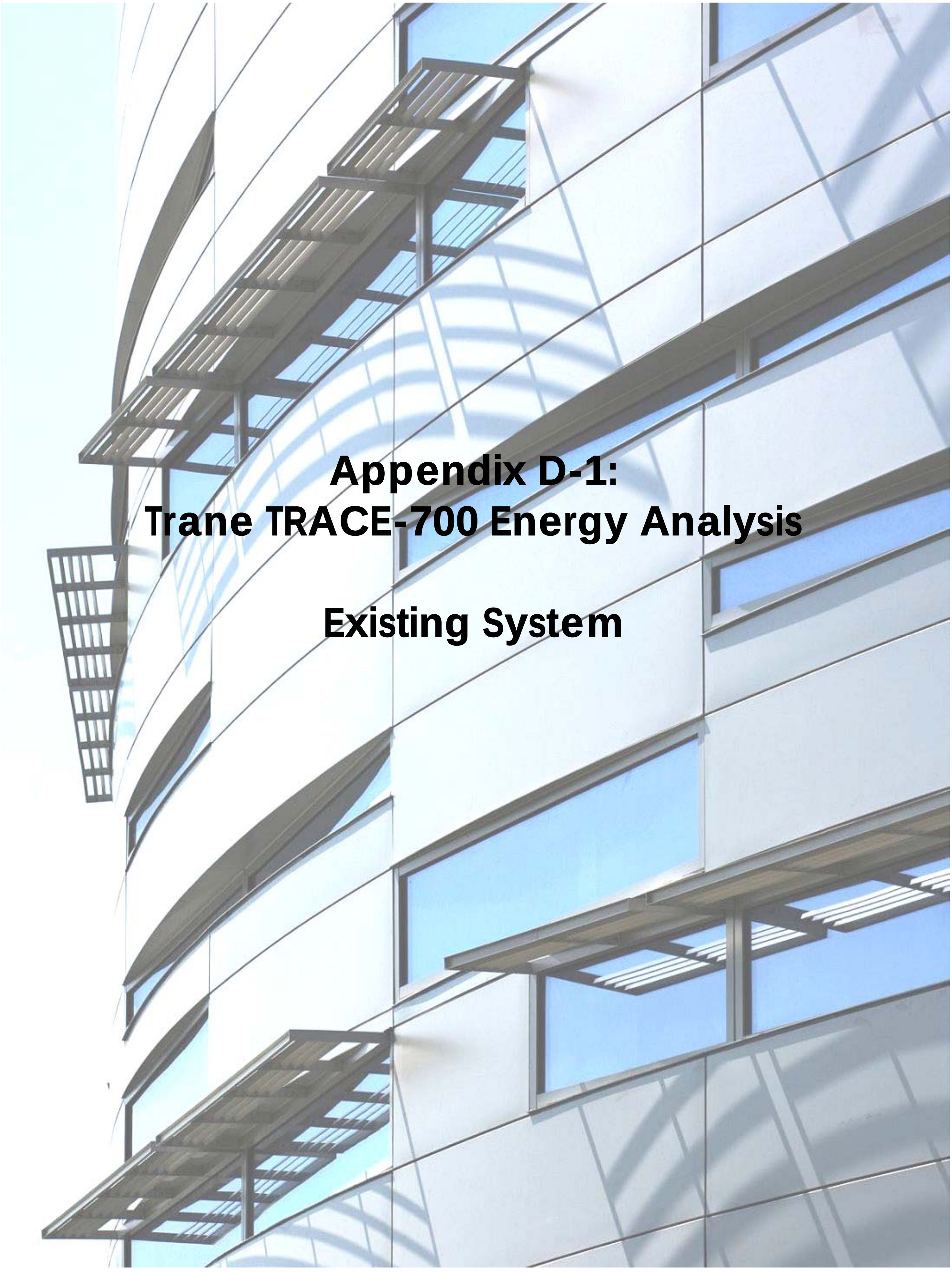
Specifics and accessories

WD = Location of pipe connections
S Front end
U On top

AC = Accessories
N=Not assigned
FT=Flexible connection pipes

Code example

CPA-130-100-315-1200-1, WD=S, AC=N



Appendix D-1:
Trane TRACE-700 Energy Analysis

Existing System

MONTHLY ENERGY CONSUMPTION

By ae

Alternative: 1

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
						------- Monthly Energy Consumption -------							
Electric													
On-Pk Cons. (kWh)	65,914	59,530	71,361	63,038	91,864	102,071	100,008	117,155	93,190	72,097	65,621	61,844	963,693
Off-Pk Cons. (kWh)	89,312	80,518	81,230	86,290	97,715	101,119	126,975	115,390	113,186	86,776	83,263	90,590	1,152,365
On-Pk Demand (kW)	216	218	220	251	433	490	534	542	488	287	240	222	542
Off-Pk Demand (kW)	212	212	214	219	307	371	403	415	385	235	218	215	415
Gas													
On-Pk Cons. (therms)	2,691	2,028	1,861	672	232	183	101	168	245	754	1,044	1,372	11,352
Off-Pk Cons. (therms)	4,497	3,649	2,834	1,539	587	530	454	509	597	1,210	1,865	2,547	20,815
On-Pk Demand (therms/hr)	12	10	9	4	2	2	2	2	2	3	5	7	12
Off-Pk Demand (therms/hr)	12	12	9	6	3	3	2	2	2	4	6	7	12

Building Energy Consumption = 177,555 Btu/(ft2-year)
Source Energy Consumption = 426,155 Btu/(ft2-year)
Floor Area = 58,792 ft2

MONTHLY UTILITY COSTS

By ae

Alternative: 1

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Electric													
On-Pk Cons. ($)	1,384	1,250	1,499	1,324	1,929	2,143	2,100	2,460	1,957	1,514	1,378	1,299	20,238
On-Pk Demand ($)	2,096	2,116	2,140	2,434	4,157	4,696	5,117	5,189	4,682	2,775	2,327	2,159	39,888
Total ($):	3,480	3,366	3,638	3,758	6,086	6,840	7,218	7,650	6,639	4,289	3,705	3,458	60,125
Gas													
On-Pk Cons. ($)	3,002	2,267	2,082	763	275	220	130	204	289	854	1,176	1,540	12,803
Water													
On-Pk Cons. ($)	186	186	186	186	186	186	186	186	186	186	186	186	2,238
Monthly Total ($):	6,669	5,819	5,907	4,707	6,548	7,246	7,534	8,040	7,115	5,330	5,068	5,184	75,166

EQUIPMENT ENERGY CONSUMPTION

By ae

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Consumption -------								
Lights													
Electric (kWh)	65,369.7	59,043.6	65,369.6	63,261.0	65,369.7	63,261.0	65,369.7	65,369.6	63,261.0	65,369.7	63,261.0	65,369.7	769,675.1
Peak (kW)	87.9	87.9	87.9	87.9	87.9	87.9	87.9	87.9	87.9	87.9	87.9	87.9	87.9
MISC LD													
Electric (kWh)	29,099.7	26,283.6	29,099.7	28,161.0	29,099.7	28,161.0	29,099.7	29,099.7	28,161.0	29,099.7	28,161.0	29,099.7	342,625.3
Peak (kW)	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1
AHU-1,2													
Eq4205 - FC rooftop w/IV & econ (Main Clg Fan)													
Electric (kWh)	17,492.2	15,799.5	17,492.2	16,928.0	20,271.9	19,293.2	21,747.0	20,447.6	19,124.3	17,492.2	16,928.0	17,492.3	220,508.4
Peak (kW)	23.5	23.5	23.5	23.9	40.2	56.3	60.3	58.5	51.3	27.7	23.5	23.5	60.3
Eq4223 - FC Centrifugal var freq drv (System Exhaust Fan)													
Electric (kWh)	9,268.4	8,324.7	8,701.4	8,276.6	10,233.2	12,125.9	12,872.8	12,289.3	9,360.0	8,617.8	8,362.8	8,612.5	117,045.5
Peak (kW)	13.1	13.1	13.1	13.4	24.3	35.7	38.6	37.3	32.1	15.9	13.1	13.1	38.6
Cpl 1: Cooling plant - 001													
McQuay Air Cooled Screw Chiller (Cooling Equipment)													
Electric (kWh)	0.0	0.0	51.3	1,382.4	28,417.3	38,492.0	54,696.6	60,775.2	49,767.1	4,814.9	912.5	239.4	239,548.5
Peak (kW)	2.0	2.1	3.4	30.1	147.3	185.0	210.6	230.4	201.7	62.0	20.9	5.8	230.4
Eq5221 - Condenser fan													
Electric (kWh)	0.0	0.0	41.0	606.3	4,071.4	5,222.7	7,024.7	7,788.4	6,541.9	1,339.8	479.6	175.2	33,290.9
Peak (kW)	1.1	1.1	1.4	4.6	17.1	21.2	23.4	25.7	23.0	8.1	3.8	1.9	25.7
Eq5302 - Cntl panel & interlocks (Misc Accessory Equipment)													
Electric (kWh)	0.0	0.0	6.2	51.0	74.4	72.0	74.4	74.4	72.0	74.4	48.0	24.8	571.6
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Hpl 1: Heating plant - 002													
Boiler - 001 (Heating Equipment)													
Gas (therms)	7,187.4	5,676.3	4,694.8	2,210.4	819.5	712.2	555.8	677.1	841.4	1,964.3	2,909.2	3,918.8	32,167.0
Peak (therms/Hr)	12.4	11.8	8.9	5.7	2.8	2.8	2.3	2.5	2.5	3.8	6.0	7.3	12.4

EQUIPMENT ENERGY CONSUMPTION

By ae

------- Monthly Consumption -------

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Hpl 1: Heating plant - 002													
Eq5020 - Heating water circ pump (Misc Accessory Equipment)													
Electric (kWh)	1,109.6	1,002.2	1,109.6	1,073.8	739.7	644.3	601.0	647.3	760.6	1,109.6	1,073.8	1,109.6	10,981.2
Peak (kW)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Eq5240 - Boiler forced draft fan (Misc Accessory Equipment)													
Electric (kWh)	1,488.0	1,344.0	1,488.0	1,440.0	992.0	864.0	806.0	868.0	1,020.0	1,488.0	1,440.0	1,488.0	14,726.0
Peak (kW)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Eq5307 - Boiler cntl panel & inter (Misc Accessory Equipment)													
Electric (kWh)	372.0	336.0	372.0	360.0	248.0	216.0	201.5	217.0	255.0	372.0	360.0	372.0	3,681.5
Peak (kW)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Eq5032 - VV Cond Wtr Pump (12 F Delta T) (Misc Accessory Equipment)													
Electric (kWh)	248.0	198.7	169.4	84.9	30.7	26.6	21.3	26.1	32.1	76.8	109.6	144.2	1,168.1
Peak (kW)	0.4	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.4
RTU-1													
Eq4223 - FC Centrifugal var freq drv (Main Clg Fan)													
Electric (kWh)	2,145.7	1,989.1	2,377.0	2,597.2	3,272.3	3,206.1	3,484.9	3,325.7	3,106.3	2,728.4	2,417.9	2,385.9	33,036.4
Peak (kW)	3.2	4.1	4.6	6.0	12.6	13.0	13.4	12.6	10.5	5.2	4.4	4.0	13.4
Eq4223 - FC Centrifugal var freq drv (Main Return Fan)													
Electric (kWh)	2,323.2	2,141.6	2,438.4	2,611.5	3,278.1	3,843.9	3,934.7	3,833.8	3,047.8	2,757.2	2,458.0	2,424.6	35,092.7
Peak (kW)	3.6	4.6	5.1	6.6	13.3	13.7	14.2	13.4	11.3	5.8	4.9	4.5	14.2
Eq4223 - FC Centrifugal var freq drv (System Exhaust Fan)													
Electric (kWh)	4,897.4	4,423.5	4,524.0	4,264.6	4,427.5	4,738.8	4,767.1	4,865.8	4,092.1	4,422.7	4,362.3	4,469.8	54,255.4
Peak (kW)	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
RTU-2													
Eq4223 - FC Centrifugal var freq drv (Main Clg Fan)													
Electric (kWh)	6,518.0	5,888.7	6,525.2	6,322.6	6,559.1	6,346.0	6,573.8	6,571.0	6,360.2	6,544.0	6,322.2	6,527.6	77,058.3
Peak (kW)	8.9	8.9	8.9	8.9	18.8	20.5	23.9	20.8	14.6	9.0	9.0	9.0	23.9

EQUIPMENT ENERGY CONSUMPTION

By ae

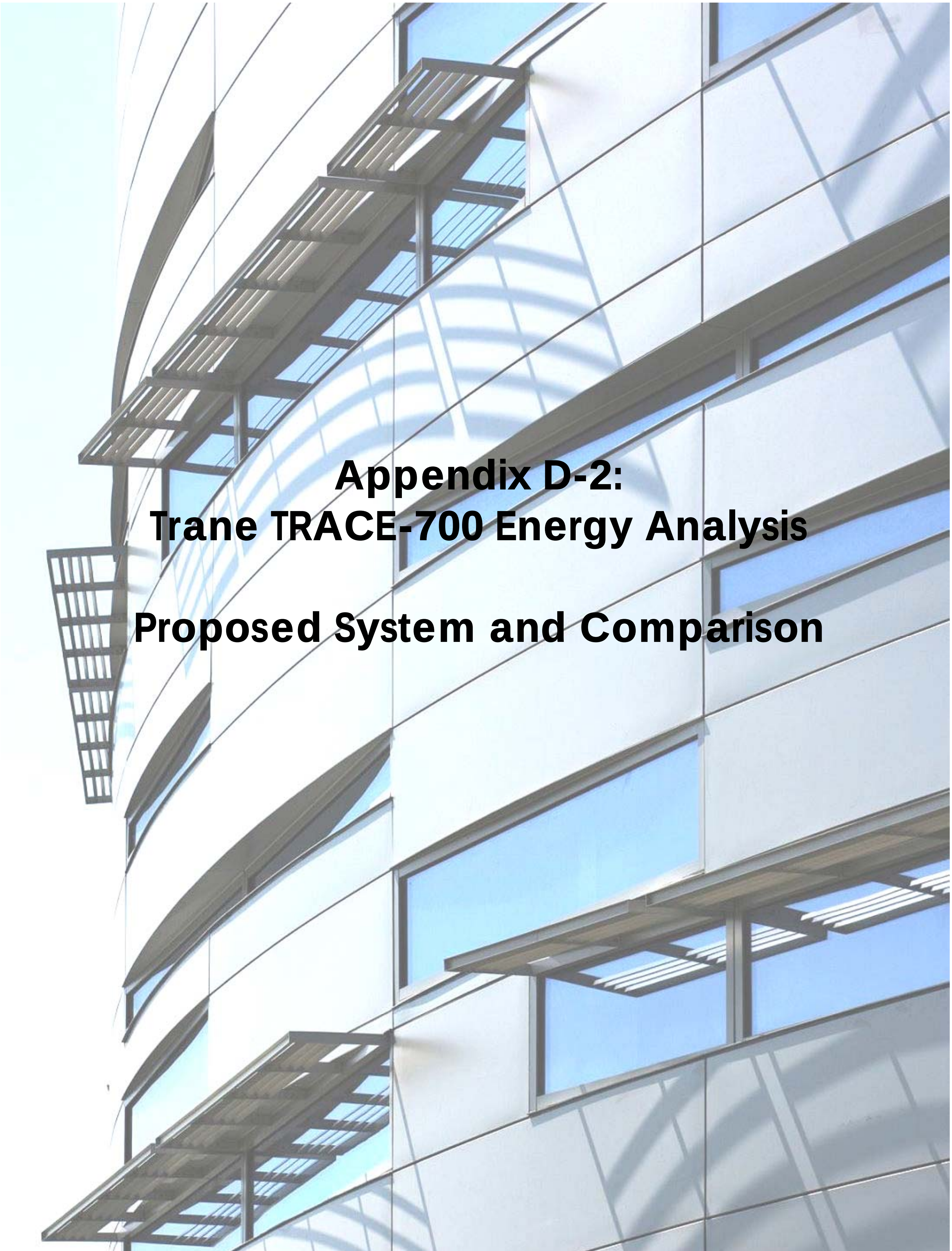
	------- Monthly Consumption -------												
Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
RTU-2													
Eq4223 - FC Centrifugal var freq drv (Main Return Fan)													
Electric (kWh)	7,294.5	6,538.6	6,686.4	6,322.9	6,603.1	8,613.0	8,049.8	8,336.8	6,188.8	6,616.4	6,413.1	6,591.7	84,255.0
Peak (kW)	10.7	10.7	10.7	10.7	21.4	23.1	26.7	23.5	16.9	10.8	10.8	10.7	26.7
Eq2003 - FC Centrifugal vav/inlet vn (System Exhaust Fan)													
Electric (kWh)	7,600.0	6,733.6	6,139.9	5,584.8	5,891.0	8,063.7	7,657.4	8,009.6	5,225.4	5,950.2	5,774.5	5,907.3	78,537.3
Peak (kW)	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1

ENERGY CONSUMPTION SUMMARY

By ae

	Elect Cons. (kWh)	Gas Cons. (therms)	Percent of Total Energy	Total Source Energy* (kBtu/yr)
Primary heating				
Primary heating	19,575.6	32,167.0	31.5 %	35,864.6
Primary cooling				
Cooling Compressor	239,548.5		7.8 %	24,529.8
Tower/Cond Fans	33,290.9		1.1 %	3,409.0
Condenser Pump			0.0 %	0.0
Other CLG Accessories	571.6		0.0 %	58.5
Cooling Subtotal....	273,411.0		8.9 %	27,997.4
Auxiliary				
Supply Fans	699,789.0		22.9 %	71,658.6
Circ Pumps	10,981.2		0.4 %	1,124.5
Base Utilities			0.0 %	0.0
Aux Subtotal....	710,770.2		23.2 %	72,783.0
Lighting				
Lighting	769,675.1		25.2 %	78,814.9
Receptacle				
Receptacles	342,625.3		11.2 %	35,084.9
Heating plant load				
Base Utilities			0.0 %	0.0
Cogeneration				
Cogeneration			0.0 %	0.0
Totals				
Totals**	2,116,057.0	32,167.0	100.0 %	250,544.8

* Note: Resource Utilization factors are included in the Total Source Energy value.
** Note: This report can display a maximum of 6 utilities. If additional utilities are used, they will be included in the total.



Appendix D-2:
Trane TRACE-700 Energy Analysis

Proposed System and Comparison

ENERGY CONSUMPTION SUMMARY

By ae

	Elect Cons. (kWh)	Gas Cons. (therms)	Percent of Total Energy	Total Source Energy* (kBtu/yr)
Primary heating				
Primary heating	19,440.2	28,891.9	35.7 %	32,403.2
Primary cooling				
Cooling Compressor	154,997.6		6.4 %	15,871.8
Tower/Cond Fans	20,988.4		0.9 %	2,149.2
Condenser Pump			0.0 %	0.0
Other CLG Accessories	554.5		0.0 %	56.8
Cooling Subtotal....	176,540.6		7.3 %	18,077.8
Auxiliary				
Supply Fans	253,438.9		10.4 %	25,952.2
Circ Pumps	19,388.9		0.8 %	1,985.4
Base Utilities	474.5		0.0 %	48.6
Aux Subtotal....	273,302.3		11.3 %	27,986.2
Lighting				
Lighting	769,675.1		31.7 %	78,814.9
Receptacle				
Receptacles	342,625.3		14.1 %	35,084.9
Heating plant load				
Base Utilities			0.0 %	0.0
Cogeneration				
Cogeneration			0.0 %	0.0
Totals				
Totals**	1,581,583.4	28,891.9	100.0 %	192,367.0

* Note: Resource Utilization factors are included in the Total Source Energy value.
** Note: This report can display a maximum of 6 utilities. If additional utilities are used, they will be included in the total.

MONTHLY ENERGY CONSUMPTION

By ae

Alternative: 2

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
	------- Monthly Energy Consumption -------												
Electric													
On-Pk Cons. (kWh)	63,036	56,991	68,842	45,461	60,174	67,140	63,496	74,529	59,749	50,096	47,113	47,642	704,270
Off-Pk Cons. (kWh)	85,629	77,246	78,830	63,072	67,372	71,410	86,535	78,564	76,032	60,962	61,453	70,207	877,314
On-Pk Demand (kW)	204	207	207	201	222	276	287	292	236	187	162	164	292
Off-Pk Demand (kW)	202	202	204	205	194	216	226	226	208	161	161	161	226
Gas													
On-Pk Cons. (therms)	2,578	1,911	1,843	195	75	430	550	949	631	65	545	1,164	10,935
Off-Pk Cons. (therms)	4,557	3,699	2,940	874	40	160	477	655	451	472	1,344	2,287	17,957
On-Pk Demand (therms/hr)	12	11	10	3	2	3	4	4	4	1	5	7	12
Off-Pk Demand (therms/hr)	13	12	10	5	1	2	3	3	3	3	6	7	13

Building Energy Consumption = 140,957 Btu/(ft2-year)
Source Energy Consumption = 327,199 Btu/(ft2-year)
Floor Area = 58,792 ft2

EQUIPMENT ENERGY CONSUMPTION
By ae

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Consumption -------								
Lights													
Electric (kWh)	65,369.7	59,043.6	65,369.6	63,261.0	65,369.7	63,261.0	65,369.7	65,369.6	63,261.0	65,369.7	63,261.0	65,369.7	769,675.1
Peak (kW)	87.9	87.9	87.9	87.9	87.9	87.9	87.9	87.9	87.9	87.9	87.9	87.9	87.9
MISC LD													
Electric (kWh)	29,099.7	26,283.6	29,099.7	28,161.0	29,099.7	28,161.0	29,099.7	29,099.7	28,161.0	29,099.7	28,161.0	29,099.7	342,625.3
Peak (kW)	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1	39.1
Bsu 1: Parking lot lights													
Electric (kWh)	40.3	36.4	40.3	39.0	40.3	39.0	40.3	40.3	39.0	40.3	39.0	40.3	474.5
Peak (kW)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Cpl 1: Cooling plant - 001													
McQuay Air Cooled Screw Chiller (Cooling Equipment)													
Electric (kWh)	0.0	0.0	7.8	418.1	19,163.7	29,364.6	36,129.4	37,892.0	27,703.0	3,866.0	375.1	77.9	154,997.7
Peak (kW)	0.0	0.3	0.3	9.1	66.0	110.0	119.2	122.8	77.6	36.4	13.7	2.0	122.8
Eq5221 - Condenser fan													
Electric (kWh)	0.0	0.0	8.1	217.2	2,620.3	3,828.6	4,659.4	4,910.2	3,619.0	851.2	212.1	62.4	20,988.4
Peak (kW)	0.0	0.3	0.3	1.8	7.6	12.5	13.2	13.7	8.9	4.8	2.2	0.8	13.7
Eq5003 - Var vol chill water pump (Misc Accessory Equipment)													
Electric (kWh)	0.0	0.0	5.3	130.5	1,064.6	1,563.4	1,981.9	2,123.8	1,469.9	427.9	128.8	39.6	8,935.6
Peak (kW)	0.0	0.2	0.2	0.8	3.2	8.4	9.4	10.3	4.2	1.9	1.0	0.4	10.3
Eq5302 - Cntl panel & interlocks (Misc Accessory Equipment)													
Electric (kWh)	0.0	0.0	3.1	45.0	74.4	72.0	74.4	74.4	72.0	74.4	46.2	18.6	554.5
Peak (kW)	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
DOAS LAB													
Eq4205 - FC rooftop w/IV & econ (Main Clg Fan)													
Electric (kWh)	31,087.0	28,078.5	31,087.0	7,626.6	3,186.0	3,074.8	3,162.0	3,166.7	3,067.8	4,284.2	7,617.5	12,292.7	137,730.7
Peak (kW)	41.8	41.8	41.8	41.8	10.6	4.4	4.4	4.4	4.4	7.3	16.0	16.9	41.8

EQUIPMENT ENERGY CONSUMPTION

By ae

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
	-------	Monthly Consumption	-------										
DOAS LAB													
Eq4223 - FC Centrifugal var freq drv (System Exhaust Fan)													
Electric (kWh)	18,450.6	16,522.0	16,742.5	3,274.3	1,311.6	1,651.9	1,554.5	1,604.6	1,230.1	1,748.1	3,354.6	5,669.8	73,114.6
Peak (kW)	26.8	26.8	26.8	26.8	5.5	2.9	2.6	2.8	2.1	3.4	7.7	8.9	26.8
Hpl 1: Heating plant - 002													
Boiler - 001 (Heating Equipment)													
Gas (therms)	7,134.4	5,610.4	4,782.5	1,069.4	115.1	590.3	1,027.1	1,604.4	1,081.9	537.0	1,889.0	3,450.5	28,891.9
Peak (therms/Hr)	12.8	12.3	9.8	4.9	2.4	3.3	3.6	4.2	4.0	2.8	5.7	6.8	12.8
Eq5020 - Heating water circ pump (Misc Accessory Equipment)													
Electric (kWh)	1,109.6	1,002.2	1,109.6	715.9	250.6	644.3	832.2	1,109.6	894.8	601.0	1,073.8	1,109.6	10,453.3
Peak (kW)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Eq5240 - Boiler forced draft fan (Misc Accessory Equipment)													
Electric (kWh)	1,488.0	1,344.0	1,488.0	960.0	336.0	864.0	1,116.0	1,488.0	1,200.0	806.0	1,440.0	1,488.0	14,018.0
Peak (kW)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Eq5307 - Boiler cntl panel & inter (Misc Accessory Equipment)													
Electric (kWh)	372.0	336.0	372.0	240.0	84.0	216.0	279.0	372.0	300.0	201.5	360.0	372.0	3,504.5
Peak (kW)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Eq5032 - VV Cond Wtr Pump (12 F Delta T) (Misc Accessory Equipment)													
Electric (kWh)	441.3	353.5	312.8	77.2	5.3	44.6	73.4	119.7	77.2	39.2	136.5	237.2	1,917.7
Peak (kW)	0.8	0.7	0.6	0.3	0.2	0.2	0.3	0.3	0.3	0.2	0.4	0.5	0.8
Office DOAS System													
Eq4223 - FC Centrifugal var freq drv (Main Clg Fan)													
Electric (kWh)	303.8	310.7	519.8	869.0	1,376.3	1,369.4	1,448.9	1,419.2	1,326.5	915.7	593.2	513.2	10,965.6
Peak (kW)	0.9	1.5	1.7	1.9	2.1	2.1	2.1	2.1	2.1	2.0	1.9	1.7	2.1
Eq4223 - FC Centrifugal var freq drv (Main Return Fan)													
Electric (kWh)	357.6	368.3	593.9	956.4	1,461.5	1,543.6	1,587.0	1,573.4	1,398.2	1,018.9	672.7	582.2	12,113.7
Peak (kW)	1.0	1.7	2.0	2.1	2.2	2.4	2.3	2.3	2.2	2.2	2.1	2.0	2.4

EQUIPMENT ENERGY CONSUMPTION
By ae

Equipment - Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Consumption -------								
Office DOAS System													
Eq2003 - FC Centrifugal vav/inlet vn (System Exhaust Fan)													
Electric (kWh)	546.0	558.3	911.8	1,542.2	2,102.2	2,852.1	2,623.6	2,730.3	1,962.3	1,714.3	1,094.4	876.7	19,514.2
Peak (kW)	2.0	3.4	3.4	3.4	3.4	5.4	4.7	5.0	3.4	3.4	3.4	3.4	5.4

MONTHLY UTILITY COSTS

By ae

Alternative: 2

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Electric													
On-Pk Cons. ($)	1,324	1,197	1,446	955	1,264	1,410	1,333	1,565	1,255	1,052	989	1,000	14,790
On-Pk Demand ($)	1,982	2,015	2,011	1,959	2,156	2,670	2,772	2,822	2,289	1,826	1,590	1,608	25,700
Total ($):	3,306	3,211	3,456	2,914	3,420	4,080	4,105	4,387	3,544	2,878	2,579	2,608	40,490
Gas													
On-Pk Cons. ($)	2,877	2,138	2,062	234	101	494	628	1,071	717	90	622	1,309	12,341
Water													
On-Pk Cons. ($)	186	186	186	186	186	186	186	186	186	186	186	186	2,238
Monthly Total ($):	6,369	5,536	5,705	3,335	3,707	4,761	4,919	5,644	4,448	3,155	3,387	4,104	55,069

TRACE® 700 Economic Summary

By ae

Project Information

Weather file	Buffalo, New York
Project Name	Hauptman-Woodward Medical Research
Location	Buffalo, NY
Building Owner	
User	Justin Schultz
Company	The Pennsylvania State University
Comments	Senior Thesis Tech Report 2

Alternative 1 - -
Alternative 2 - -

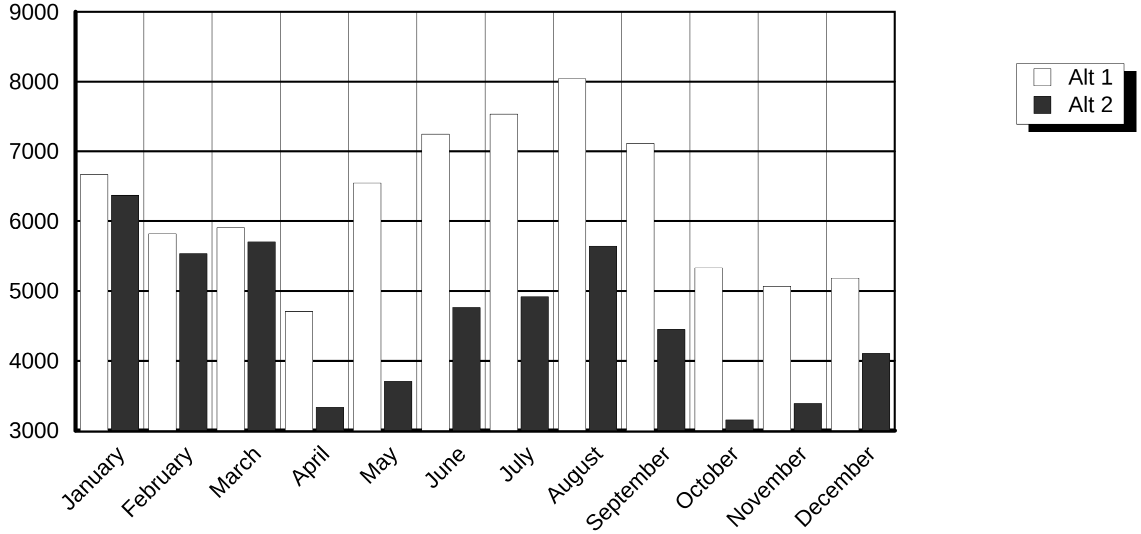
Economic Summary

Alternative Number	Installed Cost	First Year Util.Cost	Final Year Util. Cost	First Year Maint. Cost	Final Year Maint. Cost	Life Cycle Cost
1	822520.00	75166.36	75166.36	0.00	0.00	1462453.60
2	574345.00	55068.53	139155.42	0.00	0.00	1241339.68

Economic Comparison of the Alternatives

Alt. - Alt.	First Cost Difference	Simple Payback	Net Present Value	Life Cycle Payback	Internal Rate of Return
1 - 2	248175.00	Does not pay back	-221113.93	Does not pay back	1.2 %

Monthly Utility Costs



Equipment Energy Consumption by Alternative

	Elect Cons. (kWh)	Gas Cons. (therms)	Percent of Total Energy	Total Source Energy* (kBtu/yr)
Alternative: 1 -				
Primary heating	19,575.6	32,167.0	31.5%	35,864.6
Cooling Compressor	239,548.5		7.8%	24,529.8
Tower/Cond Fans	33,290.9		1.1%	3,409.0
Other CLG Accessories	571.6		0.0%	58.5
Supply Fans	699,789.0		22.9%	71,658.6
Circ Pumps	10,981.2		0.4%	1,124.5
Lighting	769,675.1		25.2%	78,814.9
Totals	**2,116,057.0**	**32,167.0**	**100.0%**	**250,544.8**
Alternative: 2 -				
Primary heating	19,440.2	28,891.9	35.7%	32,403.2
Cooling Compressor	154,997.6		6.4%	15,871.8
Tower/Cond Fans	20,988.4		0.9%	2,149.2
Other CLG Accessories	554.5		0.0%	56.8
Supply Fans	253,438.9		10.4%	25,952.2
Circ Pumps	19,388.9		0.8%	1,985.4
Base Utilities	474.5		0.0%	48.6
Lighting	769,675.1		31.7%	78,814.9
Totals	**1,581,583.4**	**28,891.9**	**100.0%**	**192,367.0**

* *Note: Resource Utilization factors are included in the Total Source Energy value.*

ALTERNATIVE COMPARISON

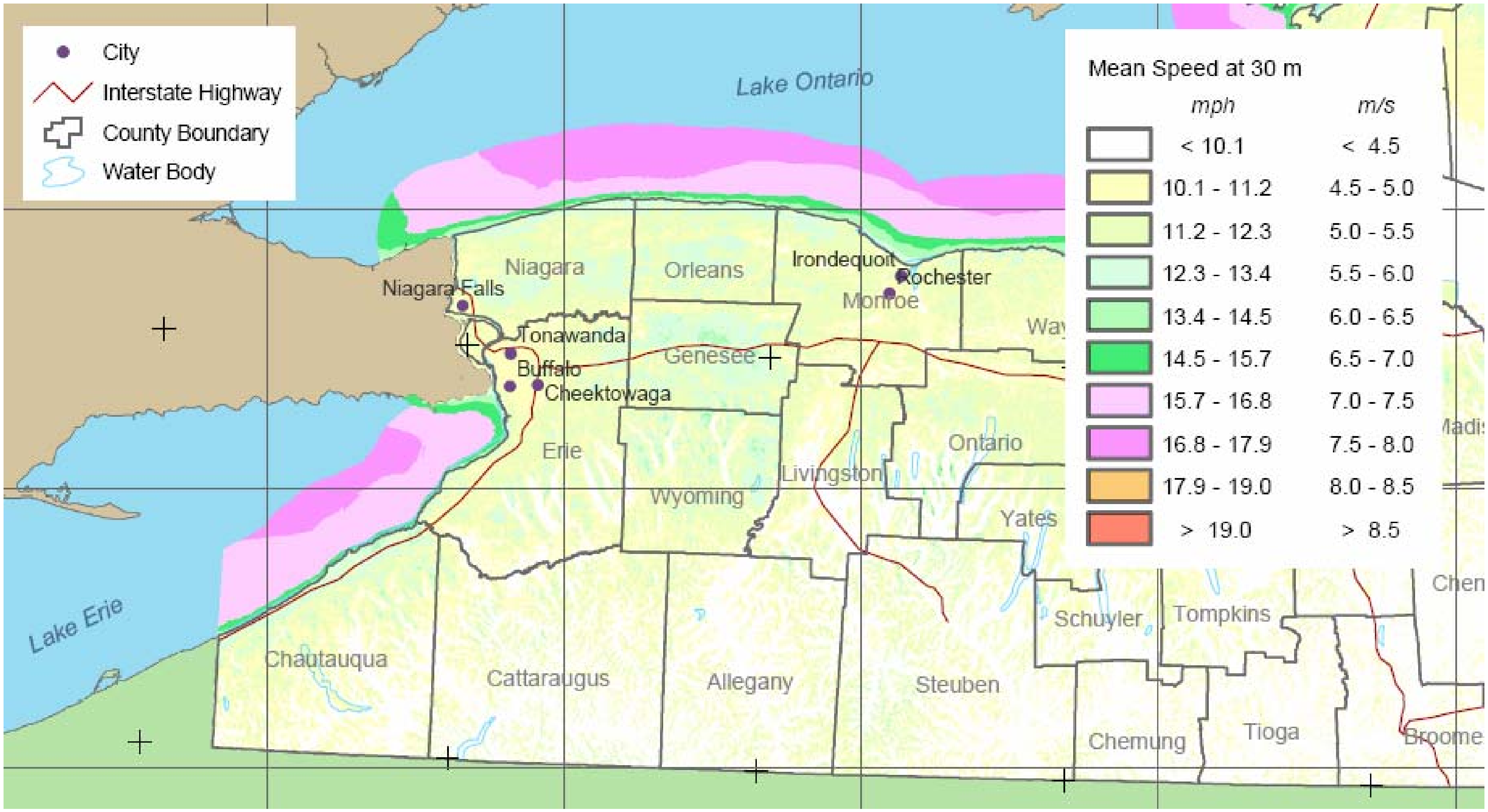
By ae

Alternative 1 vs Alternative 2 Comparison

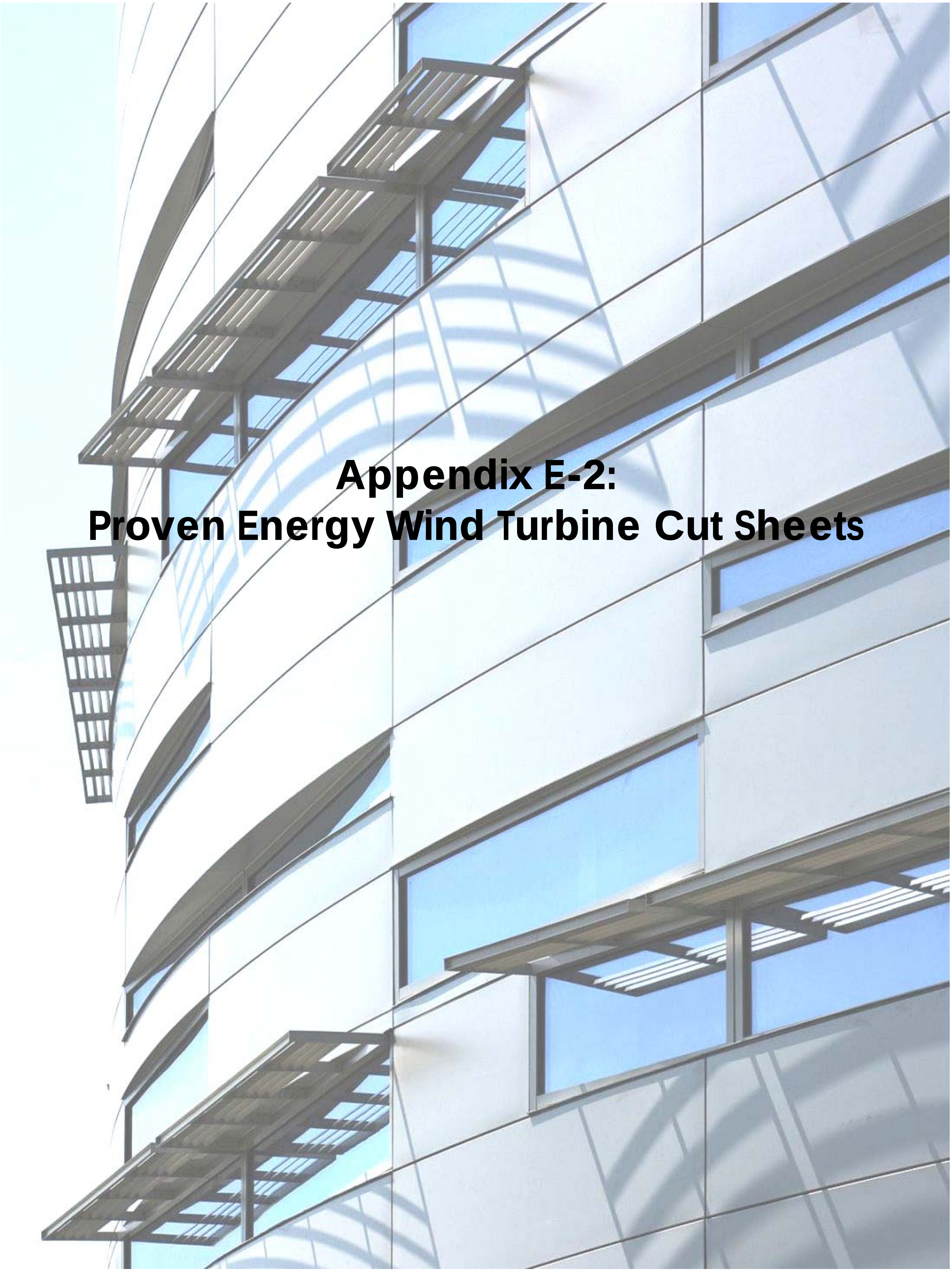
First Cost Difference	248175.00
Down Payment Difference	248175.00
Net Present Value of Incremental Cash Flows	-221113.93
Life Cycle Cost Difference	-221113.93
Revenue Penalty Difference	0.00
Simple Payback on Investment	Does not pay back
Life Cycle Payback on Investment	Does not pay back
Internal Rate of Return	1.2 %
Cost of capital (%)	10.0

Year	Cash Flow Difference	Cumulative Cash Flow Difference	Present Value of Flow Difference	Net Present Value
0	-248175.00	-248175.00	-248175.00	-248175.00
1	-20097.83	-268272.83	-18270.75	-266445.75
2	-17344.40	-285617.23	-14334.22	-280779.97
3	-14453.30	-300070.53	-10858.98	-291638.95
4	-11417.65	-311488.19	-7798.41	-299437.36
5	-8230.22	-319718.40	-5110.32	-304547.68
6	-4883.41	-324601.81	-2756.56	-307304.24
7	-1369.26	-325971.07	-702.65	-308006.88
8	2320.59	-323650.48	1082.57	-306924.31
9	6194.94	-317455.54	2627.26	-304297.05
10	10263.00	-307192.54	3956.83	-300340.22
11	14534.47	-292658.07	5094.24	-295245.97
12	19019.51	-273638.56	6060.20	-289185.77
13	23728.81	-249909.75	6873.39	-282312.38
14	28673.56	-221236.19	7550.65	-274761.74
15	33865.56	-187370.63	8107.15	-266654.59
16	39317.16	-148053.47	8556.56	-258098.03
17	45041.33	-103012.14	8911.19	-249186.84
18	51051.71	-51960.42	9182.10	-240004.74
19	57362.62	5402.19	9379.25	-230625.49
20	63989.07	69391.26	9511.57	-221113.93

Appendix E-1:
Regional Wind Maps


City
Interstate Highway
County Boundary
Water Body
Lake Ontario
Lake Erie
Mean Speed at 30 m
mph
m/s
< 10.1
< 4.5
10.1 - 11.2
4.5 - 5.0
11.2 - 12.3
5.0 - 5.5
12.3 - 13.4
5.5 - 6.0
13.4 - 14.5
6.0 - 6.5
14.5 - 15.7
6.5 - 7.0
15.7 - 16.8
7.0 - 7.5
16.8 - 17.9
7.5 - 8.0
17.9 - 19.0
8.0 - 8.5
> 19.0
> 8.5
Niagara
Niagara Falls
Orleans
Irondequoit
Rochester
Monroe
Tonawanda
Buffalo
Cheektowaga
Genesee
Erie
Wyoming
Livingston
Ontario
Yates
Chautauqua
Cattaraugus
Allegany
Steuben
Schuyler
Tompkins
Chemung
Tioga
Broome

Appendix E-2:
Proven Energy Wind Turbine Cut Sheets

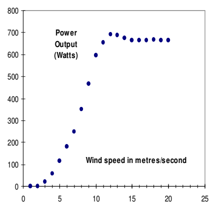


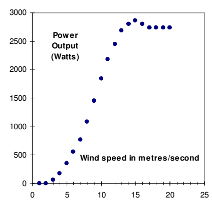
Proven Wind Turbines - Technical Specification Sheet

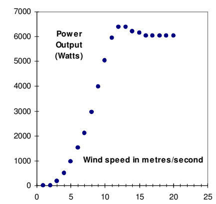
Rotor Speed Control
Above 12m/s or 25mph) blades twist to limit power in response to high rpm

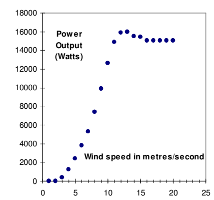
Low Speed Equals Durability

Marine Build Quality
All machines ***galvanised*** steel, ***stainless*** steel & ***plastic*** components









WT MODEL	**WT600 (0.6kW)**	**WT2500 (2.5kW)**	**WT6000 (6kW)**	**WT15000 (15kW)**
Cut In (m/s)[1]	2.5			
Cut Out m/s)	None!			
Survival m/s)	65			
Rated (m/s)	12			
Rotor Type	Downwind, Self Regulating			
No. of Blades	3			
Blade Material	Polypropylene	Polypropylene	Wood/Epoxy	Glass Polypropylene
Rotor Diameter(m)	2.55	3.5	5.5	9
Generator Type	Brushless, Direct Drive, Permanent Magnet			
Battery charging	12 , 24 ***or*** 48V DC	24 ***or*** 48V DC	48V DC	48V DC
Grid connect with *Windy Boy Inverter*	230Vac 50Hz ***or*** 240 Vac 60Hz	230Vac 50Hz ***or*** 240 Vac 60Hz	230Vac 50Hz ***or*** 240 Vac 60Hz	230Vac 50Hz ***or*** 240 Vac 60Hz
Direct Heating	n/a	120Vac ***or*** 240Vac	120Vac ***or*** 240Vac	120Vac ***or*** 240Vac
Rated RPM	500	300	200	140
Annual Output[2]	900-1,500 kWh	2,500 – 5,000 kWh	6,000 – 12,000 kWh	15,000 – 30,000 kWh
Head Weight (kg)	70	190	500	1100
Mast Type	Tilt-up, tapered, self-supporting, no guy wires (Taller guyed towers also available on request)			
Hub Height (m)	5.5 ***or*** 12	6.5 ***or*** 11	9 ***or*** 15	15
WT Found (m)	1x1x1 ***or*** 1.6x1.6x1	1.6x1.6x1 ***or*** 2.5x2.5x1	2.5x2.5x1 ***or*** 3x3x1.2	3.7x3.7x1.2
Winch Found (m)	0.65x0.65x0.65	0.65x0.65x0.65 ***or*** 1x1x1	1x1x1 ***or*** 1.5x1.5x1	1.5x1.5x1.2
Tower Weight (kg)	120 ***or*** 350	241 ***or*** 445	360 ***or*** 656	1200
Mechanical Brake	No	Yes	Yes	Yes
Noise[3] **@ 5m/s**	35 dBA	40 dBA	45 dBA	48 dBA
Noise @ 20m/)	55 dBA	60 dBA	65 dBA	65 dBA
Rotor Thrust (kN)	2.5	5	10	26
Sample of UK commercial customers	British Telecom / Scottish Youth Hostel Association / British Rail / Irish Lighthouse Authority UK Lighthouse Authority / T-mobile /Orange / Saudi Aramco / Shell / B&Q / BP / Sainsbury's			

[1] 1 metre/second = 2.24 miles per hour=3.6kph.
[2] Based on an ideal site and average wind speed of 5m/s - please refere to our website at www.provenenergy.com for further information
[3] All readings taken with an ATP SL-25 dBA meter at the base of the tower at a height of 1.5m.
* A car passing 20m away @ approx 40 mph is 70-80dBA

SECTION 3	PROVEN WT6000 (6000 Watt) WIND TURBINES, CONTROLLERS & TOWERS	*US List Price **
	6kW WIND TURBINES & CONTROLLERS - FOR BATTERY CHARGING	
WT6000/ 048	6kW wind turbine/generator (48V output)	**$18,160.00**
ECM6001/ 048	6kW 48V DC battery charging controller. Includes 2 DC and 3 AC divert load connections, Volt/Ammeters plus 8 system status indicators. 600mmHx400Wx260D Suitable for use with a DC system or DC/AC using an inverter. **Includes PAT100 MCCB**	**$2,840.00**
ECM6002/ 048	6kW 48V DC battery charging controller... Includes 3 AC divert load connections, Volt/Ammeters plus 8 system status indicators. 600mmHx400Wx260D Suitable for an AC system using a large inverter. **Includes PAT100 MCCB**	**$2,570.00**
	(Additional connections for PV input to battery charging controllers on request)	
	6kW WIND TURBINES & CONTROLLERS - FOR DIRECT HEATING	
WT6000/ 120	6kW wind turbine/generator (120V output)	**$18,160.00**
WT6000/ 240	6kW wind turbine/generator (240V output)	**$18,160.00**
ECM6003/ 120	6kW 120V heating controller. Volt and Ammeters 500mmHx300Wx260D	**$2,010.00**
ECM6003/ 240	6kW 240V heating controller. Volt and Ammeters 500mmHx300Wx260D	**$1,870.00**
	6kW WIND TURBINES & CONTROLLERS - FOR GRID CONNECT	
WT6000/ 300	6kW wind turbine/generator (300V output)	**$18,160.00**
ECM6004/ 300	Isolation and rectification controller for WT6000/300 for use with grid connect inverter. Suitable for int/ext. mount 300mmHx300Wx200D	**$850.00**
ECM6004ME/ 300	Isolation and rectification controller for WT6000/300 for use with grid connect inverter. Suitable for internal or external mount. **With V,I meters** for performance monitoring. 300mmHx300Wx200D	**$1,090.00**
	See Section 5 for SMA Windy Boy 6000U Grid Intertie Inverter price, WT6000/300 requires one WB 6000U for grid connect	
	6kW TOWERS	
TM900/ 6000	Tilt-up self supporting wind turbine mast (9m) including foundation kit and plans & gin pole	**$6,860.00**
TM1500/ 6000	Tilt-up self supporting wind turbine mast (15m) including foundation kit and plans & gin pole	**$8,650.00**
TM160/ 6000	Wind turbine mount for use with own mast (ungalvanised on request)	**$490.00**
TWT532/ 6000	Tirfor winch with 20 meters wire rope + strap (suitable for WT6000 on 9m tower)	**$1,780.00**
TWT532/ 6001	Tirfor winch with 30 meters wire rope + strap (suitable for WT6000 on 15m tower)	**$1,890.00**
	(Taller free standing or guyed towers also available upon request)	

SECTION 5	INVERTERS - GRID CONNECTED	US List Price *
WB 1800U	SMA Windy Boy 1800U, 1.8 kilowatt Grid Intertie Inverter, with LCD display, UL 1741 listec	$2,180.00
WB2500U	SMA Windy Boy 2500U, 2.5 kilowatt Grid Intertie Inverter, with LCD display, UL 1741 listec	$2,430.00
WB6000U	SMA Windy Boy 6000U, 6.0 kilowatt Grid Intertie Inverter, with LCD display, UL 1741 listec	$4,715.00
SECTION 6	ACCESSORIES & WARRANTIES	
	ACCESSORIES FOR BATTERY CHARGING SYSTEMS	
RES1000/ 024	1kW 24V Resistive heating element for use with ECM2501 & ECM6001	$200.00
RES1000/ 048	1kW 48V Resistive heating element for use with ECM2501 & ECM6001	$200.00
HBX2500/ 024/ 048	Custom stainless steel heater box containing 2 RES1000 24V or 48V heating elements. Ideal for use as DC divert load with ECM2501 or ECM6001	$700.00
	EXTENDED WARRANTY	
WAR03/600	Additional 3-years warranty on top of 2-years Manufacturers warranty to allow total 5-years cover for WT600	$400.00
WAR03/2500	Additional 3-years warranty on top of 2-years Manufacturers warranty to allow total 5-years cover for WT2500	$675.00
WAR03/6000	Additional 3-years warranty on top of 2-years Manufacturers warranty to allow total 5-years cover for WT6000	$1,475.00
WAR03/15000	Additional 3-years warranty on top of 2-years Manufacturers warranty to allow total 5-years cover for WT15000	$2,900.00
SECTION 7	EXPORT PACKING & CASES	
	WIND TURBINE PACKING & CASES	
BOX601	Sturdy export packing & case for 1 WT600 wind turbine and controller 1.4m x 1.4m x 0.5m approx 110kg, weight varies	$360.00
BOX2501	Sturdy export packing & case for 1 WT2500 wind turbine and controller 1.8m x 1.9m x 0.6m approx 300kg, weight varies	$530.00
BOX6001	Sturdy export packing & case for 1 WT6000 wind turbine and controller 2.4m x 2.2m x 1.2m approx 550kg, weight varies INCLUDES BLADES	$760.00
BOX15001	Sturdy export packing & case for 1 WT15000 wind turbine and controller 3.5 m x 1.6m x 1.5m approx 1200kg, weight varies. Note BLADE CRATE IS SEPARATE	$940.00
BOX15002	Sturdy export packing & case for 1 set of WT15000 wind turbine blades 5 m x .69m x .5m approx 130kg	$510.00
	TOWER PACKING	
TEP-01	Export tower packing for 1-section towers	$230.00
TEP-02	Export tower packing for 2-section towers	$470.00
TEP-03	Export tower packing for 3-section towers	$700.00