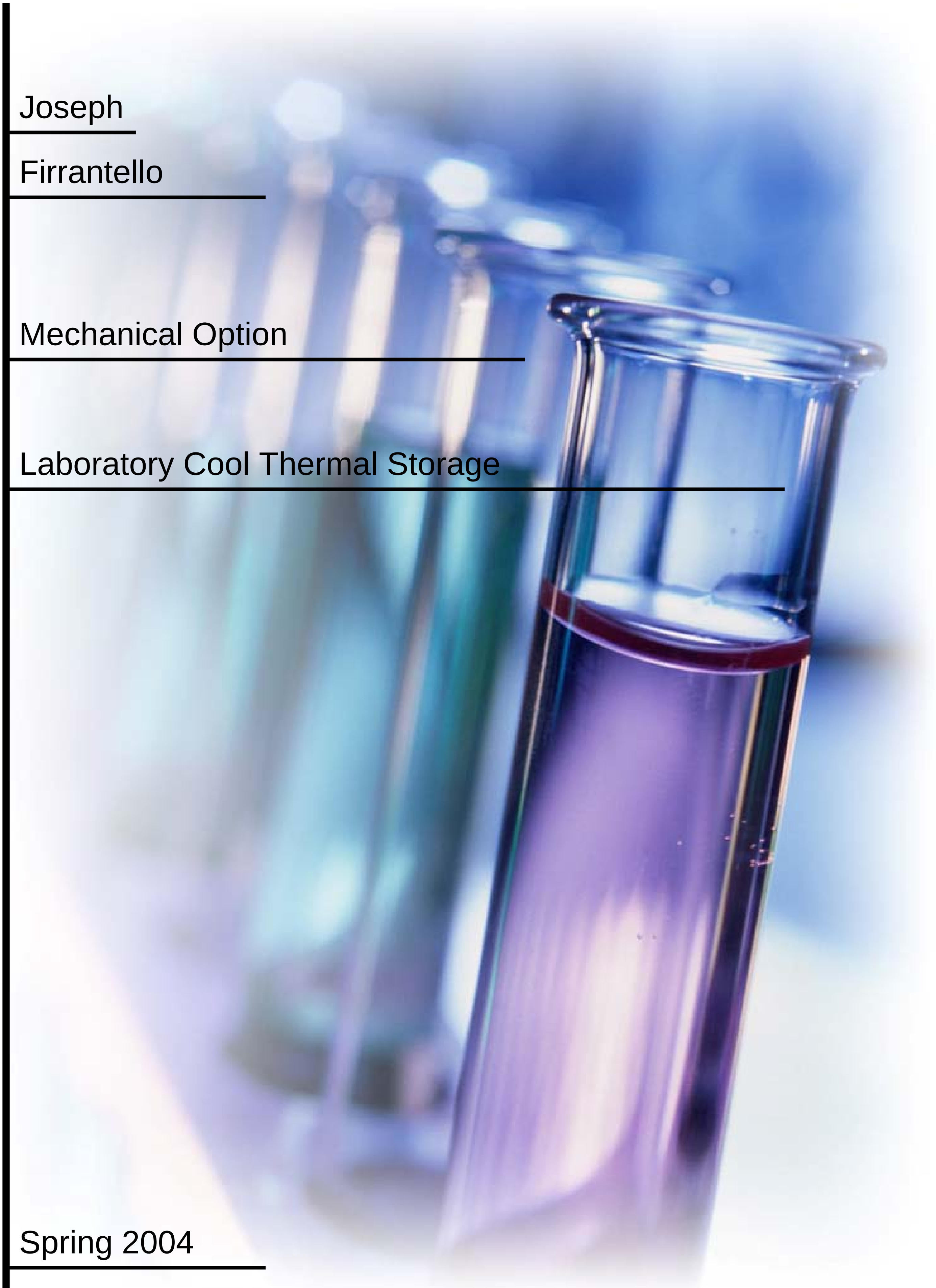


Joseph

Firrantello

Mechanical Option

Laboratory Cool Thermal Storage

Spring 2004

Joseph Firrantello

HVAC/ Mechanical

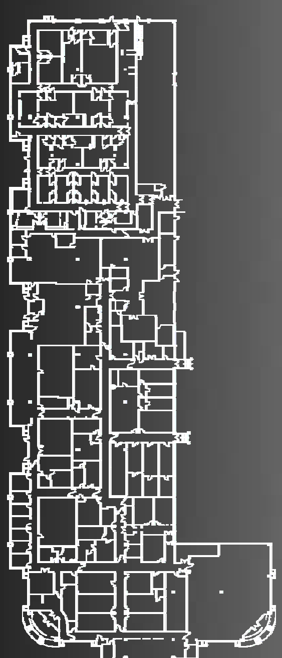
General

Construction

Mechanical

Electrical

Structural



Laboratory Facility Eastern PA

Building Shell Construction: Liberty Property Trust
MEP/Interior Space Fit-Out: Integrated Project Services (IPS)
Architect: Cathers and Associates, Inc.
Structural Engineer: Haynes Whaley Associates

- Size: 75,392 sf
- Max Design Occupancy: 198
- Start: August 2003
- Estimated Finish: May 2004
- Height: 31’ 4”, 1 story & service catwalk in plenum
- Design-Build contract for all MEP, lighting, and general interior fit-out

- 16 roof top AHUs, from 3890 cfm to 24,700 cfm
- Air distribution via overhead ductwork
- Heating accomplished through electric duct heaters, terminal air units, and unit heaters
- Cooling accomplished through coils on AHUs, 210.1 to 1116.4 MBTUH
- Office spaces served by VAV system
- Clean room and lab spaces served by constant volume systems
- Approximately 1/3 of building is clean room space, class 100,000 and class 10,000
- High pressure process steam via two gas fired Burnham LN3P-200 boilers, capacity of 6695 MBTUH and 6900 lbs/hr each
- Process chilled water via one Acme Model AARC – 140 Screw Chiller, nominal capacity 117 tons
- Lab spaces supplied with nitrogen, carbon dioxide, oxygen, and liquid nitrogen via in-house storage

- Utility supplies 480/277V 3φ, 4 Wire + Ground
- 1000kW diesel backup generator, also 480/277V 3φ
- 480/277 3φ 3 Wire panels for fluorescent lighting and mechanical equipment
- 230/120 3φ 3 Wire panels for lab equipment (freezers, centrifuges)
- 208/120 3φ, 4 Wire panels for incandescent bulbs, refrigerators, and small heaters
- Most space lighting via evenly spaced fluorescent fixtures

- Main structural system is steel column, girder, and beam grid.
- Max span: 40’
- Floor is concrete slab on grade
- Steel supports exterior curtain wall of glazing and brick or EIFS
- Roof supported via open-web chord joists with reinforcement welds for mechanical equipment structural loads
- Service catwalk in plenum suspended from roof structural system

Department of Architectural Engineering
The Pennsylvania State University

Table of Contents

Acknowledgements

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Last but not Least…
Thanks to my roommates, girlfriend, friends, family, and everyone else who had to put up with me.

I. Executive Summary

The building being studied is a 74,000 ft^2 biological clean room facility in eastern Pennsylvania. It has class 10,000 and 100,000 clean room space, non-clean lab and storage space, and administrative/office space. The existing mechanical systems are fifteen packaged rooftop air handling units, fourteen of which are included in this study. Of those fourteen, one is a VAV system serving the administrative and office spaces, nine serve clean rooms, and four serve non-clean laboratory and storage space.

The existing mechanical system performs space cooling by direct expansion coils that came with the prepackaged air handling units. While this system has a low first cost, it is possible to reduce the operating cost with a more efficient system. The goal of the redesign was to install a chilled glycol and demand limiting partial ice storage system, thereby reducing energy usage and cost. This system would enable a large portion of the cooling load to be shifted to the off-peak hours, where utility rates are cheaper. Additionally, the utility has a special energy rate (about $0.35/kWh) for off-peak thermal storage applications.

The redesign has an operating cost of about $634,000 per year, as opposed to the existing system's cost of $738,000 per year. Also, the redesign consumes about 7,400,000 kWh per year, in comparison to the existing system's consumption of 7,800,000.

In the lighting portion, an open office space in the administrative section was examined, and found to have a high illuminance incidence on the work spaces (i.e. desks) in the room: 100 foot-candles, compared to the IESNA recommendation of 50 foot-candles for office spaces.

An attempt was made to design a utilitarian splayed well skylight scheme that would save operational cost and improve the character of the room. However, a quick calculation showed relatively low savings per year (about $100) due to the small amount of hours where day-lighting could be utilized. This is not enough to justify building six skylights through a 22' plenum. Instead, lower power luminaires made for usage with visual display terminals (VDTs) were installed, and ended up giving a fairly uniform distribution of 50 foot-candles on the 2'6" work plane.

The construction management section's aim was to do quick check of site layout and calculate the years required for payback on the mechanical and lighting redesigns.

The site was found to have enough space to support the ice tanks and any other expansion of the mechanical room that may be necessary. The mechanical redesign would take about 12 years to reach equivalence with the existing design, given an interest rate of 6% and an inflation rate of 2.16% (from August 2003, the month where construction started). The lighting redesign would take about 20 years to reach simple payback.

In conclusion, the mechanical system redesign is not recommended. Even though it saves a significant amount of money per year, the time to reach equivalence with the existing design is too large to be palatable to most owners. The lighting redesign, however, is recommended, because the improved illuminance and lighting distribution in the space could have a beneficial impact on the attitude and efficiency of the workers in that space.

II. Project Background: What is Thesis?

Penn State's Undergraduate Architectural Engineering Thesis is a two-semester long process.

Before the first semester starts, students choose a building to work on. They are responsible for getting all of the design documents, specs, and information necessary to perform engineering analyses on the building systems.

The first semester consists of three of these analyses, where the student becomes familiar the engineering systems in his or her building. At the end of the first semester, the student has outlined a plan for redesigning a part of the building. The student focuses on a "Depth" redesign in his or her option (Mechanical, Structural, Lighting/Electrical, Construction Management), and then has two smaller "Breadth" redesigns in two of the other options.

The second semester consists of research and work on these redesigns. AE faculty and volunteer industry members are at the disposal of students for questions or consultations. The semester culminates in a final report and a presentation made in front of a panel of faculty judges.

In addition, each student maintains an "e-portfolio" web site that is updated continually throughout both semesters.

III. Building Background Information

This section discusses general building system information. System information specific to redesigns will be discussed in the appropriate redesign section.

A. General

Note: The building occupant and location cannot be released, as per IPS's confidentiality agreement with the client.

1. Primary Project Team

Liberty Property Trust was in charge of the building shell construction. Integrated Project Services (IPS) was responsible for design, construction, and validation of the facility from the outside wall in. Haynes Whaley Associates performed the structural engineering, and Cathers and Associates were the architects.

2. Basic Information

The one-story facility is approximately 75,000 square feet and is located in eastern Pennsylvania. About 45,000 square feet of conditioned space will be used in the mechanical systems analysis. The remainder of the space is unconditioned, billed for future construction, or part of AHU 15, which was unsuitable to use in the redesign.

The building was scheduled to be started in August 2003 and finished May 2004.

It's primary purpose is as a biological laboratory/production facility for a private corporation.

B. Architecture

The building has 3 main usage areas: clean room laboratory, laboratory/storage, and administrative/office. These are outlined respectively as sections 1, 2, and 3 in **Figure III-1**. (see **Appendix III-1** for larger version). It is located on a former military base, and is part of a large civilian occupancy project for the campus.

The building has no architectural features of note, as its primary purpose is utilitarian.

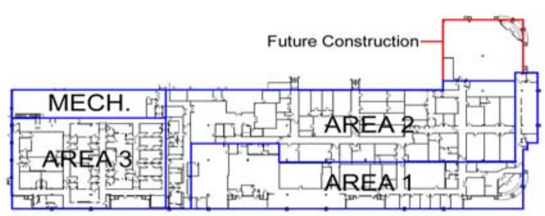

Figure III-1 – Usage Areas

C. Electrical System

The building is served by two main distribution panels. The first is sized for 3000A and serves two 208/120V 3φ and two 480V 3φ distribution panels. Each of these panels is rated at 800A. The second is also sized for 3000A and serves 3 480/277V 3φ panels (rated at 2000A, 1200A, and 800A) and 2 208/120V 3φ panels (rated at 600A each).

There are a total of eleven transformers, ten from 480 to 208/120, and one from 480 to 240. The 240V line is further modified to 230V in order to serve certain laboratory equipment (i.e. centrifuges, freezers, etc). Additionally, there is a 1000kW, 2000A back-up diesel generator tied into the second main distribution panel.

The 480/277 line primarily supplies power to the mechanical equipment and fluorescent lighting, while the 208/120 line serves the electrical outlets, some refrigerators and small heaters, and the few incandescent bulbs.

D. Lighting

Most of the space lighting is accomplished by fluorescent fixtures running on 277V. Recessed 2x4 T8's (ranging from 70W to 140W) are the primary type of fixture. 2x4's and 1x4's (both exposed and recessed) are used for the mechanical and storage spaces. 2x2's light some of the smaller areas, i.e. vestibules, closets, airlocks. Some HID and incandescent lighting is used in the small lobby area.

Two beads of silicon sealant are applied around the edges of the fixtures in the clean room spaces to prevent contamination. 200W metal halide fixtures light the reception area, and there are a few specialized fixtures for the dark room.

Additionally, a number of the fluorescent ballasts are provided with batteries to act as emergency lighting.

E. Structural

The main structural system is a steel W-shape grid (columns, girder beams) with a maximum span of 40'. There is nothing truly remarkable about the structural system, as the building is only 1 story, though it is approximately 31'4" tall.

The foundation is concrete slab on grade. The roof is supported by open-web chord joists with reinforcement welds at key points for rooftop mechanical equipment loads. The service catwalk in the 22' building plenum is hung from the roof structural system.

F. Mechanical

Ventilation and space conditioning is performed by 15 rooftop packaged air-handling units. AHUs 1 through 9 are constant volume systems with terminal reheat that serve clean room spaces. AHUs 11-15 are constant volume systems, also with terminal reheat, that serve non-clean labs, warehouse, and storage space. AHU 10 is a variable air volume system with terminal reheat that serves the administrative and office spaces in the building. Specifics on all of the AHUs can be found in **Appendix III-2**.

AHUs 2, 7, and 14 are 100% outdoor air, and the rest have some fraction of return air mixed with the incoming ventilation air. The supply air rate ranges from 3,890 to 24,700 cfm. All air is run through a 30% and a 90% filter inside each AHU.

The clean room spaces are class 10,000 and class 100,000. These numbers represent the range of numbers of different size particles that are allowed in a space.

Cooling is accomplished through DX coils that are part of the packaged AHUs. Preheat is accomplished by natural gas-fired burners in the AHUs. Reheat and supplemental heating is supplied by electric duct heaters.

Additionally, there is a 117 ton process chiller in the mechanical room, as well as two 6695 MBTUH boilers that supply steam for humidification and process loads.

G. Fire Protection

Approximately 2/3 of the building is classified as Ordinary Hazard 1, and has a heat responsive (165°F) wet pendant system set at 175 psig. The lab/clean room space is classified as Ordinary Hazard 2, and has a similar system. The only variation is in the Freezer Storage room, which has a dry pendant sprinkler system.

Detection is provided by either heat detectors or duct smoke detectors. Fire alarm strobes and horn/strobe combinations are used as an alert system. Information on passive fire protection of structural members is currently unavailable. Spray-on fire proofing (SOFP) is assumed. Fire walls are rated at 1 or 2 hours by Underwriters Laboratory.

H. Construction Management

Not a lot of information was available on the construction side of the project.

The entire project was driven by first cost considerations, as the client wanted the facility up and running in order for it to start business. Operational cost was deemed a low concern, as utility costs could be passed on to clients.

As mentioned earlier, the project takes place on a large commercial campus, and there is ample room around the site for maneuvering equipment, cranes, etc.

IV. Mechanical Depth Study

A. Introduction

This section presents the mechanical depth portion of the redesign. First, pertinent background information on the mechanical system will be established. Then, the concept and goals of the redesign will be introduced. The methodology and results of preliminary studies will be discussed, and then the procedure for the redesign itself will be talked about. The results will be summarized, and a conclusion will be reached.

B. Background Information

Ventilation and space conditioning is supplied by 15 McQuay RPS rooftop packaged air-handling units. AHUs 1 through 9 are constant volume systems with terminal reheat that serve clean room spaces. AHUs 11-15 are constant volume systems, also with terminal reheat, that serve non-clean labs, warehouse, and storage space. AHU 10 is a variable air volume system with terminal reheat that serves the administrative and office spaces in the building. Specifics on all of the AHUs can be found in **Appendix III-2**.

AHUs 2, 7, and 14 are 100% outdoor air, and the rest have some fraction of return air mixed with the incoming ventilation air. The supply air rate ranges from 3,890 to 24,700 cfm. All air is run through a 30% and a 90% filter inside each AHU.

The clean room spaces are class 10,000 and class 100,000. These numbers delineate the number of different sizes of particles that are allowed in a space.

Cooling is accomplished through DX units that are part of the packaged AHUs. Heating is accomplished by natural gas-fired burners in the AHUs.

C. Concept and Goals

The mechanical redesign involves replacing the DX units in the AHUs with a more efficient chilled glycol system, which will be supplied by chillers and ice storage tanks. This new system will be used for demand limiting partial thermal storage, which aims to reduce the amount of energy spent during a utility's peak period.

The redesign will be successful if the redesign (a) saves energy and (b) saves money.

The main part of the analysis will be done with Trane's TRACE load and energy calculation software. Other software and methodology will be explained with the associated information.

D. Preliminary Studies

1. Justification of Methodology and Baseline Results

Trane's TRACE multi-zone load and energy calculation program was used for building simulations. This program models each space as a single, well-mixed zone, and does not take into account real mixing effects that may effect how effective a space's conditioning system is.

The software, however, has enough accuracy to do a reasonable model of whole building load and energy use. It uses TETD-TA1 methodology for its calculations, which is listed as a conservative calculation method in the program's documentation.

Data such as fan pressure, required outdoor air, room area etc., was taken directly from information on the design documents. Information on process load heat gain was received from the design manager. Occupancy was taken from architectural plans when possible, and estimated when not apparent. The general occupancy for the laboratory spaces was taken at 100 ft^2/person.

Occupancy and lighting schedules were approximated as what one would expect for a typical office building, i.e. 100% occupation during the day, slight occupation after the work day has ended, and empty at night. However, lab equipment energy consumption was only reduced to 50% load at night to reflect that fact that laboratory equipment (i.e. refrigerators, centrifuges, etc.) may remain on overnight.

Sizing data for the building thermal loads can be found in **Appendix IV-1**.

<u>2. Baseline Results</u>

Table IV-1 - Yearly Economic Summary				
Utility	Peak Demand	Consumption	Yearly Cost	$/ Consumption Unit
Eletric	1387 kW	7,816,331 kWh	$726,501.00	$ 0.093
Gas	24 therms/h	59,684 therms	$ 11,708.00	$ 0.196
		Total $/year	**$738,209.00**	

The breakdown of cost and use by month is available in **Appendix IV-2**

The operating cost was calculated using the PECO General Service Rate and Philadelphia Gas Works Interruptible Tariff (see **Appendix IV-3**).

The operating cost may seem like a large number at first, but a study (Mills, et. al., 1996) done on California laboratory facilities shows that energy intensities can be 4 to 5 times higher than a normal commercial building, and 10 to 100 times higher in the case of clean rooms.

A quick calculation, taking a "normal" operating cost of $1.5/ft^2, shows that the numbers are reasonable. See **Table IV-2**.

$$O.C. = A_{office} \times \frac{\$}{ft^2}_{office} + A_{lab} \times \frac{\$}{ft^2}_{lab} + A_{class100k} \times \frac{\$}{ft^2}_{class100k} + A_{class10k} \times \frac{\$}{ft^2}_{class10k}$$

Table IV-2								
A_{office}	$(\$/ft^2)_{office}$	A_{lab}	$(\$/ft^2)_{lab}$	$A_{class100k}$	$(\$/ft^2)_{class100k}$	$A_{class10k}$	$(\$/ft^2)_{class10k}$	Total
27,569	$ 1.50	23,465	$ 7.50	10,000	$ 18.00	6,000	$ 36.00	$ 613,341

The roughly calculated number is lower than the simulation's values, but that makes sense. The published values are from an average of facilities, and this particular facility has no energy recovery, so it would be on the high side.

The building is a large energy user. Process equipment, the need for 24 hour space conditioning, and the large airflows associated with laboratory spaces are significant contributors to this load. The contribution of cooling equipment to the cooling design day energy peak can be seen in **Figure IV-1**.

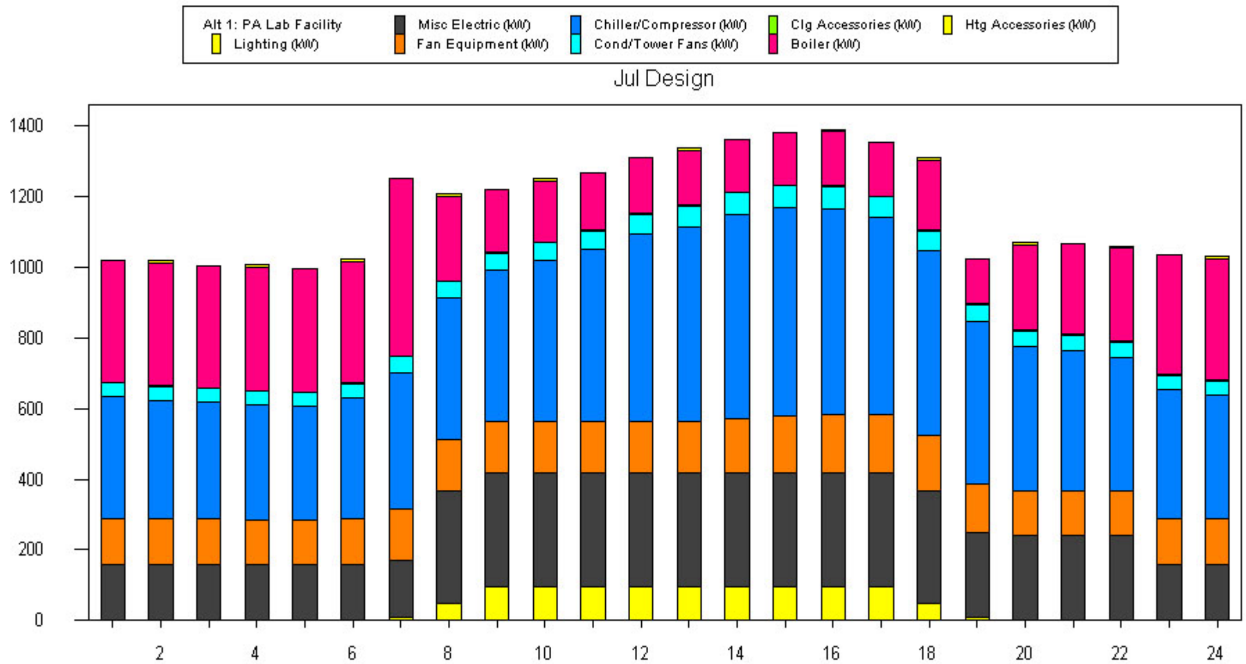

Figure IV-1 – Baseline: Contribution to Design Day Electrical Demand

Space conditioning, in general, is a large contributor to the building's energy use. In **Figure IV-2**, the red band of reheat coils is clearly visible throughout all months of the year (used for pure heating in winter, and reheat of cooled air during the summer), and cooling is a significant energy user during the summer months.

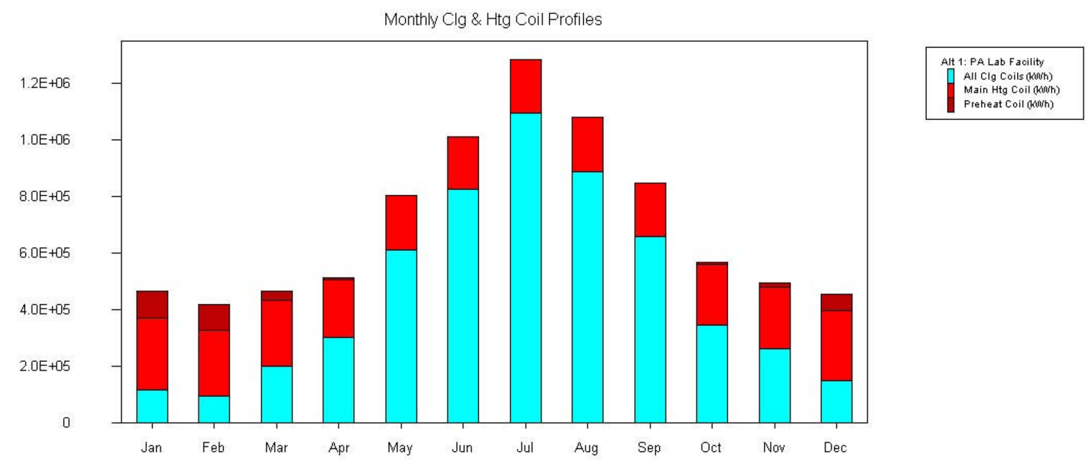

Figure IV-2 – Baseline: Energy Consumption of Space Conditioning

Given the large amount of cooling energy used, and the fact that PECO has a special low rate (about \$0.035/kWh) for any equipment associated with thermal storage, the prospect of using demand-limiting storage was decided upon. "Load Leveling", a common control methodology for ice storage, was decided against because of the relatively low ratio between on-peak load and off-peak cooling load for the design day, as shown in **Figure IV-3**.

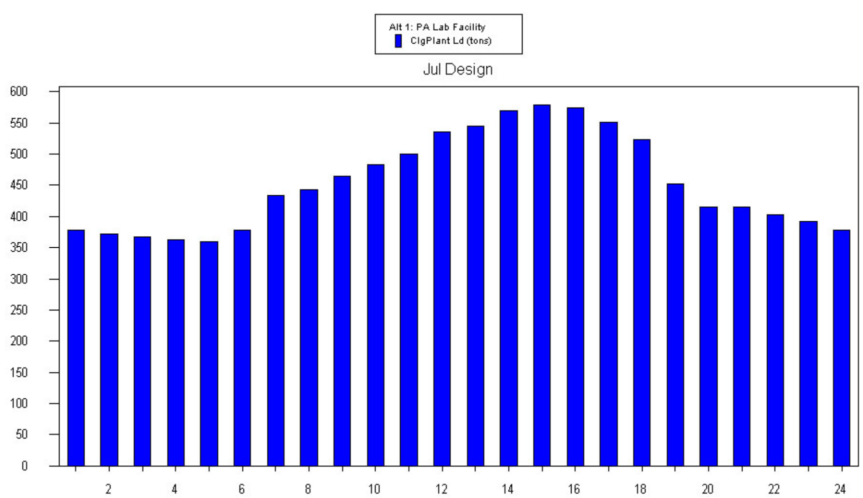

Figure IV-3 – Baseline: Cooling Load

E. Design Procedure

Since the cooling load is known from the preliminary analyses, the design itself is a matter of sizing the coils, sizing the ice tanks, sizing the chillers, and sizing the peripheral equipment.

1. AHU Cooling Coil Design

The AHU cooling coils were designed with a 40°F supply temperature and a 13°F ΔT in mind. This low temperature and high ΔT was chosen because of its potential for pump and piping savings (Taylor 2000). Additionally, it was decided that 25% glycol would be used throughout the system because it would eliminate the added first cost and added energy cost of needing to use a large heat exchanger for the system.

The coils themselves were selected with USA Coil & Air's selection program. This program enables one to input coil physical data (i.e. material, dimensions) as well as properties such as fluid type, entering fluid temperature, and entering air conditions. Coil size was decided upon by picking a McQuay air handling unit that could handle the required supply air flow (calculated with Trane's Trace software). The coil sizes were then taken directly from McQuay Skyline literature.

The coils were sized to match the cooling load and leaving air temperature required for their respective AHU with a 13°F ΔT.

A brief summary of the flows and loads associated with each AHU can be seen in **Table IV-3**. All of the data from the coil selection is available in **Appendix IV-4**. The Skyline AHU data used to select coil size is in **Appendix IV-5**.

Table IV-3 – AHU Summary

AHU Number	Skyline Model Number	Load (tons)	25% Glycol Flow (gpm)	Supply air flow (scfm)	Type of System
1	021	19.1	43.0	6,672	CAV, recirc
2	035	80.1	173.2	11,123	CAV, 100% OA
3	025	38.7	83.9	6,447	CAV, recirc
4	025	35.7	77.5	6,268	CAV, recirc
5	010	17.0	46.3	3,394	CAV, recirc
6	010	16.0	36.6	3,534	CAV, recirc
7	025	59.1	129.1	8,375	CAV, 100% OA
8	021	41.9	92.5	7,535	CAV, recirc
9	014	25.5	56.0	6,381	CAV, recirc
10	055	90.2	99.0	14,603	VAV, recirc
11	014	32.5	78.5	5,930	CAV, recirc
12	045	62.8	134.5	16,713	CAV, recirc
13	035	50.2	109.8	13,386	CAV, recirc
14	010	18.5	40.9	2,989	CAV, 100% OA
Totals		**587.3**	**1,200.8**	**113,350**	

Extensive recalculation of airside pressure drops was decided to be unnecessary, as the calculated flows are generally a bit lower than those in the design documents. Additionally, the main focus of this analysis is the water side of the cooling system. Opting for the conservative choice, total airside pressure drop were taken directly from the design documents.

2. Ice Storage Design

A preliminary evaluation of demand-limiting ice storage was done in a spreadsheet, with a cooling plant capacity of 600 tons. Given that cooling capacity, the maximum amount of ton-hours of charging on cooling design day was calculated. On-peak time for an ice storage application during the summer months is 10am – 8pm, and charging is done at all other times. The results are shown in **Figure IV-4**. As one can see, a large chunk of the cooling load and energy during the middle of the day is shifted to the off-peak hours. Based on this data, the maximum chargeable capacity is 2774 ton-hours.

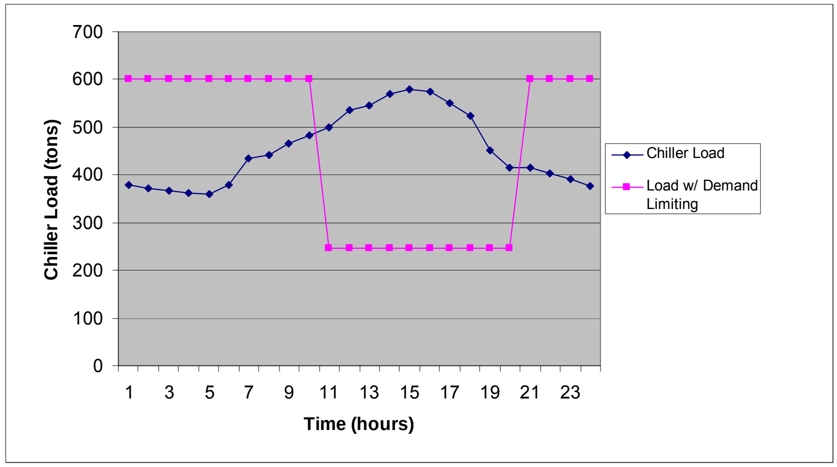

Figure IV-4 – Chiller Load vs. Time (Estimate)

Additionally, the effect on the building electrical load was looked at, and the results are presented in **Figure IV-5**. Approximately 2885 kWh is shifted to off-peak and a lower utility rate.

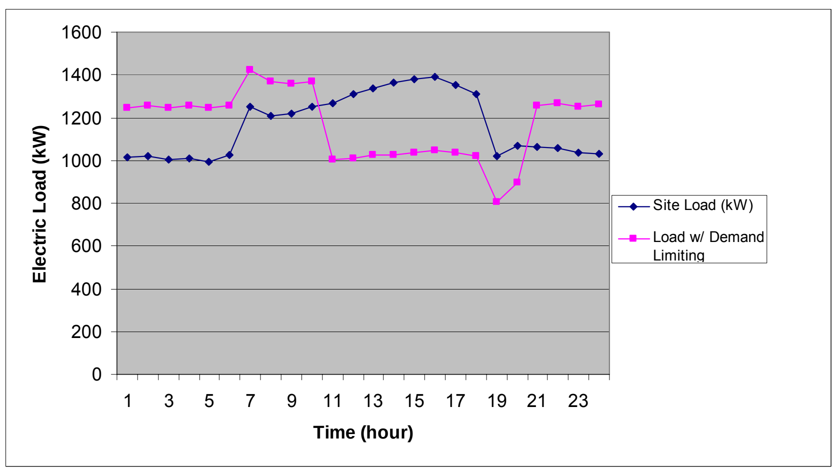

Figure IV-5 – Site Load vs. Time (Estimate)

The next step, before selecting the storage equipment, is to pick an operating strategy.

The following ice operating strategies were looked at:

- Chiller Upstream
- Chiller Downstream
- Parallel Operation

In chiller upstream operation, the return (53°F) is first cooled by the chiller, and then goes through the ice tank to be cooled down fully to 40°F. This has the effect of de-rating the ice tanks because of the low return temperature. (Dorgan and Elleson, 1994)

In chiller downstream operation, the return is first cooled by the ice tanks, and then is fully cooled to 40°F by the chiller. This has the effect of de-rating the chiller because of the lower return temperature. (Dorgan and Elleson, 1994)

Conversely, in parallel flow, both the ice tanks and the chiller see the higher 53°F return temperature. (Calmac, 2000) The system becomes more economical, but the controls and piping become a little more complex. Parallel flow was chosen as the operating scheme because there is no need to de-rate the chillers or the ice tanks, thereby providing the most efficient operation.

Flow schematics for both the charge and discharge periods are shown in **Figure IV-6** and **Figure IV-7**.

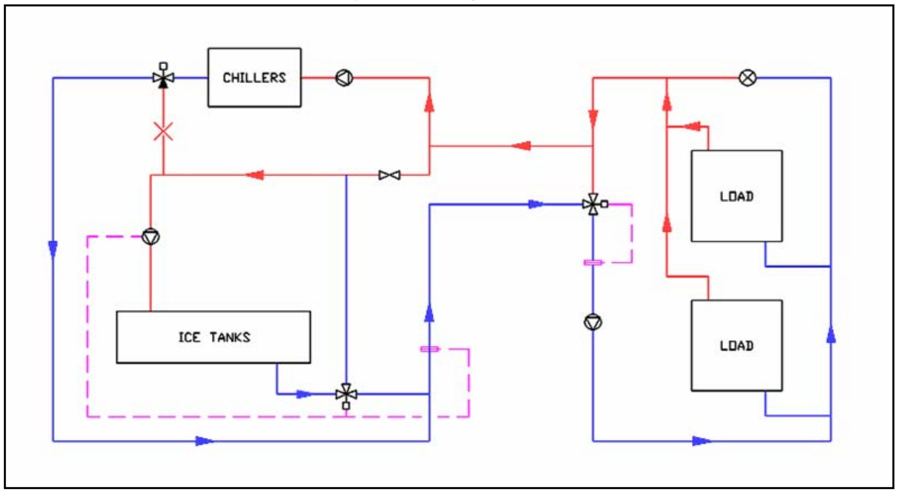

Figure IV-6 – Schematic of Discharge Period

Calmac's modular internal melt ice-on-coil system was chosen for two reasons. The first is the relative simplicity of obtaining size and operational data, and the second is ease of selection and installation of modular equipment.

The last decision that had to be made was the control scheme. The options were equipment to set-point and an optimized strategy

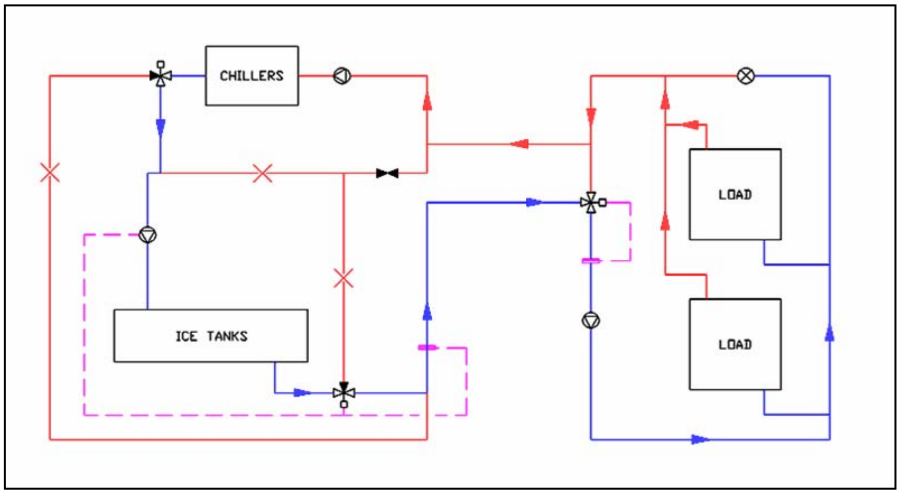

Figure IV-7 – Schematic of Charge Period

The former is the strategy illustrated previously in **Figure IV-4**. A set-point is established by that analysis, and the ice tanks are used anytime the cooling load is above that setpoint during the on-peak period.

The latter is harder to implement. It attempts to predict the load for the day using algorithms, and uses the ice tanks to keep the cooling load seen by the chillers as low as possible in such a manner as to almost fully discharge the tanks at the end of the day.

The optimization strategy was chosen as the most desirable given the plan of shifting as much load as possible to the off-peak period. With this plan, small cooling loads would still be met by ice during the day, and would get the lower utility rate associated with thermal storage applications.

3. Ice Storage Equipment Selection

a) **Choose Model –** The Calmac 1500 model was chosen, because it has the highest nominal capacity (about 570 tons). It is actually just three of the smaller 1190 models strung together.
b) **Hours On** – As discussed earlier, the ice tanks will be providing cooling for 10 hours on the design day.
c) **Hours Precool** – This is the cooling that must be done before the beginning of the day, if the temperature is allowed to "float" the night before (when the building is unoccupied). Since a lot of the laboratory space must be kept at or near design temperature at all times, this is set to 0.
d) **Diversity Factor** – Average Load/Peak Load. In this case, it is 0.78.
e) **Adjusted Hours –** Equal to Diversity Factor x Hours On = 7.8 hours
f) **Inlet and Outlet Temperatures** – 40°F and 53°F, respectively.
g) **Use Calmac Data to get Discharge Rate and Adjusted Capacity –** Calmac has charts based on system return temperature. There is one for 50°F and 60°F. Values will be taken from both charts, and then interpolation will be used to get the correct values for a 53°F return temperature. The chart for 60°F is shown in **Figure IV-8** below. The point that corresponds to a leaving water temperature of 40°F and adjusted hours of 7.8 is chosen. This gives a capacity of about 440 ton-hours/tank and a discharge rate of about 55 tons/tank. After the interpolation, total capacity is 426 ton-hours/tank and the discharge rate is about 53.25 tons/tank.

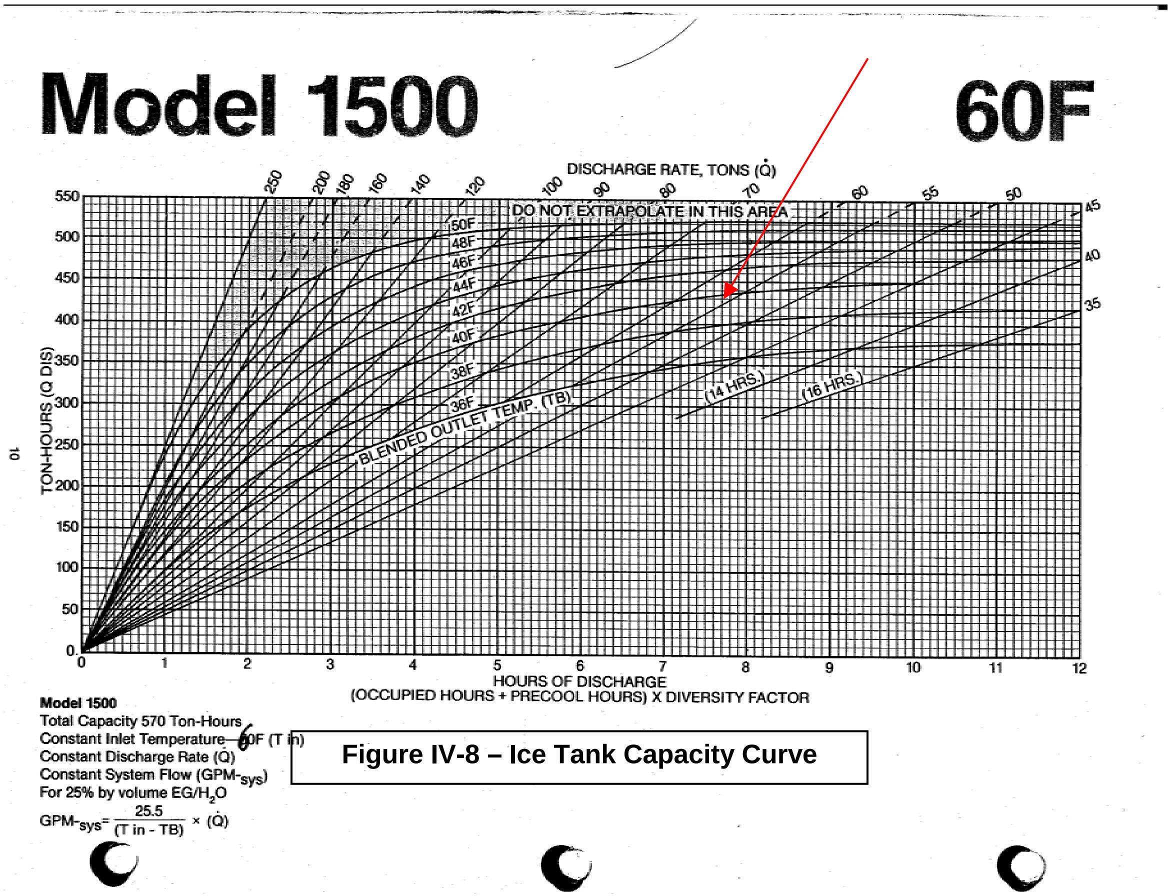

Figure IV-8 – Ice Tank Capacity Curve

h) **GPM_{SYS} –** The design flow rate is calculated using the following equation.

$$GPM_{SYS} = \frac{25.5}{T_{in} - T_B} * Q_{discharge}$$

It comes out to 104.5 gpm.

i) **Pressure Drop** – The head loss through the tanks is calculated from the following chart in **Figure IV-9**. From this chart, the head loss is about 4.5 psi, or 10.35 ft wg.

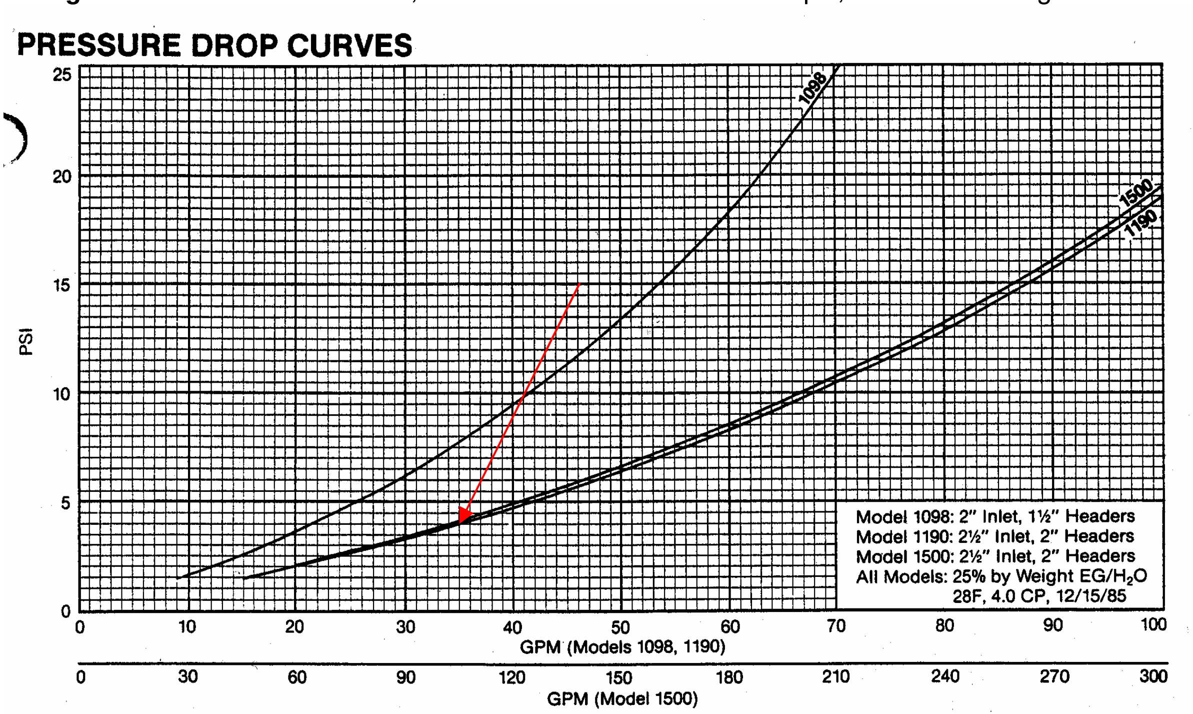

Figure IV-9 – Ice Tank Pressure Drop Curve

j) **Charging Rate** – Calculated from

$$Rate = \frac{Total\ Capacity}{\#\ of\ Tanks \times Hours\ Charging} = \frac{2982}{7 \times 12} = 35.5$$

k) **Charging Brine Temp –** From Calmac literature, **Figure IV-10**

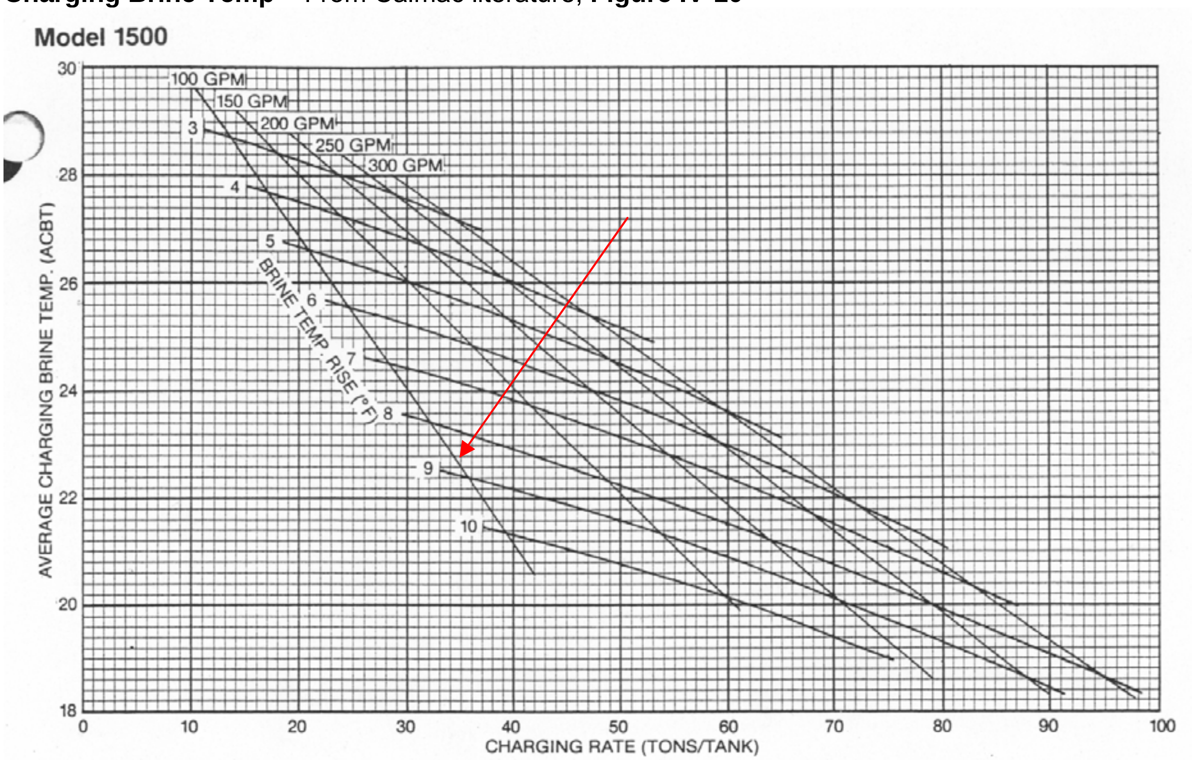

Figure IV-10 – Ice Tank Charging Temperature Curve

This gives an average charging glycol brine temperature of about 22.4°F, and a charging flow of 100 gpm/tank (close to the discharge flow). The ΔT of the charging bring is 9°F.

At this point, all the necessary information about the ice tanks has been recorded. Dimensional data will not be needed until the construction management section.

<u>4. Selecting the Chiller</u>

Chiller selection was fairly straightforward. Screw and centrifugal chillers were the first choice because of the recommendations of the ASHRAE <u>Design Guide to Cool Thermal Storage</u>.

Carrier screw chillers were looked at first, because the available selection software enabled generation of equipment, flow rates, unloading curves, and a whole library of information on command. Unfortunately, the methodology the software used to select equipment made it hard to get the right operational characteristics, so Carrier was ultimately abandoned. Additionally, a representative of Calmac recommended I pursue chillers from Trane or York for ice storage applications.

Representatives of Trane and York were also contacted, and were given a synopsis of the desired application, along with the following design data:

- Compression Method: Centrifugal
- Load: 600 tons
- Operating Fluid: 25% Glycol/Water Solution
- Flow: 1,200 gpm
- Charge Conditions: Leaving temperatre of 22.4°F with ΔT=13°F
- Discharge Conditions: Leaving temperatre of 40°F with ΔT=13°F

The York representative suggested a screw compressor with his equipment, and a system of three chillers at 200 tons a piece was decided upon.

Data on the York chillers is available in **Table IV-4**. Unloading data is available in **Table IV-5**.

Table IV-4 - York Chiller Specs		
Capacity	200	tons
Condenser Flow	600	gpm
Condenser ΔP	22.8	
ECWT	85	
LCWT	94.7	
Evaporator Flow	400	gpm
Evaporator ΔP	15.7	ft wg
Fluid	25%	ethylene glycol
Charge		
ECHGT	35.4	°T
LCHGT	22.4	°T
kW/ton	1.080	
Discharge		
ECHGT	53	°T
LCHGT	40	°T
kW/ton	0.740	

Table IV-5 - York Chiller Unloading		
% Capacity	ECWT	kW/ton
Charge		
100%	85	1.080
100%	75	0.860
100%	65	0.685
Charge		
100%	85	1.080
75%	75	0.880
50%	65	0.890
25%	65	1.520
Discharge		
100%	85	0.740
75%	75	0.673
50%	65	0.680
25%	65	0.940

This data was used to approximate the ambient modification curves and constant temperature unloading curves for use in the eventual energy simulation. The details of those calculations can be found in **Appendix IV-6**.

5. Peripheral Equipment Selection

a. Pipe Layout and Sizing

The pipe layout was roughly approximated, making certain assumptions in order to make the calculations easier. These assumptions are:

- Chilled glycol pipe will run vertical from chillers/ice tanks in mechanical room to about roof level
- Chilled glycol pipe will then run in a straight horizontal line to meet all AHU cooling coil loads.
- All AHUs are evenly spaced on roof.
- The distance between the AHU and the long run of pipe is negligible.
- Supply pipe distance is the same as return pipe distance.
- To take into account valves, fittings, etc, the total pipe length is doubled.

Using these assumptions, a general layout would look like **Figure IV-11**.

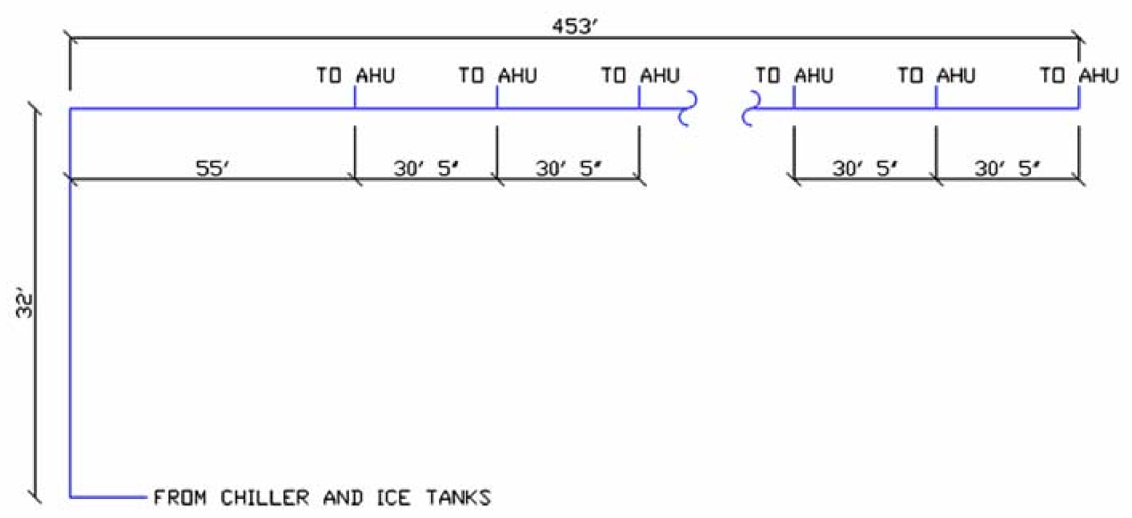

Figure IV-11 – Rough Piping Schematic

Flows to each AHU were already known from the coil calculations, and the pipe diameter was sized based on recommendations from Cool Tools (Taylor, 2000), a chiller design guide. The pipe diameters recommended by Cool Tools all keep the glycol velocity well under the 10 ft/s "rule of thumb" generally used.

Full pipe friction loss calculations are available in **Appendix IV-7**, and the summary of head loss values are tabulated in the next section, pumps.

The pipe loss calculations were performed using a Moody chart and the appropriate equations. (McQuiston 2000) Pipe roughness and glycol properties were taken from ASHRAE Fundamentals (2001).

b. Pumps

Pumps were selected using the online selection system on the Bell and Gossett website. All pumps are constant volume centrifugal base-mounted end-section. The criteria and resulting pump selection are given briefly in **Table IV-6**. More detailed information on each pump can be found in **Appendix IV-8**.

Table IV-6 - Pump Summary

Pump System	Flow (gpm)	Head (ft wg)	Unit Name	Motor Size (HP)
Chiller 1	400.0	15.7	1510 5BC	3
Chiller 2	400.0	15.7	1510 5BC	3
Chiller 3	400.0	15.7	1510 5BC	3
Load	1200.0	45.52	1510 5A	20
Ice Tank	731.5	13.25	1510 6BC	5
Condenser	1800.0	23.6	1510 8G	15

c. Cooling Towers

Marley NC class 2-speed cooling towers are being used in the simulation. Operational data was taken from the Marley Update software, and product information can be found in **Appendix IV-9**.

F. Summary of Results

After entering all of the aforementioned redesign values into the Trace energy simulation program, the results are summarized in **Table IV-7**.

Table IV-7 - Results of Mechanical Analysis

Scenario	On-Peak Demand (kw)	Total Consumption (kWh)	Consumption Shifted to TS Rate (kWh)	Yearly Operational Cost
Baseline	1,387	7,816,331	0	$ 738,209
Ice Storage	1,016	7,490,254	1,165,220	$ 634,207

A breakdown of redesign operational cost and energy usage by month can be found in **Appendix IV-10**. The redesign ends up saving about $104,000 a year, or 13.5% of the yearly operational cost.

Figure IV-12 shows the new design day cooling load profile. The dark blue bars are the load on the chillers, while the light blue bars represent the cooling load met by the ice tanks. Notice how a significant portion of the cooling load has been shifted to the off peak period.

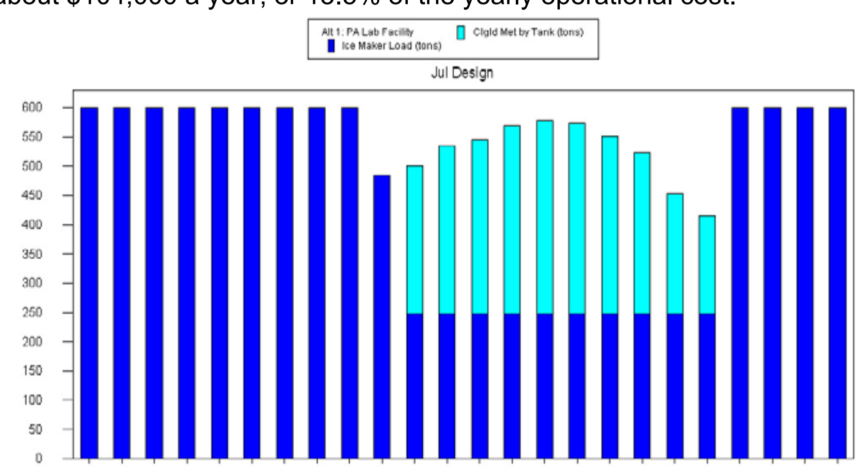

Figure IV-12 – Cooling Load After Ice Storage

G. Conclusion

The thrust of the redesign was to replace the building's existing cooling strategy (DX coils in packaged AHUs) with a chilled glycol system that incorporates ice-storage into its operation. The savings would be realized from 1) decreased peak demand 2) more efficient use of energy 3) specialty rate provided by PECO for energy consumed by off-peak cold thermal storage.

The results show that the redesign does save money and energy as intended. Even with the added energy use of the pumps and cooling, the chilled glycol/ice storage system saves $104,000 in operational cost per year.

V. Lighting Breadth Study

A. Introduction

This section presents the lighting breadth portion of the redesign. First, pertinent background information on the lighting system will be established. Then, the concept and goals of the redesign will be introduced. The results of preliminary studies will be discussed, and then the procedure for the redesign itself will be talked about. The results will be summarized, and the conclusion will be reached.

B. Background Information

The plan of this redesign is alter the lighting layout of room 123 in the administrative section (section 3) of the building (see **Figure V-1**). The room is an open office plan, about 50' long, 40' wide, and 9' high. With a building height of 31'4", this makes the plenum approximately 22' high.

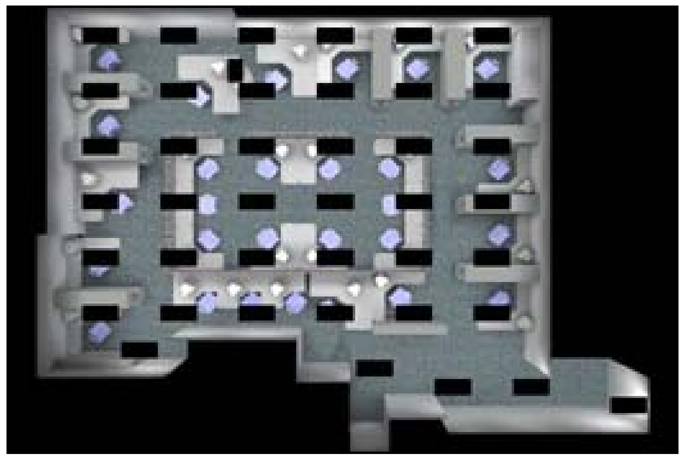

Figure V-1 – Room 123 Plan

The room is lit by forty parabolic three-lamp PM3N 2' x 4' Lithonia luminaries (see **Appendix V-1** for lighting manufacturer data). Thirty-eight of these consume about 88 watts of power, and the remaining two consume 140 watts.

During an ASHRAE 90 evaluation of the building, it was noticed that the room had a relatively high lighting power density of 1.8 W/ft^2. Additionally, the office has no source of outdoor light, which can make for a less pleasant working environment.

C. Concept and Goals

The thrust of the redesign is to daylight room 123 (an open office plan space) using skylights. The redesign must provide adequate, uniform lighting of 50 foot-candles on work surfaces, which is IESNA Handbook recommended illuminance for open office plans. The redesign must also be cost effective.

Additionally, if day-lighting the space proves infeasible, the high-energy usage lights will simply be replaced with other, more energy efficient luminaries. This design, as well, must provide adequate, uniform lighting.

D. Preliminary Studies

1. Baseline Case - Lithonia's Photometric Viewer

To get a quick idea of how the space is lit, Lithonia's Photometric Viewer was utilized. This utility has a Room Estimator, which enables one to calculate either the illuminance on the work plane given a number of evenly distributed luminaries, or the number of luminaires needed to get a given illuminance.

The IES file for the fixture, a 3-lamp parabolic fluorescent luminaire, was found on the Lithonia website (**Appendix V-1**).

The space was entered as a box of 40' by 50' by 9', with a work plane height of 2.5'. The main grid portion of six by six luminaires was entered as the number of luminaires in the space. The result of these simple calculations was an illuminance of 91 foot-candles on the work plane, clearly above IESNA recommendations of 50 foot-candles.

The next step was a more detailed study using AGI32 lighting software.

2. Baseline Case – AGI Lighting Software

AGI32 v1.66 software can be used to simulate and visualize the effects of a lighting design on a space. In this case, it was used to investigate the work plane illuminance and general lighting uniformity of the existing design.

The existing lighting layout and room geometry were entered into AGI32, and the surface reflectances were entered based on the reasons listed in **Table V-1**.

Table V-1		
Surface	**Reflectance**	**Reason**
Ceiling	0.81	Tile Data
Floor	0.20	IESNA
Wall	0.62	IESNA
Cubical Wall	0.38	Assumed
Furniture	varies	AGI values

The light loss factor was then calculated using the equation built into the AGI32 software.

$$Total\ LLF = LLD \times LDD \times BF$$

Lamp Lumen Depreciation was taken as 0.88 from IESNA estimations for fluorescent lamps. Luminaire Dirt Depreciation was calculated from the appropriate figure in the IESNA handbook. The fixtures are category IV: opaque unapertured top and a louvered bottom. Since this is a laboratory facility, cleaning was taken to be fairly rigorous. The room was designated "C" and cleaned every nine months, yielding an LDD of 0.92. Along with a ballast factor of 0.95, this yields an LLF of 0.769.

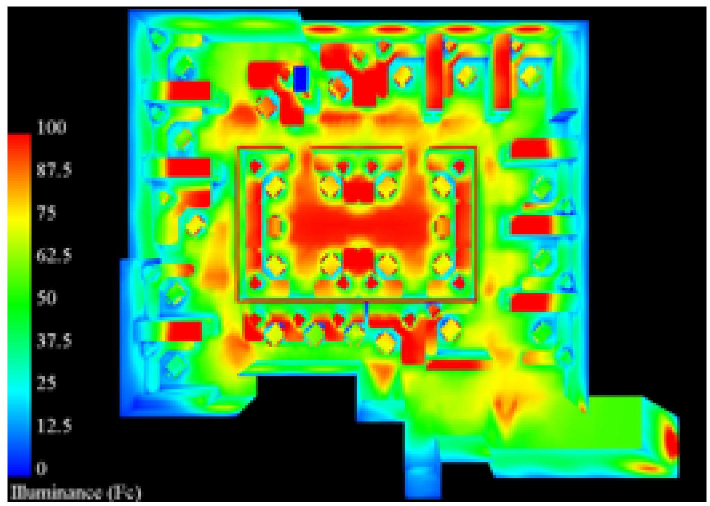

Figure V-2 – Illuminance Distribution

The model was then run to a convergence of 0.01 with a minimum element area of 0.3 ft^2 and a element luminance threshold of 1.3 (day-lighting simulations were run to a convergence of 0.001).

The output is presented in **Figure V-2**. As one can see, the illuminance values on the desks are well above IESNA recommendations, reaching 100 foot-candles on many desks. Additionally, **Figure V-3** shows that the light incident on the Visual Display Terminals (VDTs) is also quite high (50 foot-candles, the amounted recommended by IESNA for a working area, not a VDT), possibly indicating a high glare. A larger version of these and more pictures of the baseline case is available in **Appendix V-2**.

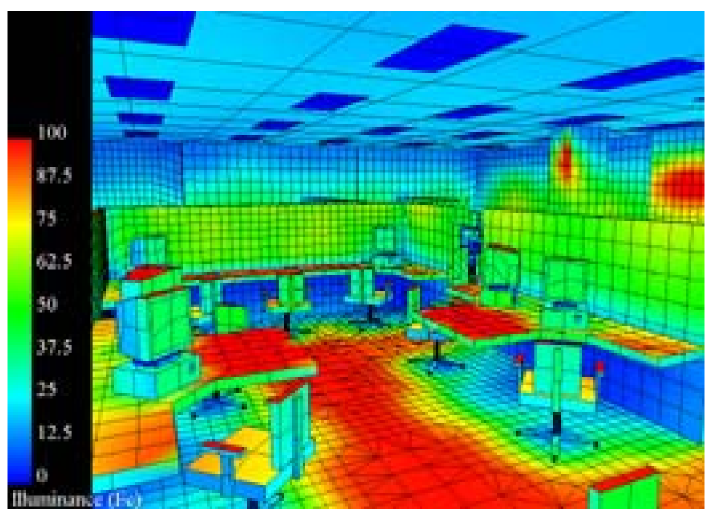

Figure V-3 – VDT Illuminance (center of room)

Based on these results, it becomes more apparent that a lighting redesign could benefit this space.

E-1. Design Procedure: Daylighting

The area of skylighted ceiling was based on 5% of the room area, giving an approximate total of:

$$50\,ft \times 40\,ft \times 5\% = 100\,ft^2$$

This works out to about six skylights of 4' by 4', yielding 96 ft^2 of skylight.

Since the ceiling plenum is so large, skylights with splayed wells were chosen instead of ones with straight walls. These have an increased efficiency over conventional straight wells. A schematic cross-section of the resulting design can be seen in **Appendix V-3**, as well as a 3D CAD view. The wells are 8' by 8' at bottom. They were given a reflectance of 0.81 (to match the ceiling) and the skylights themselves were given a transparency of 0.85.

Luminaires were selected from the Lithonia website; their data sheets can be found in **Appendix V-1**. They are 2'x4' two lamp and 2'x2' three lamp parabolic luminaires designed for use with VDTs. They were arranged in a layout (see **Figure V-4**) that approximated the uniformity of the original design.

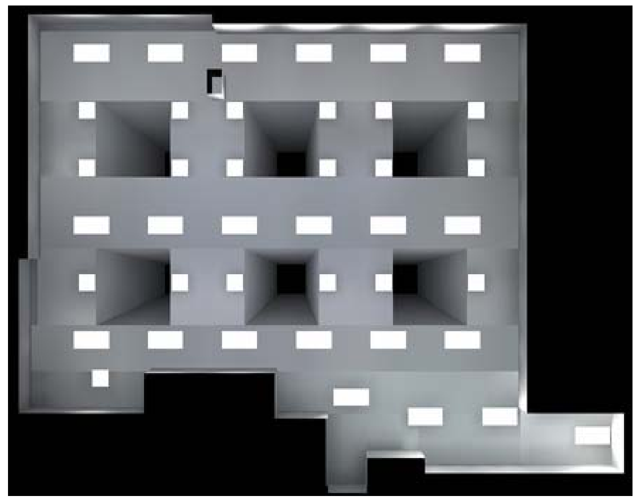

Figure V-4 – Reflected Ceiling Plan

The smaller 2'x2' luminaires that frame the skylight wells would be used when day-lighting the space is not an option, and the large 2'x4' luminaires would be on during all occupied periods.

The next step in the design would be to run the day-lighting analysis at the approximate "worst case" scenario: June 21 at 12:00pm.

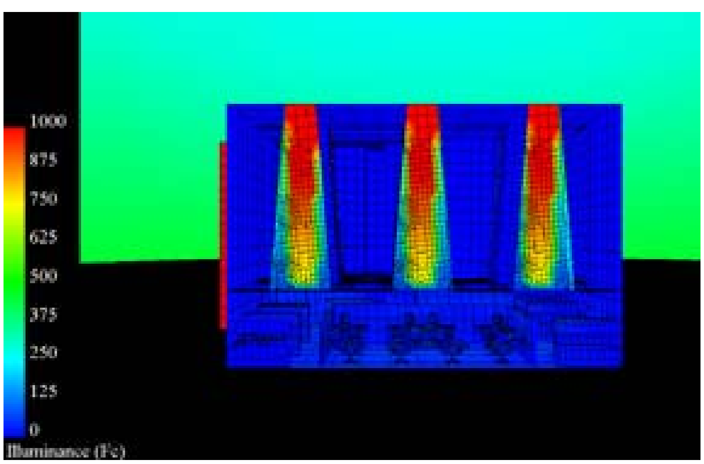

Figure V-5 – Over-Lit North Well Walls

With the smaller luminaires off, the day-lighting scheme drastically over-lit the space, so the transparency was changed to 0.45. This helped a slightly, but there were still "hot spots" on some of the desks. Upon close analysis of the model, it was found that the north walls of the skylights were getting a large amount of sun that was (because of the solar angle) traveling too deep into the well, and thereby causing hotspots. The "hot" skylights are shown in **Figure V-5**.

To remedy this problem, the reflectance of all the north well walls was changed to 0.45. The resulting illuminance on the wells can be seen in **Figure V-6**. It is significantly reduced.

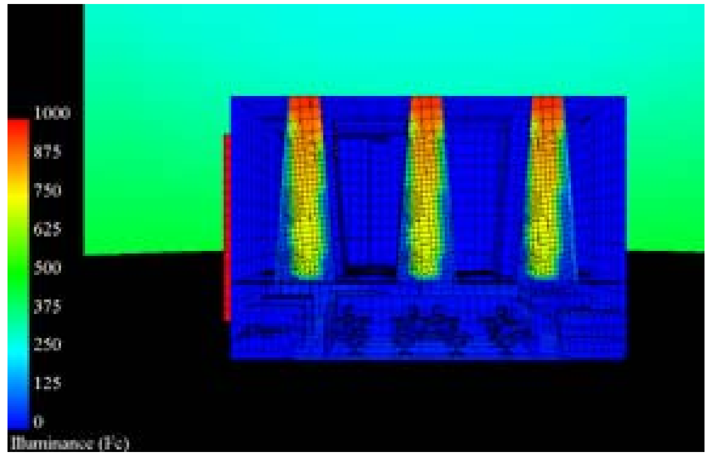

Figure V-6 – Fixed North Well Walls

After making these changes, the light distribution on June 21 at 12:00pm is represented in **Figure V-7**. The illuminance on the desks is fairly uniform, and provides adequate light. There are some darker spots over by the walls, but it is assumed that task lighting will be available through the cubicle system.

However, further analysis and a quick reality check threw some doubt onto the feasibility of the day-lighting system.

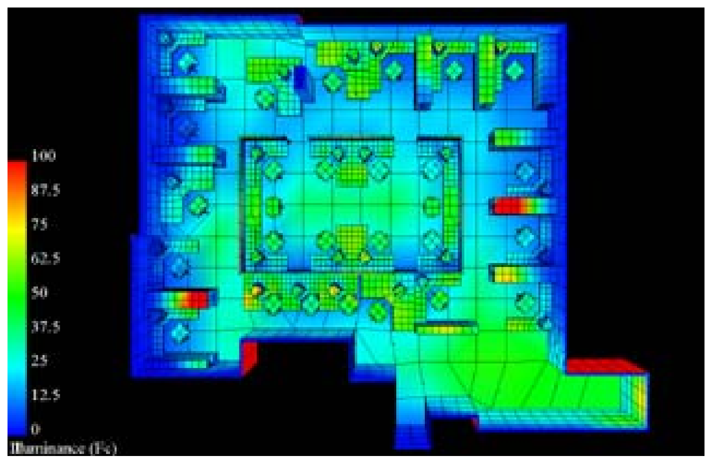

Figure V-7 – June 21 at 12:00pm

It was found that day-lighting would not adequately light the space on June 21 until approximately 11:00am, and would stop providing sufficient light at about 2pm.

At this point, a quick reality check was done to get a quick estimate of possible savings per year. The MS Excel spreadsheet is in **Appendix V-4**.

This estimate made the following assumptions:

- Day-lighting is available 6 hours out of every day.
- Day-lighting is available to provide savings on clear and partly cloudy weekdays, as defined by **Appendix V-5**.
- Energy is $0.04 per kWh. The value used is from the last block of the PECO Utility Tariff (see **Appendix IV-3**) because the high energy use of the facility will go through the more expensive blocks.

Under these assumptions, the yearly energy costs of the two designs are:

Baseline: $412.76
Daylighting: $318.43
Savings/year: $94.33

Given the unlikelihood that saving $94.33 per year would justify the construction of six 22' skylights, the day-lighting plan was abandoned, and a second option was looked at.

E-2. Design Procedure: Luminaire Replacement

The second option is simple: replace the existing luminaires with ones that provide a more uniform light distribution and lower illuminance. Given the success of the 2’x4’ VDT luminaires in providing an even light distribution, they were chosen as the replacement for the luminaires in the original lighting plan. The resulting illuminance values can be seen in **Figure V-8**.

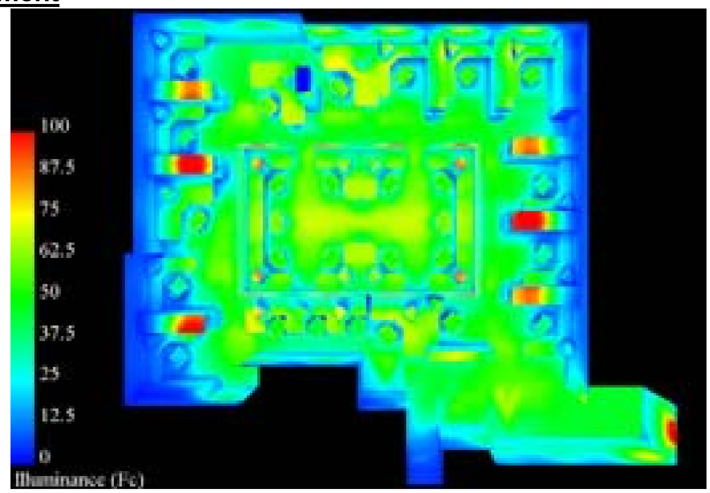

Figure V-8 – Illuminance Values

The luminaires are able to provide a very uniform distribution on almost the entire desk surface. Once again, there is a slight problem with the edges, but that can be solved by the task lighting that comes with many cubicle systems.

Figure V-9 shows the light incident upon the VDTs. It is significantly lower than the surroundings (about 25 foot-candles), reducing glare on the screens.

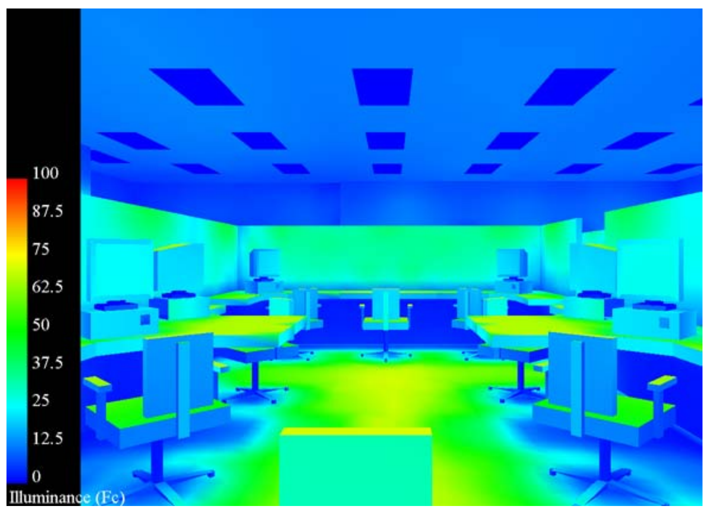

Figure V-9 – VDT Illuminance Values

Additionally, the luminaires consume 77W of power as opposed to the original 88W of power. This presents some small opportunity for cost savings, which will be calculated in the construction management section.

F. Summary of Results

The day-lighting design was initially tuned to work perfectly under the “worst case” conditions of 12:00pm on June 21. However, this design did not supply enough hours of day-lighting to be feasible. The savings under optimum conditions would be less than $100 a year, and a more detailed analysis would provide only less savings. This would seem to be a relatively small amount of savings compared to the effort and cost of installing six 22’ skylights in the office.

Replacing the existing parabolic luminaires with ones tuned to VDT gave a more even illuminance distribution at the desired value. This kind of uniformity can contribute to worker comfort with the space, and increase productivity. Additionally, the new luminaires consume 77W per luminaire compared to the 88W of the existing design.

G. Conclusion

Upon analysis, the original space seemed to be over-lit, which may reduce the comfort and productivity of the workers in it. Two different redesigns were looked at. The first was a day-lighting scheme that used splayed skylights in an attempt to provide a relatively uniform illuminance on the desks of works. The second (to be used if the day-lighting scheme proved not feasible) would simply replace existing luminaires with specialty ones made for VDT use.

The day-lighting redesign is not feasible, given the large effort for small savings and relatively little amount of time where day-lighting is available. It is not recommended. However, replacing the luminaires gave a more uniform illuminance pattern on the work plane at a lower energy consumption, and should be considered if the price difference is not too high.

VI. Breadth – Construction Management

A. Introduction

This section presents the construction breadth portion of the redesign. First, pertinent background information on the construction will be established. Then, the concept and goals of the redesign will be introduced. The methodology and results of preliminary studies will be discussed, and then the procedure for the redesign itself will be talked about. The results will be summarized, and a conclusion will be reached.

B. Background Information

Not a lot of information was available on the construction side of the project.

The entire project was driven by first cost considerations, as the client wanted the facility up and running in order for it to start making money. Operational cost was deemed a low concern, as utility costs could be passed on to clients.

As mentioned earlier, the project takes place on a large commercial campus, and there is ample room around the site for maneuvering equipment, cranes, etc.

C. Concept and Goals

This breadth options is composed of smaller reality checks and pricing calculations. It attempts to tie in the mechanical and lighting redesigns with factors such as site layout and equipment pricing. The goals for success are as follows:

1. The site has enough extra space to hold the required mechanical equipment
2. The mechanical system can pay for itself in 3 to 5 years using a simple payback calculation.
3. The lighting redesign will pay for itself in 3 to 5 years.

The lighting payback was not lumped in with the mechanical payback because of the very large differences in affect on yearly operational cost. The energy savings associated with the lighting redesign are most likely <<1% of the mechanical redesign savings.

D. Preliminary Studies

A large amount of preliminary research was not necessary for the redesign. Manufacturer data was consulted for product dimensions, and vendors were contacted in order to get accurate installation pricing, when possible. When vendors were not able to provide the necessary information, the publication RS Means Mechanical Cost Data (2003) was consulted.

E. Design Procedure

1. Site Layout Check

This section simply seeks to perform a few reality checks to make sure that the proposed mechanical redesign is feasible in the context of the site. The lighting redesign is not influenced by site considerations at all, so this section will not address it.

Figure VI-1 presents a view of the site. As one can see, there is a lot of space built around the main structure, one of the benefits of having a large campus to develop.

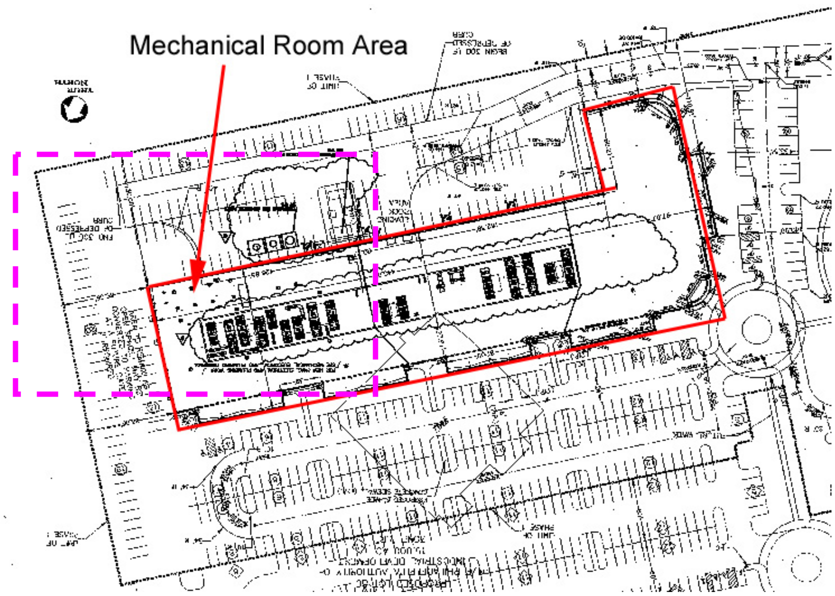

Figure VI-1 – Site Plan

Maneuvering equipment (i.e. trucks, cranes) around the site should not be a problem at all.

A closer look at the area outside of the mechanical room is presented in **Figure VI-2**.

As one can see on the note in the figure, a good portion of the area behind the building is not earmarked for anything. Some mechanical equipment is already set for placement out there. The mention of "possible future parking" is brought up, but the more immediate use of this open space to accommodate both the ice tanks and any required expansion to the mechanical room is quite feasible.

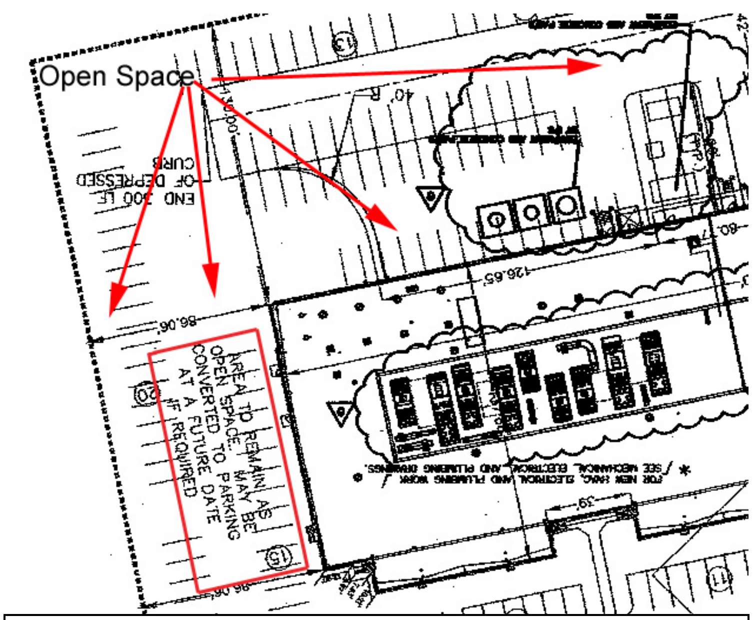

Figure VI-2 – Outside the Mechanical Room

In **Figure VI-3**, one can see the proposed placement of both the cooling tower and the ice tanks on the site. There is ample room for both.

Dimensional data on both the Calmac ice tanks and the Marley cooling tower was taken from CAD files from their respective manufacturers.

Figure VI-3 – Ice Tank and Tower Positions

2. Mechanical System Payback

Mechanical system payback will be calculated taking into account the time value of money. The assumed interest rate of 6% used will be corrected for the inflation rate of August 2003, 2.16% (www.inflationdata.com, 2004). The following correction equation is from Lindeburg (2001), where *i* is the interest rate, and *e* is inflation rate.

$$i' = i + e + ie = .06 + .0216 + .06 \times .0216 = .0829$$

Pricing used for the calculations are outlined in **Table VI-1**. RS Means values were corrected for location using the materials and installation correction factors located in the publication. A more detailed look at some of the calculations for pricing is available in **Appendix VI-1**.

Operational costs were calculated using Trace, and the equipment costs were directly from vendors.

The general purpose pumps in RS means are based on a flow rate, motor HP and 100' of head. Since those numbers did not necessarily meet the pumps that were chosen, pricing was done on the basis of motor size.

Table VI-1 - Price Summary		
Baseline		
Item	Cost	Source
Electrical/year	$ 726,501	Simulation
Gas/year	$ 11,708	Simulation
Redesign		
Item	Cost	Source
Electrical/year	$ 621,266	Simulation
Gas/year	$ 12,941	Simulation
3xYork Chillers	$ 303,000	York Rep
7xIce Tanks	$ 328,020	Calmac Rep
Pump	$ 16,776	RS Means 2003
Cooling Tower	$ 34,137	RS Means 2003
Piping	$ 84,305	RS Means 2003
Piping Insulation	$ 30,805	RS Means 2003

The cooling towers are calculated on a per ton basis, so the calculation is fairly straightforward.

Steel pipe pricing is by length, and includes couplings and hangers. Additionally, the elevation factor in RS Means was used to take into account the amount of piping installed near roof level.

Piping insulation was taken as cellular glass because of the "0 water transmission" characteristic. When dealing with glycol flowing at ~22°F, it is *crucial* that moisture does not easily reach the pipes, or else the insulation could take serious moisture damage. This could lead to a degradation of system performance and eventual leaks.

Payback time is considered to be the time (in years) at which both options have the same net present worth. The following equation (Lindeburg, 2001) is used to correct the yearly utility payments to a net present worth.

$$Annual\ to\ Present = \frac{(1+i')^n - 1}{i'(1+i')^n}$$

i' is the interest rate corrected for inflation, and *n* is the number of years. The payback equation was set up as follows:

$$C_{Base,yearly} \times AtoP = C_{Redesign} + C_{Redesign,yearly} \times AtoP$$

This equation was solved iteratively to yield the information in **Table VI-2**.

The analysis shows that it will take about 11.85 years for the two scenarios to reach equivalence.

Table VI-2 - Payback Time

n	**11.85**	
i'	0.0829	
$C_{B,Y}$	AtoP	Total
$ 738,209	7.37	$ 5,704,706
$C_{R,Y}$	AtoP	Total
$ 634,207	7.37	$ 4,901,000
$C_{R,F}$	AtoP	Total
$ 803,738	1	$ 766,238
	Total	**$ 5,704,000**

$C_{B,Y}$ = Cost, Baseline, Yearly
$C_{R,Y}$ = Cost, Redesign, Yearly
$C_{R,F}$ = Cost, Redesign, First
AtoP = Annual Cost to Present Cost Factor
i' = interest rate corrected for inflation
n = payback period (years)

3. Lighting Design Payback

Lighting payback was not based on day-lighting, which was discarded as too costly in the middle stages of the lighting analysis. It is being replaced by a fixture change-out.

Approximate pricing information from Columbia Lighting was obtained. The price breakdown is illustrated in **Table VI-3.**

Table VI-3 - Lighting First Cost			
Fixture	Number of Fixtures	Price per Fixture	**Total First Cost**
Existing – 2x4 Fluorescent Parabolic	41	$ 72.00	**$2,952.00**
Redesign – 2x4 Fluorescent VDT Parabolic	41	$ 98.00	**$4,018.00**

The lighting operational cost was done using simple calculations as illustrated in **Table VI-4**.

Table VI-4 - Lighting Operational Cost							
Fixture	Number of Fixtures	Power/ fixture (W)	kW	Operational Hours/year	kWh	$/kWh	**Operational Cost/year**
Existing – 2x4 Fluorescent Parabolic	41	88	3.61	2607	9407	$0.041	**$ 385.67**
Redesign – 2x4 Fluorescent VDT Parabolic	41	77	3.16	2607	8231	$0.041	**$ 337.46**

If we do a simple payback calculation using the following equation:

$$C_{First,Baselin} + t \times C_{Op,Baseline} = C_{First,\mathrm{Re}\,design} + t \times C_{Op,\mathrm{Re}\,design}$$

where *t* is the payback period in years, the lighting pays for itself in 21 years.

However, when making a decision on the applicability of the redesign, one must still take into account factors such as worker productivity resulting from a more pleasant, less harshly lit lighting environment.

F. Summary of Results

A simple check of the site layout shows that there is ample room for a possible mechanical room expansion and the placement of the ice tanks. The equivalent-cost payback analysis of the mechanical redesign showed a payback period of almost 12 years. The equivalent-cost payback analysis of the lighting redesign showed a payback period of 17 years.

It must be noted that there are other factors that may be added in to the mechanical analysis, i.e. cost of extra mechanical room space, cost to bury the ice tanks, but they were not taken into consideration. If the mechanical redesign had looked like it was going to payback in the allotted time, then those extra factors would have been considered.

G. Conclusion

The purpose of this breadth was to do a quick check on the site layout, and then make the final payback calculations on the mechanical and lighting redesigns.

The site layout looks fine, as there is ample room built in for expansion. The ice tanks and cooling tower fit in with the existing equipment. The mechanical payback calculations resulted in a payback of almost 12 years, clearly more than the 3 to 5 year goal. The lighting design showed a payback period of about 21 years, also clearly more than the 3 to 5 year goal.

The mechanical redesign can not be recommended, as it would be too hard to convince a client already driven by first cost to take a look at longer term savings. 3 to 5 years may not have been possible, but 12 is out of the question.

The lighting redesign is still recommended, as there are other benefits to the layout. Namely, a space with less harsh lighting can be a more productive space to work in. Even though the payback time is large, the first cost of the redesign is <<1% of other building systems.

VII. Summary

A. Background

The building being studied is a biological clean room facility in eastern Pennsylvania. It has class 10,000 and 100,000 clean room space, non-clean lab and storage space, and administrative/office space. The existing mechanical systems are fifteen packaged rooftop air handling units, fourteen of which are included in this study. Of those fourteen, one is a VAV system serving the administrative and office spaces, and the remaining thirteen are constant volume systems.

B. Mechanical Breadth

Thermal conditioning is performed by 15 packaged rooftop units and terminal reheat via electric duct heaters. The existing mechanical system performs space cooling by direct expansion coils that come with the prepackaged air handling units. While this system, has a low first cost, it may be possible to reduce the operating cost with a more efficient system.

The concept is to use a system of chillers and demand limiting partial ice storage in order to reduce the operating cost of the building. This system would shift a portion of the cooling load to the night hours, where utility costs are lower.

The baseline condition had an HVAC operating cost of about $738,000, while the redesign had an operating cost of approximately $634,000. Almost $100,000 a year in savings was realized with the redesign, which successfully saved energy and money.

C. Lighting Breadth

The building has a few open office plan areas. The lighting of one of these spaces was looked at in this analysis, and was found to have a quite high illuminance (about 100 foot-candles, vs. the IESNA recommended 50 foot-candles for open office space) on the desk areas, and about 50 foot-candles on the visual display terminals.

The redesign sought to develop a utilitarian skylighting layout that would end up saving operational cost. However, it turned out that a design that was able to keep the illuminance of day-lighting within the recommended IESNA limits has a very limited window of operation. Upon finding this out, a quick calculation was run, and it was concluded that the day-lighting redesign would only save about $94 per year at most, which is not enough to justify building six skylights into a 22’ plenum.

Instead, one of the VDT-compatible luminaires from the day-lighting scheme was used to replace the existing fixtures, and this provided a uniform illuminance of approximately 50 foot-candles on almost all of the desk space. Additionally, the new fixtures consume a little less power.

D. Construction Management Breadth

The construction management section is meant to do a quick check of the site layout, a equivalent cost analysis for the mechanical redesign, and a simple payback analysis for the lighting redesign. The goal is to get the last two items to pay back within 3 to 5 years.

The site was found to have enough space to support expansion of the mechanical room, layout of ice tanks, etc. The fact that the facility was built on a large, existing campus helped contribute to the amount of extra space.

The mechanical redesign pays back in about 12 years, using cost data from both vendors and RS Means. The lighting redesign pay back in about 20 years, using cost data from vendors.

VIII. Conclusion

The goal of the mechanical redesign was to replace the existing DX coil conditioned air with a chiller and ice storage system. The strategy was to shift a portion of the cooling load to the night hours using demand limiting partial ice storage. This would save both energy and money.

The mechanical redesign ends up saving approximately $104,000 per year (14%) in operating costs, and about 40,000 kWh (5.4%) per year. Initially, this is successful redesign, but it must be put in the context of the costs for the additional equipment.

The goal of the lighting redesign was to change the lighting strategy for an over-lit open office space. Six splayed well skylights were to be installed in the 22' plenum, and used to cut energy costs and establish a more pleasing atmosphere.

However, the amount of time where this day-lighting scheme would fulfill the utilitarian lighting requirements of an office space is small, and would only save about $94 per year, hardly enough to justify the amount of additional construction required for six skylights. Instead, lower power luminaires made for use with VDTs were installed in place of the existing luminaires, and were able to successfully save energy and provide a lower, more uniform illuminance.

The goal of the construction redesign was to do a quick check of the site layout, compute the payback period for the mechanical redesign (taking into account the time value of money), and perform a simple payback on the lighting system. The goal for the payback periods was 3 to 5 years. The results of these analyses would provide the final criteria used to evaluate the feasibility of the mechanical and lighting redesigns.

The site was found to easily support the extra space requirements (i.e. the ice tanks for thermal storage) for the redesign. The fact that the facility is located on a large existing campus makes space a minor issue.

The mechanical redesign was found to reach equivalence with the existing design in approximately 12 years (given an interest rate of 6% and an inflation rate of 2.16%). This is clearly above the goal for payback, and the redesign cannot be recommended.

The lighting redesign has a payback period of about 20 years, but there is another factor to take into consideration. The improved illuminance and lighting distribution in the space could have a beneficial impact on the attitude and efficiency of the workers in that space. Given that, and the low relative cost to the other building systems, the lighting redesign of VDT friendly luminaires is recommended.

IX. Works Cited

Note: information gleaned from computer selection programs is cited in the appropriate section in the main text.

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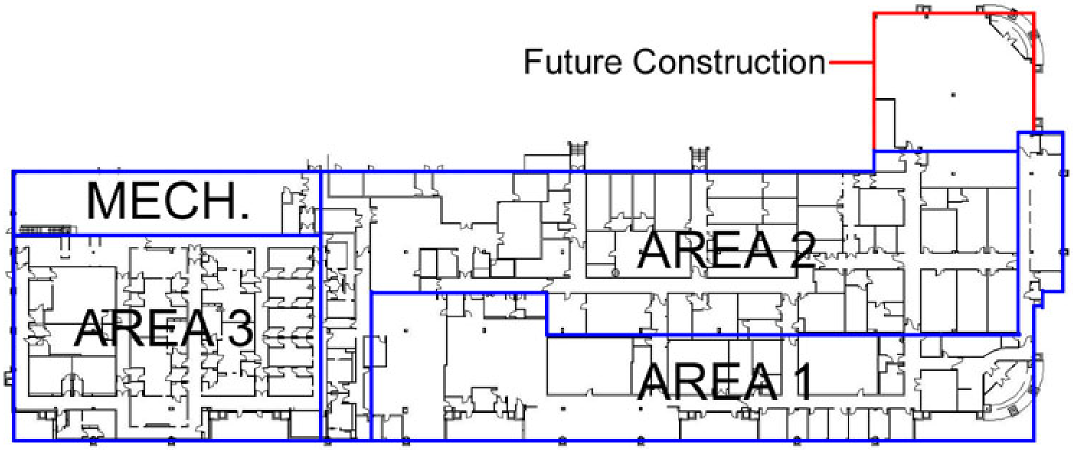
Appendix III-1



- Area 1 – Administrative and Office Space
- Area 2 – Dirty (i.e. not clean room grade) laboratory and storage space
- Area 3 – Class 100,000 and Class 10,000 clean room space
- Mech – Mechanical Room

Number	System/Serving	Supply Air Fan											Minimum Outside Air-cfm
		Number	cfm	SP Inches H_2O		Fan Type	Class	Fan RPM	Max OV FPM	Motor			
				TSP	ESP					HP	RPM	V-PH-Hz	
AHU-1	Area 1	SF-1-1	9,890	4.41	3.00	AF DWDI	11	2281	1978	20.0	1800	460-3-60	1000
AHU-2	Area 2	SF-2-1	12,730	3.60	3.00	AF DWDI	11	867	759	20.0	1800	460-3-60	12730
AHU-3	Area 3	SF-3-1	7,460	3.88	3.00	AF DWDI	11	1337	974	15.0	1800	460-3-60	4740
AHU-4	Area 4	SF-4-1	7,340	3.76	3.00	AF DWDI	11	1317	958	15.0	1800	460-3-60	4170
AHU-5	Area 5	SF-5-1	4,200	3.49	3.00	AF DWDI	11	1576	840	7.5	1800	460-3-60	1600
AHU-6	Area 6	SF-6-1	4,120	3.48	3.00	AF DWDI	11	1570	824	7.5	1800	460-3-60	1600
AHU-7	Area 7	SF-7-1	11,500	3.84	3.00	AF DWDI	11	893	834	20.0	1800	460-3-60	11500
AHU-8	Area 8	SF-8-1	17,330	4.50	3.00	AF DWDI	11	1264	1539	20.0	1800	460-3-60	4000
AHU-9	Area 9	SF-9-1	7,930	3.84	3.00	AF DWDI	11	1969	1586	15.0	1800	460-3-60	2000
AHU-10	Area 10	SF-10-1	24,700	5.51	2.00	AF DWDI	11	1534	2194	40.0	1800	460-3-60	4680
AHU-11	Area 11	SF-11-1	8,530	4.28	2.00	AF DWDI	11	1437	1281	10.0	1800	460-3-60	5060
AHU-12	Area 12	SF-12-1	24,480	6.36	3.50	AF DWDI	11	1201	1600	40.0	1800	460-3-60	8250
AHU-13	Area 13	SF-13-1	17,900	6.07	3.50	AF DWDI	11	1446	1686	30.0	1800	460-3-60	5960
AHU-14	Area 14	SF-14-1	3,890	2.65	2.00	AF DWDI	11	1388	788	5.0	1800	460-3-60	3890

Number	# of circuits	Refrigerant		Ambient Air °F on	Condenser Fan			Compressor					Crankcase Heater	Control Circuit Voltage
		Type	Suct Temp		Quant	HP Each	FLA Each	kW	RLA Each	LRA Each	Quantity	V-PH-Hz		
AHU-1	2	R-22	-	95	3	1.0	2.0	29.4	-	-	3	460-3-60	yes	120-1-60
AHU-2	2	R-22	-	95	9	1.0	2.0	98.2	39	214	4	460-3-60	yes	120-1-60
AHU-3	2	R-22	-	95	4	1.0	2.0	40	17	127	4	460-3-60	yes	120-1-60
AHU-4	2	R-22	-	95	4	1.0	2.0	39.6	17	127	4	460-3-60	yes	120-1-60
AHU-5	2	R-22	-	95	2	1.0	2.0	16.4	-	-	2	460-3-60	yes	120-1-60
AHU-6	2	R-22	-	95	2	1.0	2.0	16.4	-	-	2	460-3-60	yes	120-1-60
AHU-7	2	R-22	-	95	8	1.0	2.0	89	71	297	2	460-3-60	yes	120-1-60
AHU-8	2	R-22	-	95	6	1.0	2.0	62.1	17	127	6	460-3-60	yes	120-1-60
AHU-9	2	R-22	-	95	3	1.0	2.0	28.8	-	-	3	460-3-60	yes	120-1-60
AHU-10	2	R-22	-	95	6	1.0	2.0	63.9	17	127	6	460-3-60	yes	120-1-60
AHU-11	2	R-22	-	95	4	1.0	2.0	32.2	-	-	4	460-3-60	yes	120-1-60
AHU-12	2	R-22	-	95	9	1.0	2.0	99.2	39	214	4	460-3-60	yes	120-1-60
AHU-13	2	R-22	-	95	6	1.0	2.0	63.2	17	127	6	460-3-60	yes	120-1-60
AHU-14	2	R-22	-	95	2	1.0	2.0	23.4	-	-	2	460-3-60	yes	120-1-60

Number	Cooling Coil												
	Number	Max Face Velocity	Number of Coils	Rows	Fins/in	E.A.T. °F		L.A.T. °F		Mbtu/h		PD (wet) in. H_2O	Type
						DB	WB	DB	WB	Total	Sensible		
AHU-1	CC-1-1	366	1	5	12	71.5	59.8	47.0	47.0	336.0	265.1	0.49	DX
AHU-2	CC-2-1	209	1	5	12	93.0	75.0	48.3	48.3	1092.1	622.5	0.23	DX
AHU-3	CC-3-1	276	1	4	10	84.9	67.4	46.9	46.9	443.8	309.6	0.22	DX
AHU-4	CC-4-1	271	1	3	10	83.2	67.0	47.2	46.8	426.5	288.9	0.16	DX
AHU-5	CC-5-1	227	1	5	12	78.5	65.0	47.3	47.3	210.1	143.3	0.25	DX
AHU-6	CC-6-1	223	1	5	12	78.7	65.4	47.4	47.4	210.6	141.0	0.24	DX
AHU-7	CC-7-1	213	1	5	12	93.0	75.0	49.0	49.0	965.7	553.0	0.23	DX
AHU-8	CC-8-1	439	1	5	12	74.8	62.0	47.1	47.1	705.8	524.5	0.66	DX
AHU-9	CC-9-1	293	1	4	8	75.3	61.6	47.2	46.8	316.8	243.4	0.20	DX
AHU-10	CC-10-1	525	1	5	12	78.0	65.0	54.3	54.2	803.7	639.4	0.84	DX
AHU-11	CC-11-1	363	1	4	10	78.0	65.0	51.0	50.7	407.6	289.8	0.33	DX
AHU-12	CC-12-1	442	1	5	12	78.0	65.0	50.8	50.7	1116.4	797.9	0.67	DX
AHU-13	CC-13-1	403	1	5	12	78.0	65.0	51.2	51.1	770.5	556.5	0.58	DX
AHU-14	CC-14-1	213	1	5	12	93.0	75.0	53.1	53.1	289.9	172.0	0.23	DX

Number	Heating - Natural Gas								Stages
	Number	Type	Air °F		PD in. H_2O	Natural Gas			
			E.A.T.	L.A.T.		BTUH Input	BTUH Output	Gas Press in. H_2O	
AHU-1	PH-1-1	-	-	-	-	-	-	-	-
AHU-2	PH-2-1	Preheat	0.0	57.7	0.08	1000	800	6.5	20
AHU-3	PH-3-1	Preheat	24.8	55.5	0.07	315	250	5.5	20
AHU-4	PH-4-1	Preheat	29.4	54.4	0.03	250	200	4.5	20
AHU-5	PH-5-1	Preheat	42.1	85.8	0.01	250	200	4.5	20
AHU-6	PH-6-1	Preheat	41.6	86.1	0.01	250	200	4.5	20
AHU-7	PH-7-1	Preheat	0.0	51.9	0.36	800	640	7	20
AHU-8	PH-8-1	-	-	-	-	-	-	-	-
AHU-9	PH-9-1	-	-	-	-	-	-	-	-
AHU-10	PH-10-1	Preheat	50.0	79.7	0.30	100	800	6.5	20
AHU-11	PH-11-1	Preheat	50.0	79.7	0.30	500	400	5	20
AHU-12	PH-12-1	Preheat	50.0	87.4	0.35	1375	1100	5	20
AHU-13	PH-13-1	Preheat	50.0	88.7	0.18	1000	800	6.5	20
AHU-14	PH-14-1	Preheat	0.0	58.2	0.06	315	250	5.5	20

Number	Filters					Filters					Vibration Isolation		Basis Of Design
	Number	Type	Average Eff % (ASHRAE)	PD in. H_2O		Number	Type	Average Eff % (ASHRAE)	PD in. H_2O				
				Initial	Final				Initial	Final	Type	Defl in inches	
AHU-1	F-1-1	Cartridge	30	0.22	0.44	F-1-2	Bag	95	0.49	0.98	Spring	2	McQuay Model RPS030C
AHU-2	F-2-1	Cartridge	30	0.10	0.20	F-2-2	Bag	95	0.19	0.38	Spring	2	McQuay Model RPS105C
AHU-3	F-3-1	Cartridge	30	0.15	0.30	F-3-2	Bag	95	0.30	0.60	Spring	2	McQuay Model RPS040C
AHU-4	F-4-1	Cartridge	30	0.15	0.30	F-4-2	Bag	95	0.30	0.60	Spring	2	McQuay Model RPS040C
AHU-5	F-5-1	Cartridge	30	0.07	0.14	F-5-2	Bag	95	0.12	0.24	Spring	2	McQuay Model RPS018C
AHU-6	F-6-1	Cartridge	30	0.07	0.14	F-6-2	Bag	95	0.12	0.24	Spring	2	McQuay Model RPS018C
AHU-7	F-7-1	Cartridge	30	0.05	0.10	F-7-2	Bag	95	0.25	0.50	Spring	2	McQuay Model RPS090C
AHU-8	F-8-1	Cartridge	30	0.19	0.38	F-8-2	Bag	95	0.55	1.10	Spring	2	McQuay Model RPS070C
AHU-9	F-9-1	Cartridge	30	0.15	0.30	F-9-2	Bag	95	0.35	0.70	Spring	2	McQuay Model RPS030C
AHU-10	F-10-1	Cartridge	30	0.24	0.48	F-10-2	Bag	95	0.72	1.44	Spring	2	McQuay Model RPS070C
AHU-11	F-11-1	Cartridge	30	0.19	0.38	F-11-2	Bag	95	0.49	0.98	Spring	2	McQuay Model RPS036C
AHU-12	F-12-1	Cartridge	30	0.14	0.28	F-12-2	Bag	95	0.72	1.44	Spring	2	McQuay Model RPS105C
AHU-13	F-13-1	Cartridge	30	0.30	0.60	F-13-2	Bag	95	0.55	1.10	Spring	2	McQuay Model RPS070C
AHU-14	F-14-1	Cartridge	30	0.06	0.12	F-14-2	Bag	95	0.12	0.24	Spring	2	McQuay Model RPS020C

System Checksums

By psuae

AHU 1 **Terminal Reheat**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 93 / 75 / 102

Clg Space Peak — Mo/Hr: 6 / 16; OADB: 92

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	3,660	3,660	1.60	0	0.00
Glass Solar	0	0	0	0.00	0	0.00
Glass Cond	0	0	0	0.00	0	0.00
Wall Cond	0	0	0	0.00	0	0.00
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	0	3,660	3,660	1.60	0	0.00
Internal Loads						
Lights	7,534	1,884	9,418	4.11	7,534	5.41
People	5,041		5,041	2.20	2,521	1.81
Misc	118,871	0	118,871	51.86	118,871	85.39
Sub Total ==>	131,446	1,884	133,330	58.17	128,926	92.61
Ceiling Load	5,543	-5,543	0	0.00	5,666	4.07
Ventilation Load	0	0	69,994	30.54	0	0.00
Ov/Undr Sizing	4,740		4,740	2.07	4,617	3.32
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			17,487	7.63		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	141,730	0	229,211	100.00	139,210	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1; OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-2,909	1.86
Glass Solar	0	0	0.00
Glass Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	0	0	0.00
Sub Total ==>	0	-2,910	1.86
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	59,436	59,436	-37.92
Sub Total ==>	59,436	59,436	-37.92
Ceiling Load	-2,909	0	0.00
Ventilation Load	0	-76,449	48.78
Ov/Undr Sizing	-56,560	-56,560	36.09
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		-80,247	51.20
Grand Total ==>	-34	-156,731	100.00

TEMPERATURES

	Cooling	Heating
SADB	49.3	68.0
Plenum	85.4	58.9
Return	68.0	68.0
Ret/OA	71.8	57.8
Fn MtrTD	0.2	0.0
Fn BldTD	0.5	0.0
Fn Frict	1.6	0.0

AIRFLOWS

	Cooling	Heating
Vent	1,008	1,008
Infil	0	0
Supply	6,691	6,691
MinStop/Rh	6,691	6,691
Return	6,691	6,691
Exhaust	1,008	1,008
Rm Exh	0	0
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	15.1	15.1
cfm/ft²	6.64	6.64
cfm/ton	350.32	
ft²/ton	52.78	
Btu/hr·ft²	227.35	-155.53
No. People	10	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	19.1	229.2	184.8	6,691	71.8	58.4	51.6	47.0	45.3	42.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	19.1	229.2								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	1,008		
Part	0		
ExFlr	0		
Roof	1,008	0	0
Wall	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-156.8	6,691	47.0	68.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	0	0.0	0.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-156.8			

System Checksums

By psuae

AHU 2 **Terminal Reheat**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 93 / 75 / 102

Clg Space Peak — Mo/Hr: 6 / 15; OADB: 92

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	6,932	6,932	0.72	0	0.00
Glass Solar	4,056	0	4,056	0.42	4,404	2.00
Glass Cond	2,203	0	2,203	0.23	2,159	0.98
Wall Cond	0	0	0	0.00	0	0.00
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	6,259	6,932	13,192	1.37	6,564	2.98
Internal Loads						
Lights	10,838	2,710	13,548	1.41	10,838	4.91
People	9,400		9,400	0.98	4,700	2.13
Misc	66,245	0	66,245	6.89	66,245	30.03
Sub Total ==>	86,483	2,710	89,193	9.27	81,783	37.07
Ceiling Load	9,642	-9,642	0	0.00	9,769	4.43
Ventilation Load	0	0	712,649	74.10	0	0.00
Ov/Undr Sizing	122,923		122,923	12.78	122,491	55.52
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			23,728	2.47		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	225,308	0	961,684	100.00	220,608	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1; OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-5,425	0.64
Glass Solar	0	0	0.00
Glass Cond	-6,308	-6,308	0.74
Wall Cond	0	-1	0.00
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	-1	-1	0.00
Sub Total ==>	-6,309	-11,735	1.39
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	33,123	33,123	-3.91
Sub Total ==>	33,123	33,123	-3.91
Ceiling Load	-5,426	0	0.00
Ventilation Load	0	-843,393	99.57
Ov/Undr Sizing	-25,014	-25,014	2.95
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	-3,627	-847,020	100.00

TEMPERATURES

	Cooling	Heating
SADB	50.2	68.3
Plenum	84.2	58.9
Return	84.2	58.9
Ret/OA	93.0	0.0
Fn MtrTD	0.2	0.0
Fn BldTD	0.4	0.0
Fn Frict	1.3	0.0

AIRFLOWS

	Cooling	Heating
Vent	11,123	11,123
Infil	0	0
Supply	11,123	11,123
MinStop/Rh	11,123	11,123
Return	0	0
Exhaust	0	0
Rm Exh	11,123	11,123
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	100.0	100.0
cfm/ft²	5.92	5.92
cfm/ton	138.79	
ft²/ton	23.46	
Btu/hr·ft²	511.53	-639.65
No. People	19	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	80.1	961.7	554.4	11,123	93.0	75.0	101.9	48.3	48.2	50.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	80.1	961.7								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	1,880		
Part	0		
ExFlr	0		
Roof	1,880	0	0
Wall	147	147	100

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-248.1	11,123	48.3	68.3
Aux Htg	0.0	0	0.0	0.0
Preheat	-599.1	11,123	0.0	48.3
Humidif	-355.4	11,123	1.1	46.7
Opt Vent	0.0	0	0.0	0.0
Total	-1,202.5			

System Checksums

By psuae

AHU 3 — **Terminal Reheat**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 93 / 75 / 102

Clg Space Peak — Mo/Hr: 6 / 16; OADB: 92

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	4,332	4,332	0.93	0	0.00
Glass Solar	0	0	0	0.00	0	0.00
Glass Cond	0	0	0	0.00	0	0.00
Wall Cond	0	0	0	0.00	0	0.00
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	0	4,332	4,332	0.93	0	0.00
Internal Loads						
Lights	7,018	1,755	8,773	1.89	7,018	5.13
People	5,885		5,885	1.27	2,943	2.15
Misc	71,520	0	71,520	15.39	71,520	52.29
Sub Total ==>	84,423	1,755	86,178	18.55	81,481	59.57
Ceiling Load	6,087	-6,087	0	0.00	6,230	4.55
Ventilation Load	0	0	310,090	66.74	0	0.00
Ov/Undr Sizing	49,203		49,203	10.59	49,060	35.87
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			14,813	3.19		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	139,713	0	464,616	100.00	136,771	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1; OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-3,397	0.95
Glass Solar	0	0	0.00
Glass Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	0	0	0.00
Sub Total ==>	0	-3,397	0.95
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	35,760	35,760	-10.02
Sub Total ==>	35,760	35,760	-10.02
Ceiling Load	-3,397	0	0.00
Ventilation Load	0	-356,997	99.98
Ov/Undr Sizing	-32,426	-32,426	9.08
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	-63	-357,060	100.00

TEMPERATURES

	Cooling	Heating
SADB	49.0	68.0
Plenum	84.3	58.9
Return	68.0	68.0
Ret/OA	86.3	18.3
Fn MtrTD	0.2	0.0
Fn BldTD	0.5	0.0
Fn Frict	1.4	0.0

AIRFLOWS

	Cooling	Heating
Vent	4,708	4,708
Infil	0	0
Supply	6,442	6,442
MinStop/Rh	6,442	6,442
Return	4,278	4,278
Exhaust	2,543	2,543
Rm Exh	2,165	2,165
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	73.1	73.1
cfm/ft²	5.47	5.47
cfm/ton	166.39	
ft²/ton	30.40	
Btu/hr·ft²	394.75	-303.42
No. People	12	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	38.7	464.6	282.8	6,442	86.3	70.6	87.4	46.9	46.8	47.4
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	38.7	464.6								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	1,177		
Part	0		
ExFlr	0		
Roof	1,177	0	0
Wall	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-151.7	6,442	46.9	68.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-205.4	6,442	18.3	46.9
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-357.1			

System Checksums

By psuae

AHU 4 **Terminal Reheat**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 93 / 75 / 102
Clg Space Peak — Mo/Hr: 6 / 16; OADB: 92

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	4,201	4,201	0.98	0	0.00
Glass Solar	0	0	0	0.00	0	0.00
Glass Cond	0	0	0	0.00	0	0.00
Wall Cond	0	0	0	0.00	0	0.00
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	0	4,201	4,202	0.98	0	0.00
Internal Loads						
Lights	6,089	1,522	7,612	1.78	6,089	4.54
People	5,677		5,677	1.33	2,838	2.12
Misc	70,097	0	70,097	16.38	70,097	52.29
Sub Total ==>	81,863	1,522	83,385	19.48	79,024	58.95
Ceiling Load	5,724	-5,724	0	0.00	5,862	4.37
Ventilation Load	0	0	277,223	64.76	0	0.00
Ov/Undr Sizing	49,304		49,304	11.52	49,166	36.68
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			13,949	3.26		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	136,891	0	428,063	100.00	134,052	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1; OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-3,276	1.03
Glass Solar	0	0	0.00
Glass Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	0	0	0.00
Sub Total ==>	0	-3,277	1.03
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	35,048	35,048	-11.00
Sub Total ==>	35,048	35,048	-11.00
Ceiling Load	-3,276	0	0.00
Ventilation Load	0	-318,522	99.98
Ov/Undr Sizing	-31,835	-31,835	9.99
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	-63	-318,586	100.00

TEMPERATURES

	Cooling	Heating
SADB	48.8	68.0
Plenum	83.9	58.9
Return	68.0	68.0
Ret/OA	84.8	22.4
Fn MtrTD	0.2	0.0
Fn BldTD	0.5	0.0
Fn Frict	1.4	0.0

AIRFLOWS

	Cooling	Heating
Vent	4,201	4,201
Infil	0	0
Supply	6,261	6,261
MinStop/Rh	6,261	6,261
Return	4,425	4,425
Exhaust	2,365	2,365
Rm Exh	1,835	1,835
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	67.1	67.1
cfm/ft²	5.51	5.51
cfm/ton	175.50	
ft²/ton	31.83	
Btu/hr·ft²	377.05	-280.67
No. People	11	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	35.7	428.1	265.1	6,261	84.8	69.5	84.0	46.8	46.7	47.2
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	35.7	428.1								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	1,135		
Part	0		
ExFlr	0		
Roof	1,135	0	0
Wall	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-148.1	6,261	46.8	68.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-170.5	6,261	22.4	46.8
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-318.7			

System Checksums

By psuae

AHU 5 | **Terminal Reheat**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 93 / 75 / 102

Clg Space Peak — Mo/Hr: 6 / 16; OADB: 92

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	3,190	3,190	1.56	0	0.00
Glass Solar	0	0	0	0.00	0	0.00
Glass Cond	0	0	0	0.00	0	0.00
Wall Cond	0	0	0	0.00	0	0.00
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	0	3,190	3,190	1.56	0	0.00
Internal Loads						
Lights	5,470	1,368	6,838	3.35	5,470	7.07
People	4,346		4,346	2.13	2,173	2.81
Misc	35,496	0	35,496	17.38	35,496	45.87
Sub Total ==>	45,313	1,368	46,680	22.86	43,140	55.75
Ceiling Load	4,557	-4,557	0	0.00	4,663	6.03
Ventilation Load	0	0	117,016	57.31	0	0.00
Ov/Undr Sizing	29,681		29,681	14.54	29,575	38.22
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			7,615	3.73		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	79,551	0	204,182	100.00	77,378	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1; OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-2,508	1.90
Glass Solar	0	0	0.00
Glass Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	0	0	0.00
Sub Total ==>	0	-2,509	1.90
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	17,748	17,748	-13.46
Sub Total ==>	17,748	17,748	-13.46
Ceiling Load	-2,508	0	0.00
Ventilation Load	0	-131,819	99.96
Ov/Undr Sizing	-15,297	-15,297	11.60
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	-58	-131,877	100.00

TEMPERATURES

	Cooling	Heating
SADB	49.2	68.0
Plenum	84.6	58.9
Return	68.0	68.0
Ret/OA	79.8	35.9
Fn MtrTD	0.2	0.0
Fn BldTD	0.4	0.0
Fn Frict	1.3	0.0

AIRFLOWS

	Cooling	Heating
Vent	1,738	1,738
Infil	0	0
Supply	3,682	3,682
MinStop/Rh	3,682	3,682
Return	3,682	3,682
Exhaust	1,738	1,738
Rm Exh	0	0
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	47.2	47.2
cfm/ft²	4.24	4.24
cfm/ton	216.40	
ft²/ton	51.08	
Btu/hr·ft²	234.91	-151.76
No. People	9	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	17.0	204.2	133.5	3,682	79.8	65.7	72.2	47.3	46.3	45.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	17.0	204.2								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	869		
Part	0		
ExFlr	0		
Roof	869	0	0
Wall	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-85.1	3,682	47.3	68.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-46.8	3,682	35.9	47.3
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-131.9			

System Checksums

By psuae

AHU 6 **Terminal Reheat**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 93 / 75 / 102

Clg Space Peak — Mo/Hr: 6 / 16; OADB: 92

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	2,966	2,966	1.55	0	0.00
Glass Solar	0	0	0	0.00	0	0.00
Glass Cond	0	0	0	0.00	0	0.00
Wall Cond	0	0	0	0.00	0	0.00
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	0	2,966	2,966	1.55	0	0.00
Internal Loads						
Lights	5,057	1,264	6,322	3.30	5,057	6.86
People	4,040		4,040	2.11	2,020	2.74
Misc	33,314	0	33,314	17.38	33,314	45.21
Sub Total ==>	42,411	1,264	43,675	22.79	40,391	54.82
Ceiling Load	4,230	-4,230	0	0.00	4,328	5.87
Ventilation Load	0	0	108,697	56.71	0	0.00
Ov/Undr Sizing	29,062		29,062	15.16	28,964	39.31
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			7,267	3.79		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	75,703	0	191,667	100.00	73,683	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1; OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-2,331	1.90
Glass Solar	0	0	0.00
Glass Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	0	0	0.00
Sub Total ==>	0	-2,332	1.90
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	16,657	16,657	-13.59
Sub Total ==>	16,657	16,657	-13.59
Ceiling Load	-2,331	0	0.00
Ventilation Load	0	-122,522	99.95
Ov/Undr Sizing	-14,384	-14,384	11.73
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	-59	-122,581	100.00

TEMPERATURES

	Cooling	Heating
SADB	49.3	68.0
Plenum	84.5	58.9
Return	68.0	68.0
Ret/OA	79.5	36.8
Fn MtrTD	0.2	0.0
Fn BldTD	0.4	0.0
Fn Frict	1.3	0.0

AIRFLOWS

	Cooling	Heating
Vent	1,616	1,616
Infil	0	0
Supply	3,524	3,524
MinStop/Rh	3,524	3,524
Return	3,524	3,524
Exhaust	1,616	1,616
Rm Exh	0	0
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	45.9	45.9
cfm/ft²	4.36	4.36
cfm/ton	220.63	
ft²/ton	50.58	
Btu/hr·ft²	237.24	-151.77
No. People	8	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	16.0	191.7	126.0	3,524	79.5	65.4	71.5	47.4	46.4	45.1
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	16.0	191.7								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	808		
Part	0		
ExFlr	0		
Roof	808	0	0
Wall	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-81.0	3,524	47.4	68.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-41.6	3,524	36.8	47.4
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-122.6			

System Checksums

By psuae

AHU 7 | **Terminal Reheat**

COOLING COIL PEAK

Peaked at Time: Mo/Hr: 7 / 15
Outside Air: OADB/WB/HR: 93 / 75 / 102

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)
Envelope Loads				
Skylite Solar	0	0	0	0.00
Skylite Cond	0	0	0	0.00
Roof Cond	0	7,346	7,346	1.04
Glass Solar	0	0	0	0.00
Glass Cond	0	0	0	0.00
Wall Cond	0	0	0	0.00
Partition	0		0	0.00
Exposed Floor	0		0	0.00
Infiltration	1		1	0.00
Sub Total ==>	1	7,346	7,346	1.04
Internal Loads				
Lights	12,901	3,225	16,126	2.28
People	10,022		10,022	1.42
Misc	97,750	0	97,750	13.84
Sub Total ==>	120,673	3,225	123,898	17.54
Ceiling Load	10,571	-10,571	0	0.00
Ventilation Load	0	0	524,645	74.29
Ov/Undr Sizing	31,387		31,387	4.44
Exhaust Heat		0	0	0.00
Sup. Fan Heat			18,966	2.69
Ret. Fan Heat		0	0	0.00
Duct Heat Pkup		0	0	0.00
Reheat at Design			0	0.00
Grand Total ==>	162,632	0	706,243	100.00

CLG SPACE PEAK

Mo/Hr: 6 / 16
OADB: 92

	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads		
Skylite Solar	0	0.00
Skylite Cond	0	0.00
Roof Cond	0	0.00
Glass Solar	0	0.00
Glass Cond	0	0.00
Wall Cond	0	0.00
Partition	0	0.00
Exposed Floor	0	0.00
Infiltration	1	0.00
Sub Total ==>	1	0.00
Internal Loads		
Lights	12,901	8.18
People	5,011	3.18
Misc	97,750	62.02
Sub Total ==>	115,662	73.38
Ceiling Load	10,815	6.86
Ventilation Load	0	0.00
Ov/Undr Sizing	31,143	19.76
Grand Total ==>	157,621	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1
OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-5,784	0.92
Glass Solar	0	0	0.00
Glass Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	-1	-1	0.00
Sub Total ==>	-1	-5,786	0.92
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	48,875	48,875	-7.73
Sub Total ==>	48,875	48,875	-7.73
Ceiling Load	-5,784	0	0.00
Ventilation Load	0	-631,996	99.98
Ov/Undr Sizing	-43,235	-43,235	6.84
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	-146	-632,142	100.00

TEMPERATURES

	Cooling	Heating
SADB	51.0	68.0
Plenum	84.6	58.9
Return	68.0	68.0
Ret/OA	93.0	0.0
Fn MtrTD	0.2	0.0
Fn BldTD	0.5	0.0
Fn Frict	1.4	0.0

AIRFLOWS

	Cooling	Heating
Vent	8,335	8,335
Infil	0	0
Supply	8,335	8,335
MinStop/Rh	8,335	8,335
Return	1,032	1,032
Exhaust	1,032	1,032
Rm Exh	7,303	7,303
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	100.0	100.0
cfm/ft²	4.16	4.16
cfm/ton	141.62	
ft²/ton	34.06	
Btu/hr·ft²	352.35	-448.29
No. People	20	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	58.9	706.2	408.9	8,335	93.0	75.0	101.9	49.0	48.9	51.4
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	58.9	706.2								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	2,004		
Part	0		
ExFlr	0		
Roof	2,004	0	0
Wall	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-176.8	8,335	49.0	68.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-455.4	8,335	0.0	49.0
Humidif	-266.3	8,335	1.1	46.7
Opt Vent	0.0	0	0.0	0.0
Total	-898.6			

System Checksums

By psuae

AHU 8 **Terminal Reheat**

COOLING COIL PEAK / CLG SPACE PEAK

Peaked at Time: Mo/Hr: 7 / 15 — CLG Space Peak Mo/Hr: 7 / 9

Outside Air: OADB/WB/HR: 93 / 75 / 102 — CLG Space Peak OADB: 81

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	7,964	7,964	1.58	0	0.00
Glass Solar	32,213	0	32,213	6.40	32,213	20.67
Glass Cond	3,493	0	3,493	0.69	3,493	2.24
Wall Cond	77	274	351	0.07	125	0.08
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	35,784	8,238	44,022	8.75	35,832	22.99
Internal Loads						
Lights	12,045	3,011	15,056	2.99	12,045	7.73
People	11,608		11,608	2.31	5,804	3.72
Misc	37,424	0	37,424	7.44	37,424	24.01
Sub Total ==>	61,077	3,011	64,088	12.73	55,273	35.46
Ceiling Load	11,249	-11,249	0	0.00	11,499	7.38
Ventilation Load	0	0	303,173	60.23	0	0.00
Ov/Undr Sizing	71,909		71,909	14.29	53,251	34.17
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			20,137	4.00		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	180,019	0	503,329	100.00	155,855	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1

OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-6,632	1.80
Glass Solar	0	0	0.00
Glass Cond	-17,482	-17,482	4.74
Wall Cond	-137	-641	0.17
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	-1	-1	0.00
Sub Total ==>	-17,620	-24,756	6.72
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	18,712	18,712	-5.08
Sub Total ==>	18,712	18,712	-5.08
Ceiling Load	-7,136	0	0.00
Ventilation Load	0	-352,068	95.55
Ov/Undr Sizing	-10,363	-10,363	2.81
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	-16,406	-368,474	100.00

TEMPERATURES

	Cooling	Heating
SADB	49.5	70.0
Plenum	83.3	58.3
Return	68.0	68.0
Ret/OA	83.4	26.2
Fn MtrTD	0.2	0.0
Fn BldTD	0.5	0.0
Fn Frict	1.6	0.0

AIRFLOWS

	Cooling	Heating
Vent	4,643	4,643
Infil	0	0
Supply	7,551	7,551
MinStop/Rh	7,551	7,551
Return	5,780	5,780
Exhaust	2,871	2,871
Rm Exh	1,772	1,772
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	61.5	61.5
cfm/ft²	3.25	3.25
cfm/ton	180.04	
ft²/ton	55.35	
Btu/hr·ft²	216.81	-82.89
No. People	23	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	41.9	503.3	325.7	7,551	83.4	68.6	81.4	47.1	46.0	44.4
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	41.9	503.3								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	2,322		
Part	0		
ExFlr	0		
Roof	2,322	0	0
Wall	674	407	60

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-192.4	7,551	47.1	70.0
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	7,551	26.2	47.1
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-192.4			

System Checksums

By psuae

AHU 9 **Terminal Reheat**

COOLING COIL PEAK / CLG SPACE PEAK

Peaked at Time: Mo/Hr: 7 / 15 — CLG Space Peak Mo/Hr: 6 / 16

Outside Air: OADB/WB/HR: 93 / 75 / 102 — CLG Space Peak OADB: 92

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	CLG Space Peak: Space Sensible Btu/h	CLG Space Peak: Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	8,308	8,308	2.72	0	0.00
Glass Solar	0	0	0	0.00	0	0.00
Glass Cond	0	0	0	0.00	0	0.00
Wall Cond	0	0	0	0.00	0	0.00
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	0	8,308	8,308	2.72	0	0.00
Internal Loads						
Lights	10,114	2,528	12,642	4.13	10,114	7.50
People	11,142		11,142	3.64	5,571	4.13
Misc	21,712	0	21,712	7.10	21,712	16.09
Sub Total ==>	42,968	2,528	45,497	14.87	37,397	27.72
Ceiling Load	10,837	-10,837	0	0.00	11,108	8.23
Ventilation Load	0	0	150,954	49.34	0	0.00
Ov/Undr Sizing	86,667		86,667	28.33	86,396	64.04
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			14,520	4.75		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	140,472	0	305,947	100.00	134,901	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1

OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-6,431	3.79
Glass Solar	0	0	0.00
Glass Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	-1	-1	0.00
Sub Total ==>	-1	-6,431	3.79
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	10,856	10,856	-6.40
Sub Total ==>	10,856	10,856	-6.40
Ceiling Load	-6,431	0	0.00
Ventilation Load	0	-168,974	99.64
Ov/Undr Sizing	-5,038	-5,038	2.97
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	-613	-169,587	100.00

TEMPERATURES

	Cooling	Heating
SADB	49.0	68.1
Plenum	83.4	58.9
Return	68.0	68.0
Ret/OA	76.7	44.3
Fn MtrTD	0.2	0.0
Fn BldTD	0.5	0.0
Fn Frict	1.4	0.0

AIRFLOWS

	Cooling	Heating
Vent	2,228	2,228
Infil	0	0
Supply	6,381	6,381
MinStop/Rh	6,381	6,381
Return	6,266	6,266
Exhaust	2,113	2,113
Rm Exh	115	115
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	34.9	34.9
cfm/ft²	2.86	2.86
cfm/ton	250.27	
ft²/ton	87.40	
Btu/hr·ft²	137.29	-67.33
No. People	22	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	25.5	306.0	211.5	6,381	76.7	63.2	64.9	47.0	45.8	43.9
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	25.5	306.0								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	2,228		
Part	0		
ExFlr	0		
Roof	2,228	0	0
Wall	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-150.1	6,381	47.0	68.1
Aux Htg	0.0	0	0.0	0.0
Preheat	0.0	6,381	44.3	47.0
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-150.1			

System Checksums

By psuae

AHU 10 | **Variable Volume Reheat (30% Min Flow Default)**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 16; Outside Air: OADB/WB/HR: 93 / 74 / 100

CLG Space Peak — Mo/Hr: 6 / 17; OADB: 90

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	53,935	53,935	4.97	0	0.00
Glass Solar	338,235	0	338,235	31.18	350,068	59.45
Glass Cond	46,298	0	46,298	4.27	39,922	6.78
Wall Cond	0	2,585	2,585	0.24	0	0.00
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	384,533	56,520	441,053	40.66	389,991	66.23
Internal Loads						
Lights	75,973	18,993	94,966	8.75	75,973	12.90
People	84,825		84,825	7.82	47,125	8.00
Misc	67,485	0	67,485	6.22	67,485	11.46
Sub Total ==>	228,283	18,993	247,276	22.79	190,583	32.36
Ceiling Load	8,478	-8,478	0	0.00	8,306	1.41
Ventilation Load	0	0	314,880	29.02	0	0.00
Ov/Undr Sizing	0		0	0.00	0	0.00
Exhaust Heat		-13,964	-13,964	-1.29		
Sup. Fan Heat			95,616	8.81		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	621,293	53,071	1,084,860	100.00	588,879	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1; OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-44,218	5.73
Glass Solar	0	0	0.00
Glass Cond	-203,273	-203,273	26.35
Wall Cond	0	-3,567	0.46
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	-2	-2	0.00
Sub Total ==>	-203,275	-251,060	32.54
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	33,742	33,742	-4.37
Sub Total ==>	33,742	33,742	-4.37
Ceiling Load	-13,131	0	0.00
Ventilation Load	0	-512,414	66.42
Ov/Undr Sizing	0	0	0.00
Exhaust Heat		21,629	-2.80
OA Preheat Diff.		0	0.00
RA Preheat Diff.		-63,375	8.21
Additional Reheat		0	0.00
Grand Total ==>	-182,664	-771,478	100.00

TEMPERATURES

	Cooling	Heating
SADB	57.1	90.8
Plenum	77.1	69.8
Return	77.1	69.8
Ret/OA	80.4	25.6
Fn MtrTD	0.3	0.0
Fn BldTD	0.7	0.0
Fn Frict	2.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	6,295	6,295
Infil	0	0
Supply	29,549	9,939
MinStop/Rh	9,939	9,939
Return	29,305	9,696
Exhaust	6,052	6,052
Rm Exh	243	243
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	21.3	63.3
cfm/ft²	2.29	0.77
cfm/ton	326.85	
ft²/ton	143.02	
Btu/hr·ft²	83.91	-60.76
No. People	189	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	90.4	1,084.9	855.1	29,283	80.4	64.6	65.7	54.2	52.1	54.5
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	90.4	1,084.9								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	12,929		
Part	0		
ExFlr	0		
Roof	12,929	0	0
Wall	5,687	4,409	78

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-405.1	9,939	54.2	90.8
Aux Htg	0.0	0	0.0	0.0
Preheat	-380.5	6,295	0.0	54.2
Humidif	0.0	0	0.0	0.0
Opt Vent	0.0	0	0.0	0.0
Total	-785.5			

System Checksums

By psuae

AHU 11 **Terminal Reheat**

COOLING COIL PEAK / CLG SPACE PEAK

Peaked at Time: Mo/Hr: 7 / 14
Outside Air: OADB/WB/HR: 93 / 75 / 102

CLG SPACE PEAK: Mo/Hr: 11 / 13, OADB: 64

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	5,138	5,138	1.33	0	0.00
Glass Solar	19,714	0	19,714	5.10	50,764	41.32
Glass Cond	3,010	0	3,010	0.78	-1,541	-1.25
Wall Cond	0	0	0	0.00	0	0.00
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	22,724	5,138	27,862	7.20	49,223	40.06
Internal Loads						
Lights	12,901	3,225	16,126	4.17	12,901	10.50
People	8,328		8,328	2.15	4,164	3.39
Misc	50,162	0	50,162	12.97	50,162	40.83
Sub Total ==>	71,391	3,225	74,616	19.29	67,227	54.71
Ceiling Load	8,364	-8,364	0	0.00	6,420	5.22
Ventilation Load	0	0	242,478	62.68	0	0.00
Ov/Undr Sizing	26,956		26,956	6.97	0	0.00
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			14,924	3.86		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	129,435	0	386,837	100.00	122,871	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1
OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-4,822	1.68
Glass Solar	0	0	0.00
Glass Cond	-11,504	-11,504	4.01
Wall Cond	0	0	0.00
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	-1	-1	0.00
Sub Total ==>	-11,504	-16,326	5.70
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	25,081	25,081	-8.75
Sub Total ==>	25,081	25,081	-8.75
Ceiling Load	-4,822	0	0.00
Ventilation Load	0	-283,464	98.92
Ov/Undr Sizing	-11,850	-11,850	4.14
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	-3,095	-286,559	100.00

TEMPERATURES

	Cooling	Heating
SADB	53.3	72.5
Plenum	87.9	62.9
Return	72.0	72.0
Ret/OA	84.3	28.8
Fn MtrTD	0.2	0.0
Fn BldTD	0.5	0.0
Fn Frict	1.5	0.0

AIRFLOWS

	Cooling	Heating
Vent	3,531	3,531
Infil	0	0
Supply	5,884	5,884
MinStop/Rh	5,884	5,884
Return	4,497	4,497
Exhaust	2,143	2,143
Rm Exh	1,387	1,387
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	60.0	60.0
cfm/ft²	3.53	3.53
cfm/ton	182.54	
ft²/ton	51.67	
Btu/hr·ft²	232.26	-239.81
No. People	17	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	32.2	386.8	222.9	5,884	84.3	67.8	75.8	51.0	45.2	35.4
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	32.2	386.8								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	1,666		
Part	0		
ExFlr	0		
Roof	1,566	0	0
Wall	253	253	100

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-140.9	5,884	51.0	72.5
Aux Htg	0.0	0	0.0	0.0
Preheat	-145.7	5,884	28.8	51.0
Humidif	-112.8	3,531	1.1	46.7
Opt Vent	0.0	0	0.0	0.0
Total	-399.4			

Appendix IV-1

System Checksums

By psuae

AHU 12 — **Terminal Reheat**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 93 / 75 / 102

Clg Space Peak — Mo/Hr: 7 / 16; OADB: 93

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	28,360	28,360	3.75	0	0.00
Glass Solar	0	0	0	0.00	0	0.00
Glass Cond	0	0	0	0.00	0	0.00
Wall Cond	171	286	457	0.06	157	0.05
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	171	28,645	28,817	3.81	157	0.05
Internal Loads						
Lights	51,127	12,782	63,908	8.45	51,127	15.34
People	40,574		40,574	5.37	20,287	6.09
Misc	219,349	0	219,349	29.02	219,349	65.81
Sub Total ==>	311,050	12,782	323,832	42.84	290,763	87.24
Ceiling Load	41,427	-41,427	0	0.00	42,380	12.72
Ventilation Load	0	0	339,077	44.86	0	0.00
Ov/Undr Sizing	939		939	0.12	0	0.00
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			63,215	8.36		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	353,587	0	755,880	100.00	333,300	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1; OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-24,726	5.23
Glass Solar	0	0	0.00
Glass Cond	0	0	0.00
Wall Cond	-242	-754	0.16
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	-2	-2	0.00
Sub Total ==>	-244	-25,482	5.39
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	109,675	109,675	-23.21
Sub Total ==>	109,675	109,675	-23.21
Ceiling Load	-25,238	0	0.00
Ventilation Load	0	-471,330	99.75
Ov/Undr Sizing	-85,358	-85,358	18.07
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	-1,165	-472,496	100.00

TEMPERATURES

	Cooling	Heating
SADB	54.2	72.1
Plenum	88.1	62.2
Return	72.0	72.0
Ret/OA	79.4	46.8
Fn MtrTD	0.3	0.0
Fn BldTD	0.8	0.0
Fn Frict	2.3	0.0

AIRFLOWS

	Cooling	Heating
Vent	5,870	5,870
Infil	0	0
Supply	16,773	16,773
MinStop/Rh	16,773	16,773
Return	14,474	14,474
Exhaust	3,571	3,571
Rm Exh	2,299	2,299
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	35.0	35.0
cfm/ft²	2.07	2.07
cfm/ton	266.28	
ft²/ton	128.83	
Btu/hr·ft²	93.15	-81.36
No. People	81	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	63.0	755.9	534.0	16,773	79.4	65.1	70.1	50.8	49.7	51.4
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	63.0	755.9								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	8,115		
Part	0		
ExFlr	0		
Roof	8,115	0	0
Wall	290	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-397.9	16,773	50.8	72.1
Aux Htg	0.0	0	0.0	0.0
Preheat	-74.8	16,773	46.8	50.8
Humidif	-187.6	5,870	1.1	46.7
Opt Vent	0.0	0	0.0	0.0
Total	-660.3			

System Checksums

By psuae

AHU 13 **Terminal Reheat**

COOLING COIL PEAK / CLG SPACE PEAK

Cooling Coil Peak — Peaked at Time: Mo/Hr: 7 / 15; Outside Air: OADB/WB/HR: 93 / 75 / 102

Clg Space Peak — Mo/Hr: 6 / 16; OADB: 92

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	26,375	26,375	4.36	0	0.00
Glass Solar	0	0	0	0.00	0	0.00
Glass Cond	0	0	0	0.00	0	0.00
Wall Cond	0	0	0	0.00	0	0.00
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	0	26,375	26,375	4.36	0	0.00
Internal Loads						
Lights	40,871	10,218	51,089	8.44	40,871	15.44
People	37,385		37,385	6.18	18,693	7.06
Misc	167,715	0	167,715	27.72	167,715	63.34
Sub Total ==>	245,970	10,218	256,188	42.34	227,278	85.84
Ceiling Load	36,592	-36,592	0	0.00	37,503	14.16
Ventilation Load	0	0	273,251	45.16	0	0.00
Ov/Undr Sizing	910		910	0.15	0	0.00
Exhaust Heat		0	0	0.00		
Sup. Fan Heat			48,325	7.99		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	283,474	0	605,049	100.00	264,781	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1; OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-22,846	6.03
Glass Solar	0	0	0.00
Glass Cond	0	0	0.00
Wall Cond	0	0	0.00
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	-2	-2	0.00
Sub Total ==>	-2	-22,848	6.03
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	83,857	83,857	-22.12
Sub Total ==>	83,857	83,857	-22.12
Ceiling Load	-22,846	0	0.00
Ventilation Load	0	-377,526	99.61
Ov/Undr Sizing	-62,504	-62,504	16.49
Exhaust Heat		0	0.00
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	-1,494	-379,020	100.00

TEMPERATURES

	Cooling	Heating
SADB	54.3	72.1
Plenum	87.5	62.4
Return	72.0	72.0
Ret/OA	79.4	46.8
Fn MtrTD	0.3	0.0
Fn BldTD	0.7	0.0
Fn Frict	2.2	0.0

AIRFLOWS

	Cooling	Heating
Vent	4,702	4,702
Infil	0	0
Supply	13,435	13,435
MinStop/Rh	13,435	13,435
Return	11,746	11,746
Exhaust	3,013	3,013
Rm Exh	1,689	1,689
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	35.0	35.0
cfm/ft²	1.80	1.80
cfm/ton	266.45	
ft²/ton	148.29	
Btu/hr·ft²	80.92	-70.80
No. People	75	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	50.4	605.1	423.2	13,435	79.4	65.0	69.8	51.1	49.7	50.6
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	50.4	605.1								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	7,477		
Part	0		
ExFlr	0		
Roof	7,477	0	0
Wall	0	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-314.7	13,435	51.1	72.1
Aux Htg	0.0	0	0.0	0.0
Preheat	-64.4	13,435	46.8	51.1
Humidif	-150.3	4,702	1.1	46.7
Opt Vent	0.0	0	0.0	0.0
Total	-529.4			

System Checksums

By psuae

AHU 14 **Terminal Reheat**

COOLING COIL PEAK / CLG SPACE PEAK

Peaked at Time: Mo/Hr: 7 / 15 — Outside Air: OADB/WB/HR: 93 / 75 / 102

CLG Space Peak: Mo/Hr: 7 / 15 — OADB: 93

	Space Sens. + Lat. Btu/h	Plenum Sens. + Lat Btu/h	Net Total Btu/h	Percent Of Total (%)	Space Sensible Btu/h	Percent Of Total (%)
Envelope Loads						
Skylite Solar	0	0	0	0.00	0	0.00
Skylite Cond	0	0	0	0.00	0	0.00
Roof Cond	0	4,544	4,544	2.06	0	0.00
Glass Solar	0	0	0	0.00	0	0.00
Glass Cond	0	0	0	0.00	0	0.00
Wall Cond	124	294	419	0.19	147	0.33
Partition	0		0	0.00	0	0.00
Exposed Floor	0		0	0.00	0	0.00
Infiltration	0		0	0.00	0	0.00
Sub Total ==>	124	4,839	4,963	2.25	147	0.33
Internal Loads						
Lights	7,844	1,961	9,805	4.44	7,844	17.51
People	5,177		5,177	2.34	2,589	5.78
Misc	33,609	0	33,609	15.22	33,609	75.02
Sub Total ==>	46,630	1,961	48,591	22.01	44,042	98.31
Ceiling Load	611	-611	0	0.00	612	1.37
Ventilation Load	0	0	168,749	76.42	0	0.00
Ov/Undr Sizing	23		23	0.01	0	0.00
Exhaust Heat		-6,188	-6,188	-2.80		
Sup. Fan Heat			4,676	2.12		
Ret. Fan Heat		0	0	0.00		
Duct Heat Pkup		0	0	0.00		
Reheat at Design			0	0.00		
Grand Total ==>	47,389	0	220,814	100.00	44,800	100.00

HEATING COIL PEAK

Mo/Hr: 13 / 1 — OADB: 0

	Space Peak Space Sens Btu/h	Coil Peak Tot Sens Btu/h	Percent Of Total (%)
Envelope Loads			
Skylite Solar	0	0	0.00
Skylite Cond	0	0	0.00
Roof Cond	0	-3,398	1.50
Glass Solar	0	0	0.00
Glass Cond	0	0	0.00
Wall Cond	-135	-461	0.20
Partition	0	0	0.00
Exposed Floor	0	0	0.00
Infiltration	0	0	0.00
Sub Total ==>	-136	-3,859	1.71
Internal Loads			
Lights	0	0	0.00
People	0	0	0.00
Misc	16,805	16,805	-7.44
Sub Total ==>	16,805	16,805	-7.44
Ceiling Load	-335	0	0.00
Ventilation Load	0	-225,800	100.00
Ov/Undr Sizing	-16,334	-16,334	7.23
Exhaust Heat		3,389	-1.50
OA Preheat Diff.		0	0.00
RA Preheat Diff.		0	0.00
Additional Reheat		0	0.00
Grand Total ==>	0	-225,799	100.00

TEMPERATURES

	Cooling	Heating
SADB	54.5	68.0
Plenum	69.9	67.0
Return	69.9	67.0
Ret/OA	93.0	0.0
Fn MtrTD	0.1	0.0
Fn BldTD	0.3	0.0
Fn Frict	1.0	0.0

AIRFLOWS

	Cooling	Heating
Vent	2,978	2,978
Infil	0	0
Supply	2,978	2,978
MinStop/Rh	2,978	2,978
Return	2,978	2,978
Exhaust	2,978	2,978
Rm Exh	0	0
Auxiliary	0	0

ENGINEERING CKS

	Cooling	Heating
% OA	100.0	100.0
cfm/ft²	2.88	2.88
cfm/ton	161.83	
ft²/ton	56.27	
Btu/hr·ft²	213.26	-308.44
No. People	10	

COOLING COIL SELECTION

	Total Capacity ton	Total Capacity MBh	Sens Cap. MBh	Coil Airflow cfm	Enter DB °F	Enter WB °F	Enter HR gr/lb	Leave DB °F	Leave WB °F	Leave HR gr/lb
Main Clg	18.4	220.8	132.5	2,978	93.0	75.0	101.9	53.1	53.1	60.1
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	18.4	220.8								

AREAS

	Gross Total	Glass ft²	Glass (%)
Floor	1,035		
Part	0		
ExFlr	0		
Roof	1,035	0	0
Wall	171	0	0

HEATING COIL SELECTION

	Capacity MBh	Coil Airflow cfm	Ent °F	Lvg °F
Main Htg	-49.5	2,978	53.1	68.0
Aux Htg	0.0	0	0.0	0.0
Preheat	-176.3	2,978	0.0	53.1
Humidif	-93.5	2,978	1.1	45.9
Opt Vent	0.0	0	0.0	0.0
Total	-319.4			

MONTHLY ENERGY CONSUMPTION

By psuae

Alternative: 1 PA Lab Facility

------- Monthly Energy Consumption -------

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Electric													
On-Pk Cons. (kWh)	598,696	536,139	599,426	589,246	686,188	733,552	817,214	761,597	680,118	622,950	592,722	598,482	7,816,331
On-Pk Demand (kW)	959	937	970	994	1,184	1,318	1,387	1,295	1,190	1,021	1,019	988	1,387
Off-Pk Demand (kW)	999	997	1,041	1,072	1,075	1,137	1,250	1,151	1,091	1,093	1,041	1,039	1,250
Gas													
On-Pk Cons. (therms)	11,943	11,548	7,555	3,991	2,046	1,231	703	947	1,597	3,860	5,389	8,875	59,684
On-Pk Demand (therms/hr)	24	24	16	9	4	3	3	3	3	8	13	18	24
Water													
Cons. (1000gal)	0	0	0	0	0	6	12	12	3	0	0	0	33

Building Energy Consumption = 731,077 Btu/(ft2-year)
Source Energy Consumption = 1,933,129 Btu/(ft2-year)
Floor Area = 44,654 ft2

MONTHLY UTILITY COSTS

By psuae

Alternative: 1

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Electric													
On-Pk Cons. ($)	47,262	44,182	47,570	47,706	56,189	64,845	70,088	65,399	59,272	49,723	48,449	47,956	648,641
On-Pk Demand ($)	5,632	5,505	5,700	5,837	6,950	7,733	8,135	7,601	6,983	5,994	5,985	5,805	77,860
Total ($):	52,894	49,687	53,271	53,543	63,139	72,579	78,224	72,999	66,255	55,717	54,434	53,762	726,501
Gas													
On-Pk Cons. ($)	2,132	2,067	1,404	812	490	354	267	307	415	791	1,045	1,623	11,708
Monthly Total ($):	55,026	51,753	54,675	54,355	63,629	72,933	78,490	73,307	66,670	56,508	55,478	55,385	738,209

RATE-GS GENERAL SERVICE

AVAILABILITY.

Service through a single metering installation for offices, professional, commercial or industrial establishments, governmental agencies, and other applications outside the scope of the Residence Service rate schedules.

CURRENT CHARACTERISTICS.

Standard single-phase or polyphase secondary service.

MONTHLY RATE TABLE.

FIXED DISTRIBUTION SERVICE CHARGE:

$ 6.74 for single-phase service without demand measurement, or **(I)**
$ 8.81 for single-phase service with demand measurement, or **(I)**
$23.82 for polyphase service. **(I)**

METERING AND BILLING CREDITS A customer receiving Advanced Meter Services from a AMSP other than the Company will receive a credit on the Fixed Distribution Service Charge equal to the Total Metering Credit set forth for this Base Rate in Appendix B to the Joint Petition for Full Settlement. A customer receiving Consolidated EGS Billing will receive a credit on the Fixed Distribution Service Charge equal to the Billing and Collection Credit set forth for this Base Rate in Appendix B to the Joint Petition for Full Settlement.

VARIABLE DISTRIBUTION SERVICE CHARGE:

3.32¢ per kWh for the first 80 hours' use of billing demand **(I)**
* 1.56¢ per kWh for the next 80 hours' use of the billing demand **(I)**
0.98¢ per kWh for additional use; except **(I)**
0.43¢ per kWh over both 400 hours' use of billing demand and 2,000 kWh **(I)**

COMPETITIVE TRANSITION CHARGE:

6.92¢ per kWh for the first 80 hours' use of billing demand **(I)**
* 3.32¢ per kWh for the next 80 hours' use of billing demand **(I)**
2.13¢ per kWh for additional use; except
1.00¢ per kWh over both 400 hours' use of billing demand and 2,000 kWh. (**D)**

ENERGY AND CAPACITY CHARGE: The following Energy and Capacity Charges will apply to the customer if the customer receives Default PLR Service. These charges are not applicable to the customer if it obtains Competitive Energy Supply.

10.64¢ per kWh for the first 80 hours' use of billing demand **(I)**
* 5.79¢ per kWh for the next 80 hours' use of billing demand **(I)**
4.20¢ per kWh for additional use; except **(I)**
2.67¢ per kWh over both 400 hours' use of billing demand and 2,000 kWh. **(I)**

* During October through May this block is eliminated.

TRANSMISSION SERVICE FOR CUSTOMERS RECEIVING DEFAULT PLR SERVICE: Unless such a customer is able to obtain transmission service on its own, PECO Energy will provide transmission service, and will impose charges on such a customer for such transmission service.

STATE TAX ADJUSTMENT CLAUSE, NUCLEAR DECOMMISSIONING COST ADJUSTMENT APPLY TO THIS RATE.

DETERMINATION OF DEMAND.

The billing demand will be measured where consumption exceeds 1,100 kilowatt-hours per month for three consecutive months; or where load tests indicate a demand of five or more kilowatts; or where the heating modification is applied; or where the customer requests demand measurement. Measured demands will be determined to the nearest 0.1 of a kilowatt but will not be less than 1.2 kilowatts, and will be adjusted for power factor in accordance with the Rules and Regulations.

For those customers with demand measurement, during October through May the billing demand will not be less than 40% of the highest billing demand in the preceding months of June through September (applied on an unbundled basis)., nor less than the minimum value stated in the contract for service. If a measured demand customer has less than 1,100 monthly kilowatt-hours of use, the monthly billing demand will be the measured demand or the metered monthly kilowatt-hours divided by 175 hours, whichever is less, but not less than 40% of the highest billing demand in the preceding months of June through September, nor less than 1.2 kilowatts. There will be a one-time waiver of the application of the previous sentences as they relate to minimums associated with PLR Energy and Capacity charges the first time a customer at a service location elects to receive Competitive Energy Supply. This one-time waiver is specific to a particular service location unless a new entity has assumed operation of the service location from a customer which has ceased operations at that location as a result of dissolution provided the new entity was not created through merger, partnership, joint venture, acquisition and/or any other type of combined business structure with the former customer.

For those customers without demand measurement, the monthly billing demand will be computed by dividing the metered monthly kilowatt-hours by 175 hours. The computed demand will be determined to the nearest 0.1 of a kilowatt, but will not be less than 1.2 kilowatts.

(D) Denotes Decrease
(I) Denotes Increase

MINIMUM CHARGE

The monthly minimum charge for customers without demand measurement will be the Fixed Distribution Service Charge. The monthly minimum charge for customers with demand measurement will be the Fixed Distribution Service Charge, plus a charge of $**5.85** per KW of billing demand**, as follows: Variable Distribution-$0.85 per kW; Competitive Transition Charge-$1.85 per kW; Energy and Capacity-$3.15 per kW (Energy and Capacity Charge applicable only if Customer receives Default PLR Service).** **(I)**

HEATING MODIFICATION.

Wood, solar, wind, water, and biomass systems may be used to supply a portion of the heating requirements in conjunction with service provided hereunder. Any customer system of this type that produces electric energy may not be operated concurrently with service provided by the Company except under written agreement setting forth the conditions of such operation as provided by and in accordance with the provisions of the Auxiliary Service Rider.

METERING.

A. Single Meter.

Applicable where an area is heated solely by permanently connected electric space heating installations (1) acceptable to the Company, (2) sensitive to outdoor temperature and (3) not less than 5 kilowatts. Qualifying electric heating systems are (1) electric resistance coils, (2) electric resistance baseboards, (3) electric boilers and (4) heat pumps with electric back-up.

During October through May the monthly maximum measured demand shall be reduced by one-half of the difference between the peak winter measured demand and the base load demand over the two most recent winter seasons preceding the start of the current winter season (October 1st). The demand reduction will be subject to annual review and any revisions will be based on the two most recent winter seasons. The base load demand will be defined as the lowest measured demand during the period from October to May. For time-of-use metered customers, the demand reduction will be based upon the difference between the peak winter and base load demands regardless of whether they occur on or off peak. During this period, the billing demand shall never be less than 15 kilowatts; except for those customers in service as of February 18, 1971, the billing demand during October through May shall not be less than one-half of the monthly measured demand.

A customer whose demand reduction was calculated under the methods in effect on October 17, 1996, will continue to receive the same reduction until January 2, 2000 unless the current method (described in the preceding paragraph) yields a smaller billed demand for the customer.

A customer who adds new electrical connected heating load will receive the same proportion of forgiven demand to total demand that they currently receive.

This demand modification will only be applicable within 30 days of the date that the customer requests billing under this provision. It shall be the responsibility of the customer to notify the Company of any subsequent changes to its heating equipment or requirements.

B. Separate Meters.

At the option of the customer, electricity supplying permanently connected space heating installations or heating equipment sensitive to outdoor temperature with a total capacity of not less than 5 kilowatts, which are acceptable to the Company, will be measured apart from the customer's other requirements for electric service at the premises. Air conditioning equipment of rated electrical capacity up to twice that of the heating equipment also may be supplied through this separate heating circuit.

During October through May the usage of this separate circuit shall be billed at the charges listed below in lieu of the pricing of the basic Monthly Rate Table.

VARIABLE DISTRIBUTION SERVICE CHARGE: 0.77¢ per kWh **(I)**

COMPETITIVE TRANSITION CHARGE: 1.70¢ per kWh **(D)**

ENERGY AND CAPACITY CHARGE: The following Energy and Capacity Charges will apply to the customer if the customer receives Default PLR Service. These charges are not applicable to the customer if it obtains Competitive Energy Supply:

3.62¢ per kWh **(I)**

During June through September the combined usage shall be billed under the price provisions of the basic Monthly Rate Table.

TRANSMISSION SERVICE FOR CUSTOMERS RECEIVING DEFAULT PLR SERVICE: Unless such a customer is able to obtain transmission service on its own, PECO Energy will provide transmission service, and will impose charges on such a customer for such transmission service.

OFF-PEAK THERMAL STORAGE PROVISION.

Off-peak energy may be provided exclusively for qualifying Thermal Storage applications only in conjunction with this rate schedule when the load supplied is separately metered. This service will be billed separately at the rate of $11.39 per month, plus the charges listed below. **(I)**

OFF-PEAK USAGE DURING THE WINTER AND SUMMER MONTHS:

VARIABLE DISTRIBUTION SERVICE CHARGE: 1.30¢ per kWh **(I)**

COMPETITIVE TRANSITION CHARGE: 0.87¢ per kWh **(I)**

ENERGY AND CAPACITY CHARGE: The following Energy and Capacity Charges will apply to the customer if the customer receives Default PLR Service. These charges are not applicable to the customer if it obtains Competitive Energy Supply:

1.75¢ per kWh **(I)**

(D) Denotes Decrease
(I) Denotes Increase

ON-PEAK USAGE DURING THE WINTER MONTHS:

VARIABLE DISTRIBUTION SERVICE CHARGE:	2.01¢ per kWh
COMPETITIVE TRANSITION CHARGE:	1.32¢ per kWh

ENERGY AND CAPACITY CHARGE: The following Energy and Capacity Charges will apply to the customer if the customer receives Default PLR Service. These charges are not applicable to the customer if it obtains Competitive Energy Supply. 2.69¢ per kWh

TRANSMISSION SERVICE FOR CUSTOMERS RECEIVING DEFAULT PLR SERVICE: Unless such a customer is able to obtain transmission service on its own, PECO Energy will provide transmission service, and will impose charges on such a customer for such transmission service.

During the summer months, any on-peak demand and energy will contribute to the pricing of the basic Monthly Rate Table. To qualify for this provision, the customer must submit an engineering study performed by a professional engineer registered in the Commonwealth of Pennsylvania to the Company for technical review and approval. On-peak hours are defined as the hours between 8:00 a.m. and 8:00 p.m., Eastern Standard Time or Daylight Saving Time, whichever is in common use, daily except Saturdays, Sundays and holidays; except that the on-peak hours will end at 4:00 p.m. on Fridays. Off-peak hours are defined as the hours other than those specified as on-peak hours. For Cooling Thermal Storage applications, during the months of June through September, on-peak hours will commence at 10:00 a.m. instead of 8:00 a.m.

SPECIAL PROVISION.

In accordance with Section 1511, Title 66 Public Utilities, a volunteer fire company, non-profit rescue squad, non-profit ambulance service or a non-profit senior citizen center meeting the requirements set forth below, may, upon application, elect to have its electric service billed at any of the following rate schedules: Rate R Residential Service, Rate RT Residential Time of Use, Rate R-H Residential Heating Service, or Rate OP Off-Peak Service as appropriate for the application. The execution of an electric service contract for a minimum term of one year at the chosen rate will be required of any entity electing service pursuant to the options provided by this provision. **(C)**

For the purposes of this provision, the following words and terms shall have the following meanings, unless the context clearly indicates otherwise:

VOLUNTEER FIRE COMPANY - a separately metered service location consisting of a building, sirens, a garage for housing vehicular fire fighting equipment, or a facility certified by the Pennsylvania Emergency Management Agency (PEMA) for fire fighter training. The use of electric service at this location shall be to support the activities of the volunteer fire company. Any fund raising activities at this service location must be used solely to support volunteer fire fighting operations.

The customer of record at this service location must be a predominantly volunteer fire company recognized by the local municipality or PEMA as a provider of fire fighting services.

NON-PROFIT SENIOR CITIZEN CENTER - a separately metered service location consisting of a facility for the use of senior citizens coming together as individuals or groups and where access to a wide range of services to senior citizens is provided. The customer of record at this service location must be an organization recognized by the Internal Revenue Service (IRS) or the Commonwealth as a non-profit entity and recognized by the Pennsylvania Department of Aging as an operator of a senior citizen center. **(C)**

NON-PROFIT RESCUE SQUAD – a separately metered service location consisting of a building, sirens, a garage for housing vehicular rescue equipment; and qualified by the Commonwealth as a non-profit entity; and a facility recognized by the Pennsylvania Emergency Management Agency (PEMA) or the Pennsylvania Department of Health as a provider of rescue services. The use of electric service at this location shall be to support the activities of the non-profit rescue squad. Any fund raising activities at this service location must be used solely to support the non-profit rescue squad operations. **(C)**

NON-PROFIT AMBULANCE SERVICE – a separately metered service location consisting of a building, sirens, a garage for housing vehicular rescue equipment; and qualified by the Commonwealth as a non-profit entity; and a facility licensed by the Pennsylvania Department of Health as a provider of ambulance services. The use of electric service at this location shall be to support the activities of the non-profit ambulance service. Any fund raising activities at this service location must be used solely to support the non-profit ambulance service operations. **(C)**

TERM OF CONTRACT.

The initial contract term shall be for at least one year.

PAYMENT TERMS.

Standard.

(C) Denotes Change

SERVICE AGREEMENT (C)

Customer must execute a service agreement in the form prepared by the Company. Such agreement shall specify, among other things, the maximum daily interruptible transportation quantity or the total daily capacity of the customer's equipment. The standard agreement shall have a term of not less than one year, and shall continue from month to month thereafter unless terminated by the customer or the Company upon written notice to the other not less than sixty (60) days prior to the end of a term. Notwithstanding the above, the service agreement executed under this pilot Rate Schedule shall terminate at the conclusion of this Pilot Program. The Company may also terminate a service agreement at any time as provided by law or by provisions of this Tariff. A service agreement for a period of more or less than one year may be executed only upon the mutual agreement of the Company and the customer. Service initiation cannot take place until the special metering equipment is installed and operating to the Company's satisfaction. Service will be initiated only on the first day of a calendar month.

INTERRUPTIBLE SERVICE

1. QUALITY OF SERVICE

The Company may curtail (reduce) or interrupt deliveries to the customer whenever, at the Company's sole discretion, it determines that the available capacity in all or a portion of its system is projected to be insufficient to meet the requirements of all customers. Although the Company will endeavor to provide as much notice as is reasonable and practical, the customer shall maintain the ability to curtail or interrupt usage upon eight (8) hours notice. In the event of a system emergency, upon notice by the Company, the customer shall use its best efforts to curtail or interrupt usage upon less than eight (8) hours notice.

2. ALTERNATE FUEL CAPABILITY

In order to qualify for interruptible daily transportation service under this Rate Schedule, a customer must: (1) have installed and operable alternate fuel equipment, including appropriate fuel storage capacity, capable of displacing the daily quantity of gas subject to curtailment or interruption as specified in the appropriate subpart of section 5 below; or (2) or in the alternative demonstrate to the Company's sole satisfaction the ability to manage its business without the use of gas during periods of curtailment or interruption.

3. REQUIREMENTS

Customer is responsible for providing to the Company continuously-updated mailing and electronic addresses, as well as fax and voice telephone numbers, for communication of interruption notices on a 24-hour per day, 7-day per week basis. Interruption notices shall be considered received by the customer upon transmission by the Company to the electronic address and/or telephone number provided by the customer.

(C) - Change

4. PENALITIES FOR UNAUTHORIZED USAGE (C)

During any period of curtailment or interruption, the Company shall have the right to immediate access, without prior notice to the customer, to inspect the Company's gas measurement equipment and all gas-using facilities at the customer's premises. If the Company determines that the customer is using or has used a quantity of gas in excess of the quantity authorized by the notice of curtailment or interruption, the Company shall have the right to impose the following penalties: (a) to take measures to physically restrict the flow of gas into the customer's premises, or, if flow restriction is not practical, to terminate service; and, (b) to impose a penalty equal to the greater of any actual cost incurred or penalty imposed upon the Company as a result of the violation by the customer, or $25.00/Dth, in addition to the Company's cost of the gas used, for each Dth taken in excess of the quantity authorized in the notice. In addition to the foregoing, the customer shall hold the Company harmless and defend the Company against any and all claims against the Company arising from service problems caused or materially contributed to by the customer's violation of the notice of curtailment or interruption.

LEVELS OF SERVICE

For the purposes of the pilot program, existing customers will be placed into their corresponding rate class. The Company at its sole discretion will determine Level of Service.

1. IT-1

This interruptible rate will be available to customers who otherwise do not qualify for rates IT-2 through IT-8

2. IT-2

An applicant for service under this rate shall be required to execute a Service Agreement, contracting for not less than 2,500 Dth of gas transportation service per year under the terms of this Tariff, in which shall be defined maximum and minimum quantities of gas to be delivered. Customers electing service under this rate shall have and maintain complete and adequate standby non-natural gas energy (e.g., oil, propane, electric, steam) and equipment for alternate operation in the event of interruption of gas service.

3. IT-3

An applicant for service under this rate shall be required to execute a Service Agreement, contracting for not less than 5,000 Dth of gas transportation service per year under the terms of this Tariff, in which shall be defined maximum and minimum quantities of gas to be delivered. Customers electing service under this rate shall have and maintain complete and adequate standby non-natural gas energy (e.g., oil, propane, electric, steam) and equipment for alternate operation in the event of interruption of gas service.

(C) - Change

4. IT-4 (C)

An applicant for service under this rate shall be required to execute a Service Agreement, contracting for not less than 5,000 Dth of gas transportation service per year under the terms of this Tariff, in which shall be defined maximum and minimum quantities of gas to be delivered. Customers electing service under this rate shall have and maintain complete and adequate standby No. 4 oil and equipment for alternate operation in the event of interruption of gas service.

5. IT-5

An applicant for service under this rate shall be required to execute a Service Agreement, contracting for not less than 5,000 Dth of gas transportation service per year under the terms of this Tariff, in which shall be defined maximum and minimum quantities of gas to be delivered. Customers electing service under this rate shall have and maintain complete and adequate standby No. 5 or No. 6 oil and equipment for alternate operation in the event of interruption of gas service.

6. IT-6

An applicant for service under this rate shall be required to execute a Service Agreement, contracting for not less than 80,000 Dth of gas transportation service per year under the terms of this Tariff, in which shall be defined maximum and minimum quantities of gas to be delivered. Customers electing service under this rate shall have and maintain complete and adequate standby non-natural gas energy (e.g., oil, propane, electric, steam) and equipment for alternate operation in the event of interruption of gas service.

7. IT-7

An applicant for service under this rate shall be required to execute a Service Agreement, contracting for not less than 350,000 Dth of gas transportation service per year under the terms of this Tariff, in which shall be defined maximum and minimum quantities of gas to be delivered. Customers electing service under this rate shall have and maintain complete and adequate standby non-natural gas energy (e.g., oil, propane, electric, steam) and equipment for alternate operation in the event of interruption of gas service.

(C) - Change

8. IT-8 (C)

An applicant for service under this rate shall be required to execute a Service Agreement, in which shall be defined maximum and minimum quantities of gas to be delivered. Service shall be for gas transportation service for use in any form of combined cooling, heating and power production where there is sequential usage of energy in at least two distinct applications from the same fuel source or in sequential production of electrical energy and useful thermal energy from the same fuel source by a qualifying facility as defined in Section 201 of the Public Utilities Regulatory Policies Act of 1978. The determination by the Company as to the Customer's ability to co-generate will be final. Customers electing service under this rate shall have and maintain complete and adequate standby non-natural gas energy (e.g., oil, propane, electric, steam) and equipment for alternate operation in the event of interruption of gas service.

CHARGES

1. MONTHLY BILL

The monthly bill shall consist of the sum of the monthly customer charge and the transportation charge as detailed below:

CUSTOMER CHARGE	Per Meter Location Per Month
IT-1:	$ 75
IT-2:	$ 75
IT-3:	$ 150
IT-4:	$ 150
IT-5:	$ 150
IT-6:	$ 250
IT-7:	$ 250
IT-8:	$ 250

TRANSPORTATION CHARGE	Per Dth Delivered
IT-1:	$ 3.94 maximum
IT-2:	$ 3.70 maximum
IT-3:	$ 1.72 maximum
IT-4:	$ 1.28 maximum
IT-5:	$ 0.84 maximum
IT-6:	$ 0.83 maximum
IT-7:	$ 0.74 maximum
IT-8:	$ 0.75 maximum

(C) - Change

USA Coil & Air

Multi-Performance

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(610) 296-9763 (FAX)

Customer:
Project:
Date: 03/30/2004

No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
1	42.00	69.00	10	10		20.13	6672	71.80	58.40
LVG DB	**LVG WB**	**FACE VEL**	**AIR PD IN**	**ENT GLY**	**LVG GLY**	**GLY PD (FT)**	**GPM**	**TOTAL BTUH**	**SENSIBLE BTUH**
44.72	44.72	332	0.48	40.00	52.54	4.84	40.00	236191	199570
Qty: 1	Item: AHU-1		Model: GW58-KK-06942-F				Type: Glycol - %		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
2	48.00	85.00	9	10		28.33	11123	93.00	75.00
LVG DB	**LVG WB**	**FACE VEL**	**AIR PD IN**	**ENT GLY**	**LVG GLY**	**GLY PD (FT)**	**GPM**	**TOTAL BTUH**	**SENSIBLE BTUH**
46.33	46.32	393	0.74	40.00	53.00	31.25	161.0 0	985034	562478
Qty: 1	Item: AHU-2		Model: GW58-JK-08548-F				Type: Glycol - %		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
3	42.00	69.00	9	10		20.13	6447	86.30	70.60
LVG DB	**LVG WB**	**FACE VEL**	**AIR PD IN**	**ENT GLY**	**LVG GLY**	**GLY PD (FT)**	**GPM**	**TOTAL BTUH**	**SENSIBLE BTUH**
45.92	45.91	320	0.49	40.00	52.75	10.69	78.00	468305	283767
Qty: 1	Item: AHU-3		Model: GW58-JK-06942-F				Type: Glycol - %		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
4	42.00	69.00	9	10		20.13	6268	84.80	69.50
LVG DB	**LVG WB**	**FACE VEL**	**AIR PD IN**	**ENT GLY**	**LVG GLY**	**GLY PD (FT)**	**GPM**	**TOTAL BTUH**	**SENSIBLE BTUH**
45.81	45.80	311	0.46	40.00	52.74	9.39	72.00	431788	266734
Qty: 1	Item: AHU-4		Model: GW58-JK-06942-F				Type: Glycol - %		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

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No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
5	33.00	53.00	10	10		12.15	3394	79.80	65.70
LVG DB	LVG WB	FACE VEL	AIR PD IN	ENT GLY	LVG GLY	GLY PD (FT)	GPM	TOTAL BTUH	SENSIBLE BTUH
43.86	43.86	279	0.40	40.00	50.10	5.67	43.00	204468	133940
Qty: 1	Item: AHU-5		Model: GW58-KK-05333-F				Type: Glycol - %		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
6	33.00	53.00	10	10		12.15	3534	79.40	65.40
LVG DB	LVG WB	FACE VEL	AIR PD IN	ENT GLY	LVG GLY	GLY PD (FT)	GPM	TOTAL BTUH	SENSIBLE BTUH
45.35	45.35	291	0.43	40.00	52.31	4.52	34.00	197087	131989
Qty: 1	Item: AHU-6		Model: GW58-KK-05333-F				Type: Glycol - %		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
7	48.00	73.00	8	10		24.33	8375	93.00	75.00
LVG DB	LVG WB	FACE VEL	AIR PD IN	ENT GLY	LVG GLY	GLY PD (FT)	GPM	TOTAL BTUH	SENSIBLE BTUH
47.51	47.49	344	0.52	40.00	52.70	15.66	120.00	717610	412274
Qty: 1	Item: AHU-7		Model: GW58-HK-07348-F				Type: Glycol - %		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
8	42.00	69.00	10	10		20.13	7535	83.40	68.60
LVG DB	LVG WB	FACE VEL	AIR PD IN	ENT GLY	LVG GLY	GLY PD (FT)	GPM	TOTAL BTUH	SENSIBLE BTUH
45.37	45.36	374	0.71	40.00	52.42	13.13	86.00	502894	313304
Qty: 1	Item: AHU-8		Model: GW58-KK-06942-F				Type: Glycol - %		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

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No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
9	42.00	69.00	10	10	28	20.13	6381	76.70	63.20
LVG DB	**LVG WB**	**FACE VEL**	**AIR PD IN**	**ENT GLY**	**LVG GLY**	**GLY PD (FT)**	**GPM**	**TOTAL BTUH**	**SENSIBLE BTUH**
45.08	45.07	317	0.49	40.00	52.84	6.15	52.00	314206	221891
Qty: 1	Item: AHU-9		Model: GW58-KK-06942-F				Type: Glycol - 25%		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
10	33.00	93.00	7	10	22	21.31	14603	80.40	64.60
LVG DB	**LVG WB**	**FACE VEL**	**AIR PD IN**	**ENT GLY**	**LVG GLY**	**GLY PD (FT)**	**GPM**	**TOTAL BTUH**	**SENSIBLE BTUH**
51.20	50.89	685	1.36	40.00	53.28	19.07	92.00	575199	464582
Qty: 2	Item: AHU-10		Model: GW58-GK-09333-F				Type: Glycol - 25%		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
11	36.00	67.00	10	10	24	16.75	5930	84.30	67.80
LVG DB	**LVG WB**	**FACE VEL**	**AIR PD IN**	**ENT GLY**	**LVG GLY**	**GLY PD (FT)**	**GPM**	**TOTAL BTUH**	**SENSIBLE BTUH**
44.50	44.49	354	0.63	40.00	51.36	13.02	73.00	390320	257987
Qty: 1	Item: AHU-11		Model: GW58-KK-06736-F				Type: Glycol - 25%		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
12	54.00	89.00	8	10	36	33.38	16713	79.40	65.10
LVG DB	**LVG WB**	**FACE VEL**	**AIR PD IN**	**ENT GLY**	**LVG GLY**	**GLY PD (FT)**	**GPM**	**TOTAL BTUH**	**SENSIBLE BTUH**
48.63	48.55	501	0.91	40.00	53.35	15.83	125.0 0	785561	562238
Qty: 1	Item: AHU-12		Model: GW58-HK-08954-F				Type: Glycol - 25%		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

USA Coil & Air

Multi-Performance

P.O.BOX 578
DEVAULT, PA 19432
(800) 872-2645 (USA & CANADA)
(610) 296-9668
(610) 296-9763 (FAX)

Customer:
Project:
Date: 03/30/2004

No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
13	48.00	85.00	7	11	32	28.33	13386	79.40	65.00
LVG DB	**LVG WB**	**FACE VEL**	**AIR PD IN**	**ENT GLY**	**LVG GLY**	**GLY PD (FT)**	**GPM**	**TOTAL BTUH**	**SENSIBLE BTUH**
49.12	49.02	472	0.80	40.00	52.69	11.66	102.0 0	609100	442946
Qty: 1	Item: AHU-13		Model: GW58-GL-08548-F				Type: Glycol - 25%		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

No.	Fin HGT	Fin LTH	ROWS	FPI	CIRCT	FACE (SQ FT)	SCFM	EAT DB	EAT WB
14	33.00	53.00	6	10	22	12.15	2989	93.00	75.00
LVG DB	**LVG WB**	**FACE VEL**	**AIR PD IN**	**ENT GLY**	**LVG GLY**	**GLY PD (FT)**	**GPM**	**TOTAL BTUH**	**SENSIBLE BTUH**
51.52	51.45	246	0.22	40.00	52.64	3.89	38.00	226034	133649
Qty: 1	Item: AHU-14		Model: GW58-FK-05333-F				Type: Glycol - 25%		
Tube OD: 5/8"		Wall Thk: 0.02		Fin Thk: 0.006		Aluminum		Corrugated	

Quick select table

DESCRIPTION	UNIT SIZE						
	003	**004**	**006**	**008**	**010**	**012**	**014**
Airflow Range, CFM	900-2500	1200-3100	1700-4600	2200-6000	2900-7700	3600-9700	4200-11200
CFM @ 500 Feet/Minute Through Large Face Area Coil	1550	1950	2850	3750	4800	6050	7000
Height x Width, in.	34 x 38	38 x 40	38 x 52	40 x 58	44 x 64	50 x 66	50 x 74
COOLING COIL FACE AREA, sq.ft.							
Staggered Large	3.9	4.8	6.6	8.5	10.7	13.5	15.4
Large	3.1	3.9	5.7	7.5	9.6	12.1	14.0
Staggered Medium	2.6	3.4	4.7	6.4	8.3	9.8	11.2
Medium	2.1	2.8	4.1	5.6	7.4	8.8	10.2
Small	NA	2.3	3.3	4.7	6.4	7.7	8.9
FAN SECTION - depth, in. / weight, lbs.							
Largest Housed Fan & Motor Avail. w/ Top Hor. Discharge	32/478	32/492	36/24	40/928	40/951	46/1175	46/1271
Largest Inline Fan and Motor Available	N/A	N/A	N/A	N/A	N/A	44/1189	44/1222
Largest Belt Drive Plenum Fan and Motor Available	N/A	N/A	N/A	N/A	34/947	42/1271	42/932
Largest Direct Drive Plenum Fan and Motor Available	N/A	N/A	N/A	44/902	46/1054	56/1431	56/1514
Largest Twin Fan and Motor Available	N/A	N/A	N/A	50/1099	54/1461	56/1537	58/1726
MIXING BOX - depth, in. / weight, lbs.							
Mixing Box Only	20/232	20/252	20/299	20/344	22/421	24/454	24/493
ECONOMIZER - depth, in. / weight, lbs.							
	66/602	66/675	70/760	66/804	74/950	72/959	77/1130
BLENDER - depth, in. / weight, lbs.							
Largest Kees	18/189	20/219	24/292	26/348	28/401	34/492	36/554
Largest Blender Products IV	18/187	22/224	26/311	30/384	34/459	38/525	40/604
SIDE LOAD FILTER SECTIONS - depth, in. / weight, lbs.							
Flat 2" and 4"	12/163	12/174	12/209	12/235	12/259	12/281	12/301
2” Angular	32/324	30/332	30/397	30/437	30/479	30/504	30/548
Cartridge (12” deep w/2” Pre-Filter)	22/257	22/286	22/343	22/400	22/438	22/474	22/514
Bag (36” w/2” Pre-Filter)	42/398	42/431	42/517	42/584	42/640	42/677	42/734
FRONT LOAD FILTER SECTIONS - depth, in. / weight, lbs.							
Cartridge (12” deep w/2” Pre-Filter)	16/222	16/239	16/294	16/340	16/368	16/424	16/456
Bag (36” w/2” Pre-Filter)	40/388	40/419	40/497	40/570	40/611	40/678	40/735
FACE AND BYPASS - depth, in. / weight, lbs.							
Internal	12/188	12/206	12/248	12/284	12/321	12/352	12/386
External	18/264	18/289	18/349	20/415	22/482	24/549	24/595
COIL SECTIONS - depth, in. / weight, lbs.							
Heating Only (2 Row Water)	12/326	12/358	12/407	12/459	12/503	12/558	12/597
Cooling Only (4 Row Water)	24/495	24/663	24/767	24/733	24/814	24/903	24/1004
Cooling Only (6 Row Water)	24/527	24/703	24/822	24/805	24/905	24/1017	24/1136
Cooling and Reheat (12 Row Cooling & 1 Row Heating)	36/797	36/1033	36/1236	36/1289	36/1475	36/1690	36/1868
ACCESS SECTIONS - depth, in. / weight, lbs.							
16” Deep	16/171	16/183	16/217	16/241	16/260	16/277	16/299
24” Deep	24/217	24/231	24/274	24/304	24/329	24/349	24/377
30” Deep	30/252	30/270	30/320	30/355	30/384	30/407	30/440
36” Deep	36/293	36/313	36/371	36/410	36/444	36/470	36/509
42” Deep	42/329	42/352	42/417	42/461	42/499	42/529	42/572
48” Deep	48/366	48/391	48/464	48/513	48/556	48/588	48/688
54” Deep	54/386	54/411	54/489	54/581	54/631	54/663	54/722
DIFFUSER - depth, in. / weight, lbs.							
With Housed Fan	10/122	10/132	10/159	12/195	12/211	16/265	16/285
With Inline Fan	N/A	N/A	N/A	N/A	N/A	18/287	18/309
ATTENUATOR - depth, in. / weight, lbs.							
Short	40/368	40/449	40/531	40/673	40/749	40/831	40/901
Medium	52/485	52/595	52/742	52/858	52/958	52/1166	52/1280
Long	64/590	64/726	64/944	64/1091	64/1216	64/1420	64/1560
SUPPLY OR RETURN PLENUM - depth, in. / weight, lbs.							
Top, Bottom or End Opening	14/160	16/194	16/232	18/277	20/319	22/360	22/391

NOTES: Values based on typical industry sizes. Skyline Air Handling units are available in 2 inch increments of height and width to fit exact space requirements. Approximate shipping weights include roofcap option, 6"curb-ready base and double wall construction. Coil weights based on aluminum fins and 12 fins per inch with 18" vestibule. Mixing box section includes an end damper with hood. Economizer section includes side dampers with hoods. Front load filter sections include 24" upstream plenum section with tread plate for heavy duty floor liner. Height dimension includes 6" curb-ready base. Only horizontal units are available. Upblast and downblast poises not available for either housed fans or twin fans.

Quick select table - continued

DESCRIPTION	UNIT SIZE						
	017	**021**	**025**	**030**	**035**	**045**	**055**
Airflow Range, CFM	5000-13500	6000-16000	7300-19400	8500-22500	10000-26500	9600-25500	11400-30200
CFM @ 500 Feet/Minute Through Large Face Area Coil	8400	10050	12150	14150	16700	21300	25200
Height x Width, in.	52 x 80	52 x 82	66 x 86	66 x 98	72 x 102	84 x 106	96 x 106
COOLING COIL FACE AREA, sq. ft.							
Staggered Large	18.3	21.9	27.4	31.9	37.1	50.4	N/A
Large	16.8	20.1	24.3	28.3	33.4	42.6	50.4
Staggered Medium	13.7	17.2	21.3	24.8	29.7	34.9	46.5
Medium	12.6	15.8	18.2	21.2	24.1	31.0	38.8
Small	11.2	14.4	16.7	19.5	22.3	27.1	34.9
FAN SECTION - depth, in. / weight, lbs.							
Largest Housed Fan & Motor Available w/ Top Horizontal Dishcharge	50/1584	52/1735	58/2137	58/2410	58/2485	58/2574	60/2718
Largest Inline Fan & Motor Available	48/1520	54/1930	64/2810	64/2953	70/3505	82/4184	82/4524
Largest Belt Drive Plenum Fan & Motor Available	48/1823	52/2103	56/2690	58/3063	62/3430	66/3773	66/4150
Largest Direct Drive Plenum Fan & Motor Available	66/1608	68/1672	78/2643	78/2965	84/4082	86/4382	92/4633
Largest Twin Fan and Motor Available	58/1821	66/2296	66/2639	74/3269	82/3839	78/4415	78/5077
MIXING BOX - depth, in. / weight, lbs.							
Mixing Box Only	26/564	30/657	32/872	32/1022	36/1168	42/1248	48/1328
ECONOMIZER - depth, in. / weight, lbs.							
	80/1226	84/1319	84/1409	86/1768	100/1911	106/2136	112/2318
BLENDER - depth, in. / weight, lbs.							
Largest Kees	38/627	42/721	46/1023	48/1219	58/1496	64/1747	68/1921
Largest Blender Products IV	46/775	48/841	52/1087	60/1434	64/1588	70/1902	70/2287
SIDE LOAD FILTER SECTIONS - depth, in. / weight, lbs.							
Flat 2" and 4"	12/330	12/348	12/487	12/609	12/643	12/675	12/709
2” Angular	30/616	30/638	32/836	32/984	32/1055	32/1129	32/1208
Cartridge (12” deep w/2” Pre-Filter)	22/576	22/627	22/795	22/970	22/1042	22/1115	22/1193
Bag (36” w/2” Pre-Filter)	42/796	42/844	42/1054	42/1279	42/1348	44/1428	44/1515
FRONT LOAD FILTER SECTIONS - depth, in. / weight, lbs.							
Cartridge (12” deep w/2” Pre-Filter)	16/540	16/573	16/771	16/882	16/1012	20/1495	20/1787
Bag (36” w/2” Pre-Filter)	40/814	40/863	40/1074	40/1299	40/1403	44/1815	44/2122
FACE AND BYPASS - depth, in. / weight, lbs.							
Internal	12/422	12/452	12/617	12/747	12/800	12/896	12/897
External	26/684	30/778	32/1032	32/1200	34/1313	44/1458	50/1656
COIL SECTIONS - depth, in. / weight, lbs.							
Heating Only (2 Row Water)	12/657	16/740	12/1042	12/1133	12/1144	16/1219	16/1339
Cooling Only (4 Row Water)	24/1105	24/1208	36/2087	36/2292	36/2320	48/2390	48/2461
Cooling Only (6 Row Water)	24/1262	24/1396	42/2506	42/2829	42/2888	48/3177	48/3494
Cooling and Reheat (12 Row Cooling & 1 Row Heating)	36/2100	36/2358	42/2450	42/3084	42/3724	42/4170	42/4671
ACCESS SECTIONS - depth, in. / weight, lbs.							
16” Deep	16/323	16/339	16/478	16/587	16/618	16/655	16/687
24” Deep	24/407	24/426	24/577	24/697	24/731	24/775	24/814
30” Deep	30/474	30/497	30/657	30/784	30/823	30/783	30/822
36” Deep	36/549	36/575	36/744	36/879	36/923	36/969	36/1017
42” Deep	42/617	42/645	42/823	42/1032	42/1084	42/1138	42/1195
48” Deep	48/741	48/774	48/964	48/1121	48/1177	48/1235	48/1297
54” Deep	54/777	54/811	54/1025	54/1188	54/1247	54/1309	54/1374
DIFFUSER - depth, in. / weight, lbs.							
With Housed Fan	16/309	16/326	24/568	24/685	24/717	30/1004	30/1295
With Inline Fan	18/334	22/406	26/603	26/723	28/789	32/1222	32/2016
ATTENUATOR - depth, in. / weight, lbs.							
Short	40/1006	40/1095	40/1529	40/1749	40/1894	40/2083	40/2294
Medium	52/1436	52/1585	52/2051	52/2285	52/2591	52/2850	52/3135
Long	64/1752	64/1973	64/2518	64/2799	64/3124	64/3436	64/3779
SUPPLY OR RETURN PLENUM - depth, in. / weight, lbs.							
Top, Bottom or End Opening	24/475	28/547	30/741	30/881	32/962	36/1077	40/1195

NOTES: Values based on typical industry sizes. Skyline Air Handling units are available in 2 inch increments of height and width to fit exact space requirements. Approximate shipping weights include roofcap option, 6"curb-ready base and double wall construction. Coil weights based on aluminum fins and 12 fins per inch with 18" vestibule. Mixing box section includes an end damper with hood. Economizer section includes side dampers with hoods. Front load filter sections include 24" upstream plenum section with tread plate for heavy duty floor liner. Height dimension includes 6" curb-ready base. Only horizontal units are available. Upblast and downblast poises not available for either housed fans or twin fans.

Coil data

Table 12: Unit coil dimensional data — English units of measure

STANDARD CHILLED WATER, DX, or 3 & 4 ROW HEATING COILS *(English Units — inches and square feet)*							CLEANABLE COILS OR 1 & *2* ROW HEATING COILS *(English Units — inches and square feet)*					
Unit Size		**Stagg./ Large**	**Large**	**Stagg./ Medium**	**Medium**	**Small**		**Stagg./ Large**	**Large**	**Stagg./ Medium**	**Medium**	**Small**
003	FH x FL	—	18 x 25	—	12 x 25	—	FH x FL	—	18 x 22	—	12 x 22	—
	Face Area	—	3.1	—	2.1	—	Face Area	—	2.8	—	1.8	—
004	FH x FL	—	21 x 27	—	18 x 27	12 x 27	FH x FL	—	21 x 24	—	18 x 24	12 x 24
	Face Area	—	3.9	—	3.4	2.3	Face Area	—	3.5	—	3	2
006	FH x FL	—	21 x 39	—	18 x 39	12 x 39	FH x FL	—	21 x 36	—	18 x 36	12 x 36
	Face Area	—	5.7	—	4.9	3.3	Face Area	—	5.3	—	4.5	3
008	FH x FL	—	24 x 45	—	18 x 45	15 x 45	FH x FL	—	24 x 42	—	18 x 42	15 x 42
	Face Area	—	7.5	—	5.6	4.7	Face Area	—	7	—	5.3	4.4
010	FH x FL	—	27 x 51	—	21 x 51	18 x 51	FH x FL	—	27 x 48	—	21 x 48	18 x 48
	Face Area	—	9.6	—	7.4	6.4	Face Area	—	9	—	7	6
012	FH x FL	—	33 x 53	—	24 x 53	21 x 53	FH x FL	—	33 x 50	—	24 x 50	21 x 50
	Face Area	—	12.1	—	8.8	7.7	Face Area	—	11.5	—	8.3	7.3
014	FH x FL	—	33 x 61	—	27 x 61	21 x 61	FH x FL	—	33 x 58	—	27 x 58	21 x 58
	Face Area	—	14	—	11.4	8.9	Face Area	—	13.3	—	10.9	8.5
017	FH x FL	—	36 x 67	—	27 x 67	24 x 67	FH x FL	—	36 x 64	—	27 x 64	24 x 64
	Face Area	—	16.8	—	12.6	11.2	Face Area	—	16	—	12	10.7
021	FH x FL	—	42 x 69	—	33 x 69	30 x 69	FH x FL	—	42 x 66	—	33 x 66	30 x 66
	Face Area	—	20.1	—	15.8	14.4	Face Area	—	19.3	—	15.1	13.8
025	FH x FL	—	48 x 73	—	36 x 73	33 x 73	FH x FL	—	—	42 x 70	36 x 70	33 x 70
	Face Area	—	24.3	—	18.2	16.7	Face Area	—	—	20.4	17.5	16
	FH x FL	(2) 27 x 73	(2) 24 x 73	(2) 21 x 73	—	—	FH x FL	(2) 27 x 70	(2) 24 x 70	—	—	—
	Face Area	27.4	24.3	21.3	—	—	Face Area	26.2	23.3	—	—	—
030	FH x FL		48 x 85	—	36 x 85	33 x 85	FH x FL	—	—	42 x 82	36 x 82	33 x 82
	Face Area		28.3	—	21.2	19.5	Face Area	—	—	23.9	20.5	18.8
	FH x FL	(2) 27 x 85	(2) 24 x 85	(2)21 x 85	—	—	FH x FL	(2) 27 x 82	(2) 24 x 82	—	—	—
	Face Area	31.9	28.3	24.8	—	—	Face Area	30.8	27.3	—	—	—
035	FH x FL		54 x 89	—	42 x 89	39 x 89	FH x FL	—	—	—	42 x 86	39 x 86
	Face Area		33.4	—	24.1	22.3	Face Area	—	—	—	23.3	21.5
	FH x FL	(2) 30 x 89	(2) 27 x 89	(2)24 x 89	—	—	FH x FL	(2) 30 x 86	(2) 27 x 86	(2)24 x 86	—	—
	Face Area	37.1	33.4	29.7	—	—	Face Area	35.8	32.3	28.7	—	—
045	FH x FL	—	—	—	48 x 93	—	FH x FL	—	—	—	—	—
	Face Area	—	—	—	31	—	Face Area	—	—	—	—	—
	FH x FL	(2) 39 x 93	(2) 33 x 93	(2) 27 x 93	(2) 24 x 93	—	FH x FL	(2) 39 x 90	(2) 33 x 90	(2) 27 x 90	(2) 24 x 90	—
	Face Area	50.4	42.6	34.9	31.0	—	Face Area	48.8	41.3	33.8	30.0	—
055	FH x FL	(2) 45 x 93	—	—	—	—	FH x FL	—	—	—	—	—
	Face Area	58.1	—	—	—	—	Face Area	—	—	—	—	—
	FH x FL	—	(2) 39 x 93	(2) 36 x 93	(2) 30 x 93	—	FH x FL	—	(2) 39 x 90	(2) 36 x 90	(2) 30 x 90	—
	Face Area	—	50.4	46.5	38.8	—	Face Area	—	48.8	45.0	37.5	—

Coil section depth limitation by number of rows in coil for single banks of coils (excludes staggered coils)

Section depth	Maximum number of rows
12"	2 row water or steam
14"	4 row water (except 5WM & 5WD)
16"	4 row 5WM & 5WD water

Cooling only section (no moisture eliminator)

Section depth	Maximum number of rows
18"	4 row DX or water (except 5WM & 5WD)
24"	8 row DX or water
30”	10 row DX or 12 water

Combination cooling and 1 or 2 row reheat (no moisture eliminator)

Section depth	Maximum number of rows
24"	6 row water or DX
30"	10 row water or DX
36"	12 row water

NOTES: The spacing between coil casings is a minimum of 4". If more access between coils is required, increase the section depth. Cooling coil sections are available in section depths of 18", 24", 30", 36", 42", 48", 54". If a moisture eliminator is required, use the next larger section size.

Direct Cooling

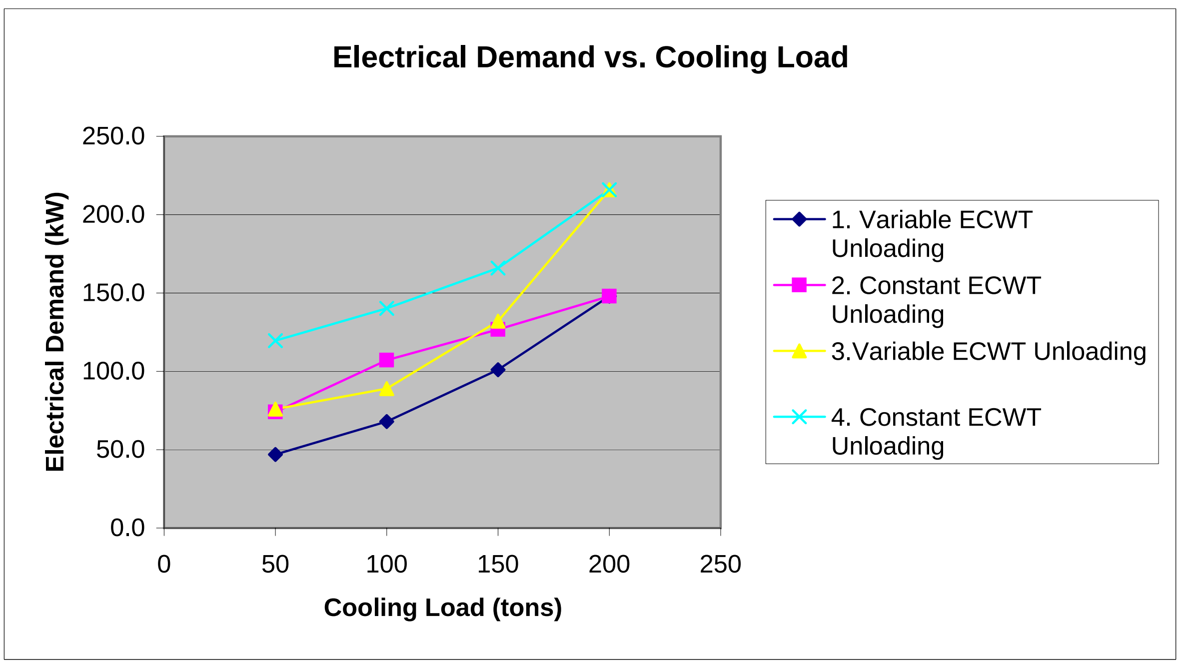
1. Variable ECWT Unloading							
Capacity	% Capacity	kW	%kW	kW/ton	CWT	ambient reduct	
200	100%	148.0	100%	0.740	85	0	@ 85
150	75%	101.0	68%	0.673	75	20.40%	@ 75
100	50%	68.0	46%	0.680	65	36.50%	@ 65
50	25%	47.0	32%	0.940	65	36.50%	@ 65

2. Constant ECWT Unloading					
Capacity	% Capacity	kW	%kW	kW/ton	CWT
200	100%	148.0	100%	0.740	85
150	75%	126.8	86%	0.845	85
100	50%	107.1	72%	1.071	85
50	25%	74.0	50%	1.480	85

Ice Making

3.Variable ECWT Unloading							
Capacity	% Capacity	kW	%kW	kW/ton	CWT	ambient reduct	
200	100%	216.0	100%	1.080	85	0	@ 85
150	75%	132.0	61%	0.880	75	20.40%	@ 75
100	50%	89.0	41%	0.890	65	36.50%	@ 65
50	25%	76.0	35%	1.520	65	36.50%	@ 65

4. Constant ECWT Unloading					
Capacity	% Capacity	kW	%kW	kW/ton	CWT
200	100%	216.0	100%	1.080	85
150	75%	165.8	77%	1.106	85
100	50%	140.2	65%	1.402	85
50	25%	119.7	55%	2.394	85



25% Ethylene Glycol Properties, Discharging

Spec Grav	1.04	
Density	64.90	lbm/cf
Viscosity	3.07	centipoise
Viscosity	0.0307	poise
Viscosity	0.00206	lbm/(ft*s)

	Glycol Property Interpolation		
	20%	25%	30%
40	2.59		3.54
40	2.59	3.065	3.54
50	2.18		2.95

1200.8

skyline coil	Branch #	AHU	Individual Flows gpm	Entering branch flow gpm	Pipe D in.	Pipe D ft.	Pipe Area (sf)	Eq H Run Length ft	Volume flow (cf/s)	Velocity (ft/s)	Density (lbm/cf)	μ @ 49 F	ε ft (steel)	ε/D	Re	f	Δh	Coil Pdrop	running pipe	running @ coil
021	CHWP-01	**1**	43.0	1200.8	10.0	0.833	0.54542	220.0	2.675	4.9053	64.90	0.00206	0.00015	0.000180	1.29E+05	0.0155	1.52891	4.84	1.53	6.37
035	CHWP-02	**2**	173.2	1157.8	8.0	0.667	0.34907	122.5	2.580	7.3898	64.90	0.00206	0.00015	0.000225	1.55E+05	0.0170	2.648858	31.25	4.18	35.43
025	CHWP-03	**3**	83.9	984.5	8.0	0.667	0.34907	122.5	2.194	6.2841	64.90	0.00206	0.00015	0.000225	1.32E+05	0.0170	1.915474	10.69	6.09	16.78
025	CHWP-04	**4**	77.5	900.6	8.0	0.667	0.34907	122.5	2.007	5.7484	64.90	0.00206	0.00015	0.000225	1.21E+05	0.0175	1.649963	9.39	7.74	17.13
014	CHWP-05	**9**	56.0	823.1	8.0	0.667	0.34907	122.5	1.834	5.2539	64.90	0.00206	0.00015	0.000225	1.10E+05	0.0180	1.417688	6.15	9.16	15.31
010	CHWP-06	**6**	36.6	767.2	8.0	0.667	0.34907	122.5	1.709	4.8968	64.90	0.00206	0.00015	0.000225	1.03E+05	0.0180	1.231507	4.52	10.39	14.91
010	CHWP-07	**5**	46.3	730.6	8.0	0.667	0.34907	122.5	1.628	4.6633	64.90	0.00206	0.00015	0.000225	9.80E+04	0.0180	1.116856	5.67	11.51	17.18
025	CHWP-08	**7**	129.1	684.3	8.0	0.667	0.34907	122.5	1.525	4.3680	64.90	0.00206	0.00015	0.000225	9.18E+04	0.0185	1.007097	15.66	12.52	28.18
021	CHWP-09	**8**	92.5	555.2	6.0	0.500	0.19635	122.5	1.237	6.3001	64.90	0.00206	0.00015	0.000300	9.93E+04	0.0185	2.793508	13.13	15.31	28.44
014	CHWP-10	**11**	78.5	462.7	6.0	0.500	0.19635	122.5	1.031	5.2501	64.90	0.00206	0.00015	0.000300	8.27E+04	0.0190	1.992367	13.02	17.30	30.32
2 x 045	CHWP-11	**12**	134.5	384.1	5.0	0.417	0.13635	122.5	0.856	6.2767	64.90	0.00206	0.00015	0.000360	8.24E+04	0.0190	3.417237	15.83	20.72	36.55
2 x 055	CHWP-12	**10**	99.0	249.6	4.0	0.333	0.08727	122.5	0.556	6.3734	64.90	0.00206	0.00015	0.000450	6.69E+04	0.0205	4.751875	19.07	25.47	44.54
010	CHWP-13	**14**	40.9	150.6	4.0	0.333	0.08727	122.5	0.336	3.8460	64.90	0.00206	0.00015	0.000450	4.04E+04	0.0225	1.899213	3.89	27.37	31.26
035	CHWP-14	**13**	109.8	109.8	3.0	0.250	0.04909	122.5	0.245	4.9815	64.90	0.00206	0.00015	0.000600	3.92E+04	0.0225	4.248266	11.66	31.62	43.28
								1812									**31.61882**			44.54
	Vertical Run		1200.8	1200.8	10.0	0.833	0.54542	128.0	2.675	4.9053	64.90	0.00206	0.00015	0.000180	1.29E+05	0.0170	**0.975633**			
																			45.52	ft wg

	Individual Flows gpm	Entering branch flow gpm	Pipe D in.	Pipe D ft.	Pipe Area (sf)	Eq V Run Length ft	Volume flow (cf/s)	Velocity (ft/s)	Density (lbm/cf)	μ @ 49 F	ε ft (steel)	ε/D	Re	f	Δh		
Condenser Pump	1800	n/a	12.0	1.000	0.78540	128	4.010	5.1062	64.90	0.00206	0.00015	0.000150	1.61E+05	0.0160	0.829169	0.8291693	ft wg
														(@ disch)	cond	22.8	ft wg
																23.629169	ft wg

Appendix IV-8

1510 5BC

Flow Rate (GPM)	1200	Pump Head (Feet)	45.52
Viscosity (SSU)	37	Specific Gravity	1.04
Speed (RPM)	1750	NPSHr (Feet)	16.8
Weight (lbs)	610	Cost Index	100%
Suction Size (in.)	6	Suction Velocity (fps)	13.3
Discharge Size (in.)	5	Discharge Velocity (fps)	19.2
Impeller Size (in.)	9.0	Pump Efficiency (%)	76.10
Max. Flow (GPM)	1287	Duty Flow/Max Flow (%)	93.3
Flow @ BEP (GPM)	975	Min. Rec. Flow (GPM)	243.7
Selected Motor Size (HP)	20	Selected Motor Size (kw)	14.91
Duty-Point Power (BHP)	19.02	Duty-Point Power (kw)	14.18
Maximum Power (BHP)	19.64	Maximum Power (kw)	14.65
Motor Manufacturer	US Prem Eff	Full Load Amps	24.00
Manufacturer Catalog Number	E906	Full Load Efficiency (%)	94.0
Frame Size	256T	Full Load Power Factor (%)	80.4

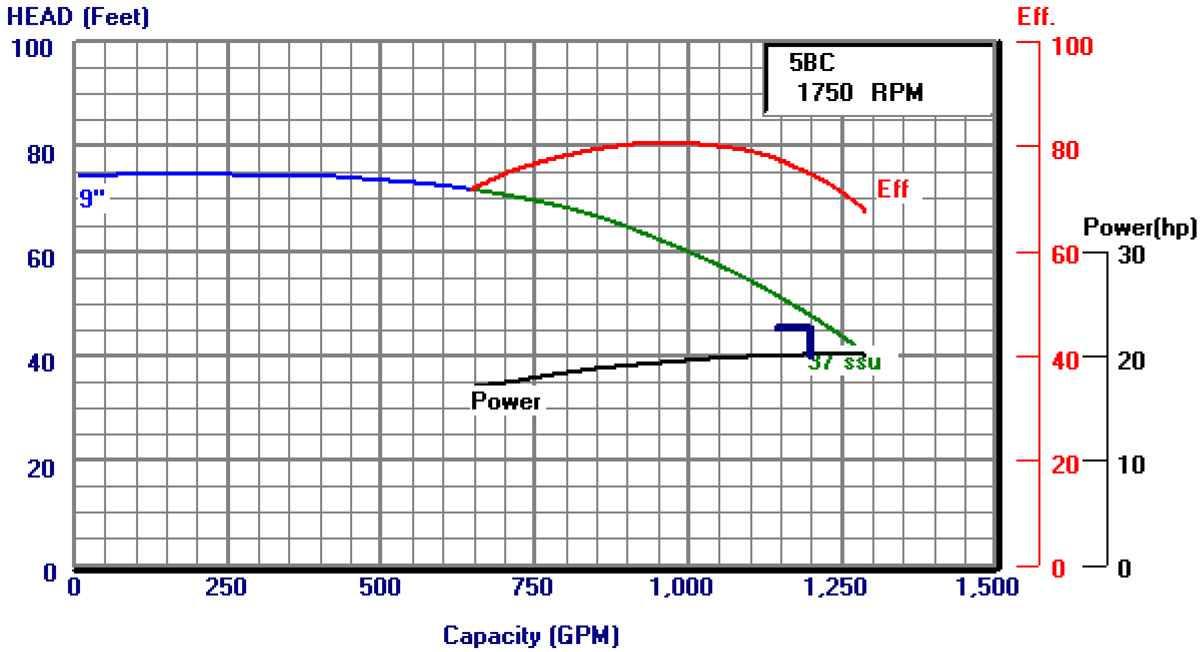
Select another pump
Return to Bell & Gosssett Home Page

Appendix IV-8

Bell & Gossett

ITT Industries

Curve Generation
Version CE1.18



Pump Series: 1510
Suction Size = 6 "
Discharge Size = 5 "

Min Imp Dia = 7 "
Max Imp Dia = 9.5 "
Cut Dia = 9 "

Design Capacity =1200.0
Design Head =45.5
Motor Size =20 HP

ITT Bell & Gossett
8200 N. Austin
Morton Grove, Il 60053

The Power and Eff. curves shown are corrected for viscosity.

Generate Another Pump Curve

- [ ] Display Max/Min Imp. curves
- [x] Display Efficiency Curve
- [x] Display Power Curve
- [ ] Display NPSHr Curve
- [x] Display Duty-Point Marker
- [ ] Display System Curve
- [x] Display Minor Gridlines
- [ ] Display Dark Background

Single Pump Operation

Constant Speed Operation

Enter RPM values for variable speed operation

or leave blank to have ESP choose values.

0 RPM #1

0 RPM #2

If Variable Speed (or Open System),
Enter a Control Head (or Static Head)

0

Appendix IV-8

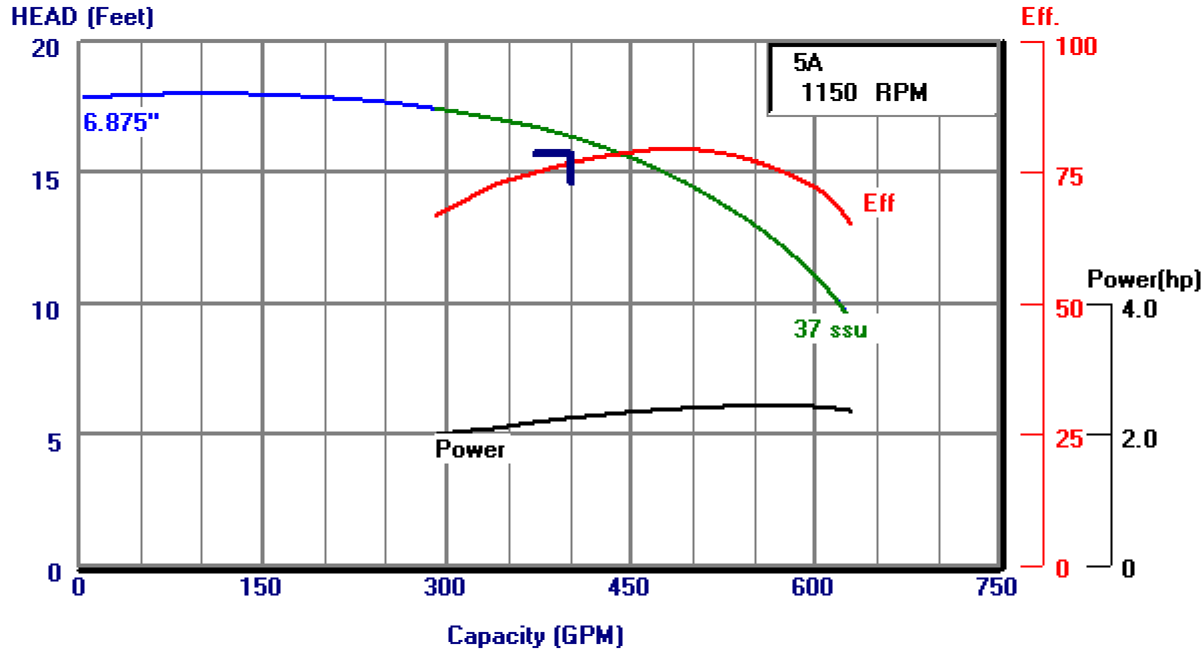
1510 5A			
Flow Rate (GPM)	400	Pump Head (Feet)	15.7
Viscosity (SSU)	37	Specific Gravity	1.04
Speed (RPM)	1150	NPSHr (Feet)	3.0
Weight (lbs)	440	Cost Index	100%
Suction Size (in.)	6	Suction Velocity (fps)	4.4
Discharge Size (in.)	5	Discharge Velocity (fps)	6.4
Impeller Size (in.)	6.875	Pump Efficiency (%)	80.88
Max. Flow (GPM)	619	Duty Flow/Max Flow (%)	64.6
Flow @ BEP (GPM)	491	Min. Rec. Flow (GPM)	122.7
Selected Motor Size (HP)	3	Selected Motor Size (kw)	2.24
Duty-Point Power (BHP)	2.06	Duty-Point Power (kw)	1.54
Maximum Power (BHP)	2.27	Maximum Power (kw)	1.69
Motor Manufacturer	US High Eff	Full Load Amps	4.40
Manufacturer Catalog Number	R334	Full Load Efficiency (%)	89.5
Frame Size	213T	Full Load Power Factor (%)	64.2

Select another pump
Return to Bell & Gosssett Home Page

Appendix IV-8

Bell & Gossett
ITT Industries

Curve Generation
Version CE1.18



Pump Series: 1510
Suction Size = 6 "
Discharge Size = 5 "

Min Imp Dia = 5.5 "
Max Imp Dia = 7 "
Cut Dia = 6.875 "

Design Capacity =400.0
Design Head =15.7
Motor Size =3 HP

ITT Bell & Gossett
8200 N. Austin
Morton Grove, Il 60053

The Power and Eff. curves shown are corrected for viscosity.

Generate Another Pump Curve

☐ Display Max/Min Imp. curves
☑ Display Efficiency Curve
☑ Display Power Curve
☐ Display NPSHr Curve

☑ Display Duty-Point Marker
☐ Display System Curve
☑ Display Minor Gridlines
☐ Display Dark Background

Single Pump Operation

Constant Speed Operation

Enter RPM values for variable speed operation

or leave blank to have ESP choose values.

0 RPM #1

0 RPM #2

If Variable Speed (or Open System),
Enter a Control Head (or Static Head)

0

Appendix IV-8

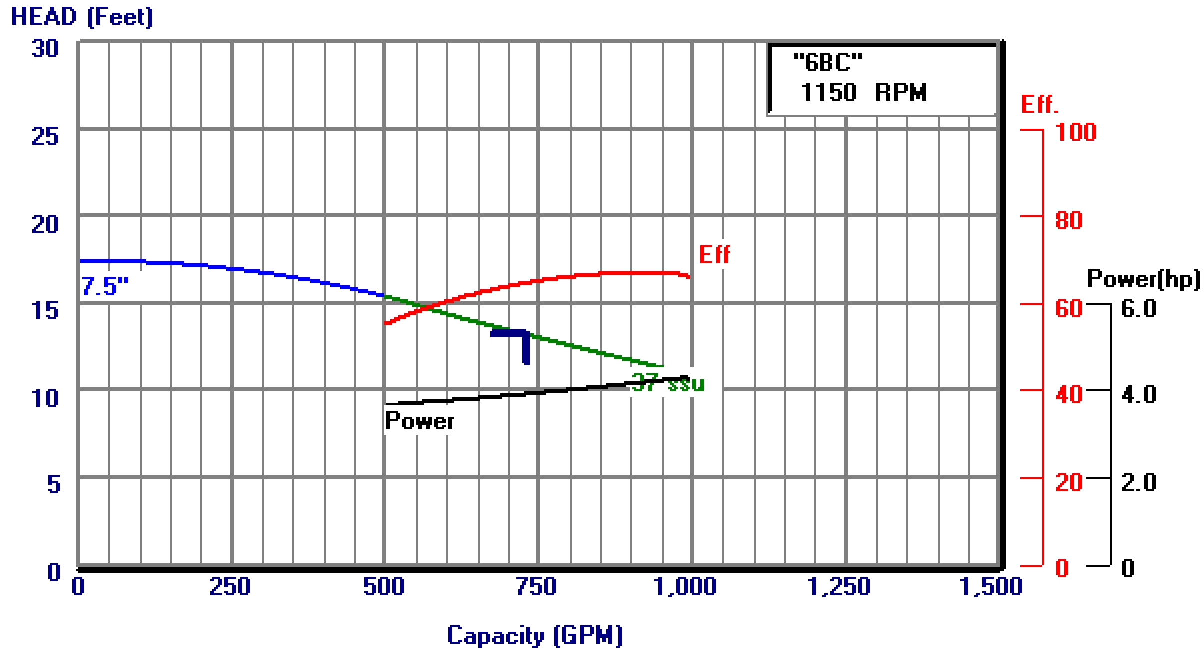
1510 6BC			
Flow Rate (GPM)	731	Pump Head (Feet)	13.25
Viscosity (SSU)	37	Specific Gravity	1.04
Speed (RPM)	1150	NPSHr (Feet)	3.9
Weight (lbs)	560	Cost Index	100%
Suction Size (in.)	8	Suction Velocity (fps)	4.7
Discharge Size (in.)	6	Discharge Velocity (fps)	8.1
Impeller Size (in.)	7.5	Pump Efficiency (%)	68.19
Max. Flow (GPM)	992	Duty Flow/Max Flow (%)	73.7
Flow @ BEP (GPM)	901	Min. Rec. Flow (GPM)	225.2
Selected Motor Size (HP)	5	Selected Motor Size (kw)	3.73
Duty-Point Power (BHP)	3.73	Duty-Point Power (kw)	2.78
Maximum Power (BHP)	4.07	Maximum Power (kw)	3.04
Motor Manufacturer	US Prem Eff	Full Load Amps	7.20
Manufacturer Catalog Number	R338	Full Load Efficiency (%)	89.9
Frame Size	215T	Full Load Power Factor (%)	66.6

Select another pump
Return to Bell & Gosssett Home Page

Appendix IV-8

Bell & Gossett
ITT Industries

Curve Generation
Version CE1.18



Pump Series: 1510
Suction Size = 8 "
Discharge Size = 6 "

Min Imp Dia = 7.5 "
Max Imp Dia = 9.5 "
Cut Dia = 7.5 "

Design Capacity =731.0
Design Head =13.3
Motor Size =5 HP

ITT Bell & Gossett
8200 N. Austin
Morton Grove, Il 60053

The Power and Eff. curves shown are corrected for viscosity.

Generate Another Pump Curve

- [ ] Display Max/Min Imp. curves
- [x] Display Efficiency Curve
- [x] Display Power Curve
- [ ] Display NPSHr Curve
- [x] Display Duty-Point Marker
- [ ] Display System Curve
- [x] Display Minor Gridlines
- [ ] Display Dark Background

Single Pump Operation

Constant Speed Operation

Enter RPM values for variable speed operation

or leave blank to have ESP choose values.

0 RPM #1

0 RPM #2

If Variable Speed (or Open System),
Enter a Control Head (or Static Head)

0

Appendix IV-8

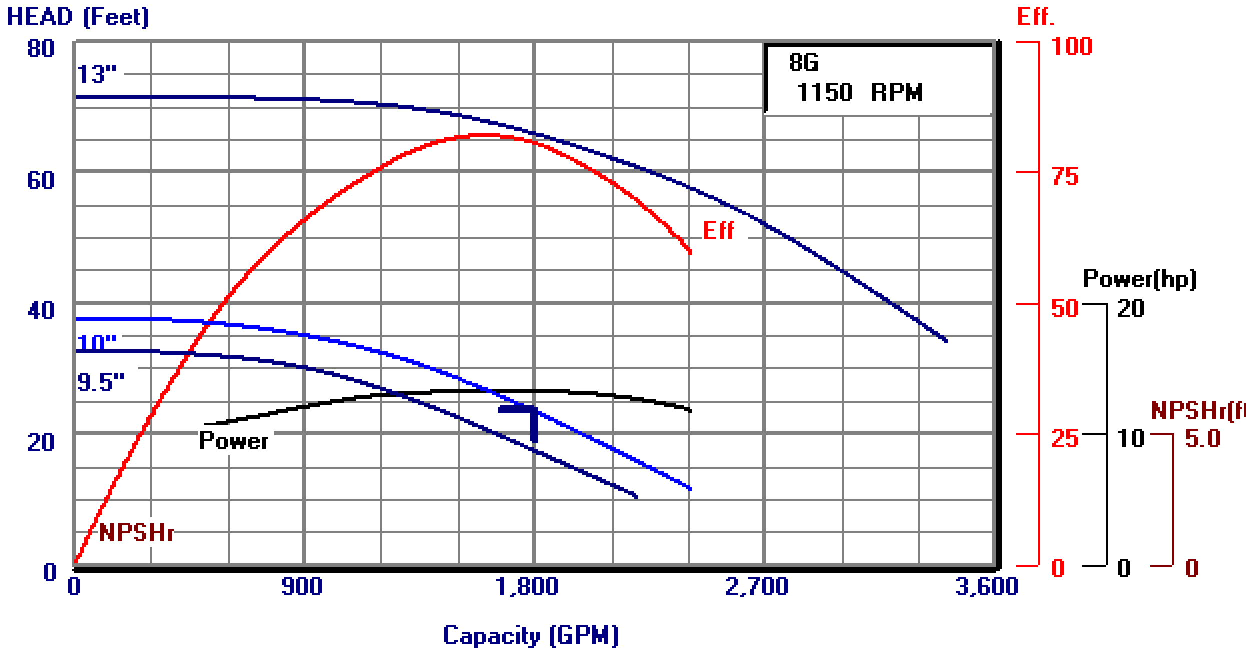
1510 8G			
Flow Rate (GPM)	1800	Pump Head (Feet)	23.6
Speed (RPM)	1150	NPSHr (Feet)	n/a
Weight (lbs)	1120	Cost Index	100%
Suction Size (in.)	10	Suction Velocity (fps)	7.3
Discharge Size (in.)	8	Discharge Velocity (fps)	11.5
Impeller Size (in.)	10.0	Pump Efficiency (%)	80.63
Max. Flow (GPM)	2409	Duty Flow/Max Flow (%)	74.7
Flow @ BEP (GPM)	1489	Min. Rec. Flow (GPM)	372.3
Selected Motor Size (HP)	15	Selected Motor Size (kw)	11.19
Duty-Point Power (BHP)	13.29	Duty-Point Power (kw)	9.91
Maximum Power (BHP)	13.23	Maximum Power (kw)	9.87
Motor Manufacturer	US Prem Eff	Full Load Amps	18.40
Manufacturer Catalog Number	J473	Full Load Efficiency (%)	92.8
Frame Size	284T	Full Load Power Factor (%)	79.4

Select another pump
Return to Bell & Gosssett Home Page

Appendix IV-8

Bell & Gossett
ITT Industries

Curve Generation Version CE1.18



Pump Series: 1510	Min Imp Dia = 9.5 "	Design Capacity =1800.0	ITT Bell & Gossett
Suction Size = 10 "	Max Imp Dia = 13 "	Design Head =23.6	8200 N. Austin
Discharge Size = 8 "	Cut Dia = 10 "	Motor Size =15 HP	Morton Grove, Il 60053

The Power and Eff. curves shown are for the cut dia. impeller.

Generate Another Pump Curve

- ☑ Display Max/Min Imp. curves
- ☑ Display Efficiency Curve
- ☑ Display Power Curve
- ☑ Display NPSHr Curve
- ☑ Display Duty-Point Marker
- ☐ Display System Curve
- ☑ Display Minor Gridlines
- ☐ Display Dark Background

Single Pump Operation

Constant Speed Operation

Enter RPM values for variable speed operation

or leave blank to have ESP choose values.

0 RPM #1

0 RPM #2

If Variable Speed (or Open System), Enter a Control Head (or Static Head)

0

Appendix IV-9

```
Product Line:            NC Class
   Model                 NC8305J1
   No. of Cells          1
   Motor                 40 HP, 1800 RPM
   Motor Output          40.0 BHP
   Tower Flow Rate       1800 GPM
   Hot Water Temp.       95.00 °F
   Cold Water Temp.      85.00 °F
   Wet-Bulb Temp.        75.00 °F

   ## CTI Certified ##

   Fan                   8.00 ft Dia., 6 Blades
   Fan Speed             473 RPM, 11888 ft/min
   Air Flow              147400 CFM Per Cell
                         147400 CFM Total

Weights:             Per Cell **    Total **
   Shipping           9147 lb        9147 lb
   Max. Operating    19442 lb       19442 lb

Dimensions:          Per Cell       Total
   Width             18.75 ft       18.75 ft
   Length            10.90 ft       10.90 ft
   Height            12.98 ft       12.98 ft
   Static Lift       12.23 ft

   For CAD layouts refer to DXF file NC8305

Minimum Clearance for Enclosures:
   Clearance required on air inlet sides of tower without
altering
   performance.  Assumes no air from below tower.

   Solid Wall         8.06 ft
   50% Open Wall      6.31 ft

Collection Basin Heater Sizing:
   Minimum ambient temperature to maintain water at 40.00
°F

   Heater kW/Cell    18.0   15.0   12.0    9.0    7.5
6.0    4.5
   Ambient Temp °F -16.14  -6.05   4.04  14.13  19.17
24.22  29.26
```

MONTHLY ENERGY CONSUMPTION

By psuae

Alternative: 1 PA Lab Facility

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Electric													
On-Pk Cons. (kWh)	561,428	506,213	553,879	545,417	664,702	720,629	827,665	753,052	667,750	584,283	550,933	554,303	7,490,254
On-Pk Demand (kW)	814	817	793	798	852	1,017	1,408	1,053	987	799	809	814	1,408
Off-Pk Demand (kW)	922	919	1,154	1,148	1,223	1,305	1,474	1,275	1,263	1,172	1,160	904	1,474
Gas													
On-Pk Cons. (therms)	12,607	11,994	8,808	5,347	2,244	1,186	700	908	1,596	5,129	6,689	9,907	67,115
On-Pk Demand (therms/hr)	24	24	17	11	4	3	3	3	4	10	14	19	24
Water													
Cons. (1000gal)	0	0	45	159	631	922	1,253	1,021	709	242	127	0	5,109

(------- Monthly Energy Consumption -------)

Building Energy Consumption = 722,797 Btu/(ft2-year)
Source Energy Consumption = 1,875,871 Btu/(ft2-year)
Floor Area = 44,654 ft2

MONTHLY UTILITY COSTS

By psuae

Alternative: 1

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Electric													
On-Pk Cons. ($)	42,316	40,107	41,491	41,262	47,432	56,368	71,072	58,670	53,415	42,886	41,762	42,005	578,787
On-Pk Demand ($)	4,788	4,801	4,661	4,690	5,006	5,971	8,258	6,187	5,797	4,697	4,757	4,783	64,396
Total ($):	47,104	44,908	46,152	45,952	52,438	62,339	79,331	64,857	59,212	47,583	46,519	46,788	643,183
Gas													
On-Pk Cons. ($)	2,243	2,141	1,612	1,038	522	347	266	301	415	1,001	1,260	1,795	12,941
Monthly Total ($):	49,346	47,049	47,764	46,990	52,960	62,685	79,597	65,158	59,627	48,585	47,780	48,583	656,124

LITHONIA LIGHTING

Catalog Number	
Appendix V-1	
Notes	Type

FEATURES & SPECIFICATIONS

INTENDED USE

High performance deep-cell parabolic luminaires for superior light control, visual comfort and light cutoff in open area applications.

ATTRIBUTES

Designed for optimal performance with T8 lamps and electronic ballasts.

Choice of low iridescent diffuse or specular louver finishes. Also available with Achroma™ non-iridescent louver finish.

CONSTRUCTION

Black reveal provides floating louver appearance, conceals optional air-supply slots.

Integral T-bar safety clips hold T-bar securely; no fasteners required to install.

Overlapping flange and modular ceiling trims factory-installed with standard swing-gate hangers or field convertible with optional trim and hangers. T-hinges die-formed for maximum strength. Latches spring-loaded, concealed in reveal.

Optional heat-removal dampers and air closure strips to control airflow.

Housing formed from cold-rolled steel. Louvers formed from anodized aluminum. No asbestos is used in this product.

FINISH

Five-stage iron-phosphate pretreatment ensures superior paint adhesion and rust resistance. Painted parts finished with high-gloss, baked white enamel.

ELECTRICAL SYSTEM

Thermally-protected, resetting, Class P, HPF, non-PCB, UL Listed, CSA certified ballast is standard. Energy saving and electronic ballasts are sound rated A.

Luminaire is suitable for damp locations. AWM, TFN or THHN wire used throughout, rated for required temperatures.

LISTING

UL Listed (standard). CSA Certified or NOM Certified (see Options).

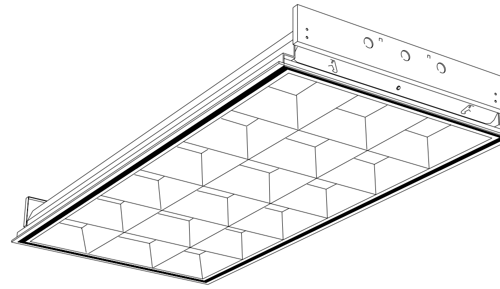
WARRANTY

Guaranteed for one year against mechanical defects in manufacture.

Specifications subject to change without notice.

PARAMAX® Parabolic Troffer

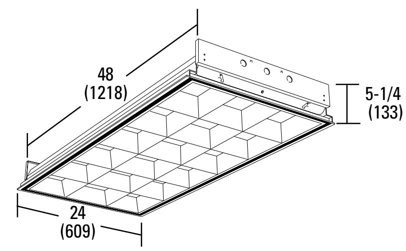
2PM3N 2'x4'



3" Deep Louver

Specifications

Length: 24 (609)
Width: 48 (1218)
Depth: 5-1/4 (133)
Weight: 35 lbs (15.9 kg)



All dimensions are inches (millimeters).

ORDERING INFORMATION

Example: **2PM3N G B 3 32 18LD 120 GEB**

2PM3N

Series

- **2PM3N** Paramax 3" deep cell parabolic, 2' wide

Trim type

- **G** Grid
- **F** Overlapping flange
- **MT** Modular fit-in
- **ST** Screw slot

Air function

- **A** Air supply/return (slots in side trim)
- **H** Heat removal (through lamp cavity, dampers available)
- **B** No air function
- **D** Dual function supply/return/ removal

Number of lamps

2, 3, 4

Lamp type

- **32** 32W T8 (48")
- **40** 40W T12 (48")

Not included.

Number of cells [1]

12 , 16 , 18 , 24, 32

Louver finish

- **LD** Low iridescent anodized diffuse silver
- **ND** Achroma™ non-iridescent diffuse silver
- **LS** Low iridescent anodized specular silver[3]
- **C** Diffuse gold anodized (champagne)[3]
- **W** White enamel[3]

Voltage

120, 277, 347, MVOLT[2]

Others available.

Options

- **1/3** One 3-lamp ballast
- **1/4** One 4-lamp ballast
- **GEB** Electronic ballast, ≤20% THD
- **GEB10IS** Electronic ballast, ≤10% THD, Instant Start
- **GEB10RS** Electronic ballast, ≤10% THD, Rapid Start
- **EL** Emergency battery pack (nominal 300 lumens; see Fluorescent Battery Packs tab)
- **LST** Tandem fixture pairs (shared ballasts)
- **PWS1836** 6' prewire, 3/8" dia., 18-gauge, 3 wires
- **GLR** Internal fast-blow fuse
- **GMF** Internal slow-blow fuse
- **LP__** Lamped; specify lamp type and color
- **CRE** Flanged trim for continuous row mounting (end)
- **CRM** Flanged trim for continuous row mounting (middle)
- **ACS** Air closure strips (A and D models only)
- **HRD** Heat-removal dampers
- **APB** Air-pattern control blades (A and D models only)[3]
- **PAF** Painted after fabrication (white enamel)[3]
- **2R** Two reflector channel covers[4]
- **JP** Palletized and stretch-wrapped (G and MT trim only)
- **CSA** CSA Certified
- **NOM** NOM Certified

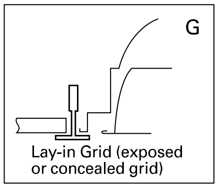
NOTES:

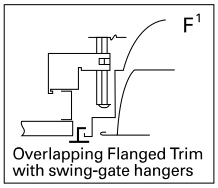
1 Typical cell configuration determined by lamp quantity unless specified otherwise.
2 MVOLT available with GEB10IS only.
3 Consult factory for housing depth.
4 Available with 3-lamp 18 or 24 cell only.

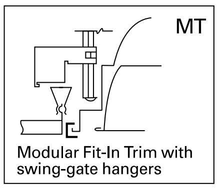
MOUNTING DATA

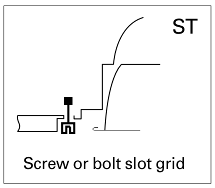
Continuous row mounting of flanged units requires CRE and CRM trim options (see options).

Ceiling Type	Appropriate Trim Type
Exposed grid tee	**G**
Concealed grid tee	**G, ST**
Concealed Z-spline	**F, MT**
Metal pan (consult factory)	**MT**
Screw slot (consult factory)	**ST**
Acoustical tile, plaster or plasterboard on rigid support parallel to lamps	**F**





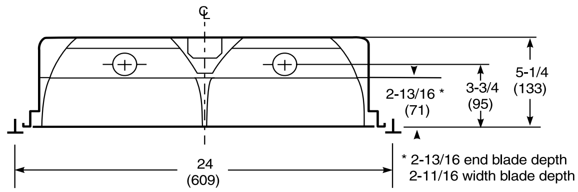


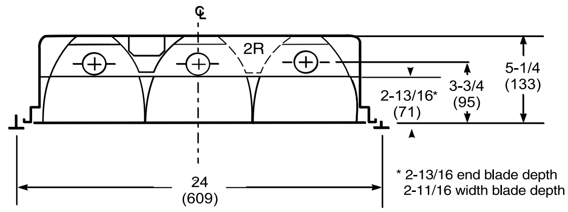


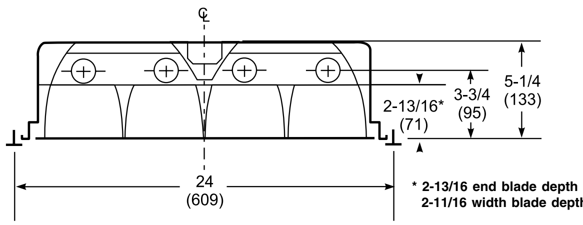
NOTE:

1 Recommended rough-in dimensions for F trim fixtures 24"x48" (Tolerance is +1/4", -O"). Swing-gate range 1-7/16" to 3-7/16", span 23-1/2" to 26-7/16".

DIMENSIONS







PHOTOMETRICS

Calculated using the zonal cavity method in accordance with IESNA LM41 procedures. Floor reflectances are 20%. Lamp configurations shown are typical. Full photometric data on these and other configurations available upon request.

Energy (Calculated in accordance with NEMA standard LE-5)

LER.FP	ANNUAL ENERGY COST*	LAMP DESCRIPTION	LAMP LUMENS	BALLAST FACTOR	WATTS
62 (LD louver)	$3.87	(2) 32WT8	2850	.88	62
60 (ND louver)	$4.00	(2) 32WT8	2850	.88	62
66 (LD louver)	$3.64	(3) 32WT8	2850	.88	86
62 (ND louver)	$3.87	(3) 32WT8	2850	.88	86
61 (LD louver)	$3.96	(4) 32WT8	2850	.88	111

* Comparative yearly lighting energy cost per 1000 lumens

2PM3N 2 32 12LD

Report LTL 6369 – Lumens per lamp = 2900

S/MH (along) 1.3 (across) 1.5

Coefficient of Utilization

Ceiling	80%			70%			50%		
Wall	70%	50%	30%	70%	50%	30%	50%	30%	10%
0	91	91	91	89	89	89	85	85	85
1	85	82	79	83	80	77	77	75	73
2	78	72	68	76	71	67	68	65	62
3	71	64	58	69	63	58	61	56	53
4	65	57	51	64	56	50	54	49	45
5	60	51	44	59	50	44	48	43	39
6	55	46	39	54	45	39	44	38	34
7	51	41	35	50	41	35	40	34	30
8	48	38	31	46	37	31	36	31	27
9	44	34	28	43	34	28	33	28	24
10	41	32	26	41	31	25	30	25	22

Zonal Lumens Summary

Zone	Lumens	%Lamp	%Fixture
0-30	1256	21.7	28.4
0-40	2133	36.8	48.2
0-60	4074	70.3	92.0
0-90	4428	76.3	100.0
90-180	0	0	0
0-180	4428	76.3	100.0

2PM3N 3 32 18LD

Report LTL 6347 – Lumens per lamp = 2900

S/MH (along) 1.3 (across) 1.6

Coefficient of Utilization

Ceiling	80%			70%			50%		
Wall	70%	50%	30%	70%	50%	30%	50%	30%	10%
0	90	90	90	88	88	88	84	84	84
1	84	81	78	82	79	77	76	74	73
2	77	72	68	76	71	67	68	65	62
3	71	65	60	70	64	59	61	57	54
4	66	58	52	64	57	52	55	51	47
5	61	52	46	59	51	46	50	45	41
6	56	47	41	55	47	41	45	40	36
7	52	43	37	51	42	37	41	36	32
8	49	39	33	48	39	33	38	33	29
9	46	36	30	45	36	30	35	30	26
10	43	33	28	42	33	27	32	27	24

Zonal Lumens Summary

Zone	Lumens	%Lamp	%Fixture
0-30	2132	24.5	32.5
0-40	3711	42.7	56.6
0-60	6142	70.6	93.7
0-90	6552	75.3	100.0
90-180	0	0	0
0-180	6552	75.3	100.0

2PM3N 4 32 32LD

Report LTL 6366 – Lumens per lamp = 2900

S/MH (along) 1.2 (across) 1.3

Coefficient of Utilization

Ceiling	80%			70%			50%		
Wall	70%	50%	30%	70%	50%	30%	50%	30%	10%
0	80	80	80	78	78	78	74	74	74
1	75	72	70	73	71	69	68	66	65
2	69	65	61	68	64	60	61	59	56
3	64	58	54	63	57	53	55	52	49
4	59	52	47	58	52	47	50	46	43
5	55	47	42	54	47	42	45	41	38
6	51	43	38	50	42	37	41	37	33
7	47	39	34	46	39	34	38	33	30
8	44	36	31	43	35	30	35	30	27
9	41	33	28	40	33	28	32	27	24
10	39	30	25	38	30	25	29	25	22

Zonal Lumens Summary

Zone	Lumens	%Lamp	%Fixture
0-30	2791	24.1	35.9
0-40	4592	39.6	59.1
0-60	7443	64.2	95.7
0-90	7775	67.0	100.0
90-180	0	0	0
0-180	7775	67.0	100.0

 Pm3n-2X4.p65

Lithonia Lighting

Acuity Lighting Group, Inc.

Fluorescent

One Lithonia Way, Conyers, GA 30012

Phone: 800-858-7763 Fax: 770-929-8789

In Canada: 1100 50th Ave., Lachine, Quebec H8T 2V3

www.lithonia.com

Type Catalog number

Appendix V-1

FEATURES

- Full family of light controlling parabolic luminaires designed to control screen glare in VDT open office environments.
- Meets IES RP-1 minimum luminance criteria for office lighting systems in VDT applications.
- Choice of diffuse or specular louvers utilize the latest developments in louver finishing for minimized louver iridescence. Ideal for use with triphosphor lamps.
- Black reveal provides floating louver appearance, conceals optional air-supply slots.
- Overlapping flange and modular ceiling trims factory-installed with standard swing-gate hangers or field convertible with optional trim and hanger kits.
- Optional heat-removal dampers and air-pattern control blades allow airflow control.
- T-hinges die-formed for maximum strength. Latches spring-loaded, concealed in reveal.
- Guaranteed for one year against mechanical defects in manufacture.

SPECIFICATIONS

BALLAST — Thermally-protected, resetting, Class P, HPF, non-PCB, UL listed, CSA certified ballast is standard. Energy-saving and electronic ballasts are sound rated A. Standard combinations are CBM approved and conform to UL 935.

WIRING & ELECTRICAL — Fixture conforms to UL 1570 and is suitable for damp locations. AWM, TFN or THHN wire used throughout, rated for required temperatures.

MATERIALS — Housing formed from cold-rolled steel. Louvers formed from anodized aluminum. No asbestos is used in this product.

FINISH — Five-stage iron-phosphate pretreatment ensures superior paint adhesion and rust resistance. Painted parts finished with high-gloss, baked white enamel.

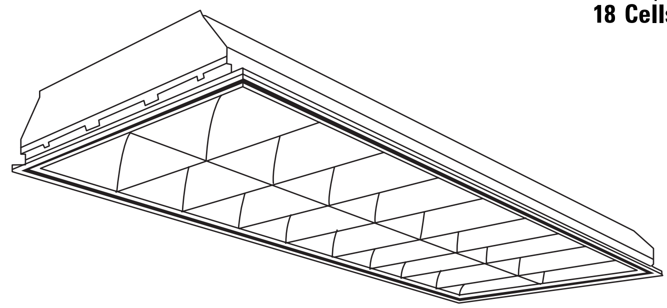
LISTING — UL listed and labeled. Listed and labeled to comply with Canadian Standards and Mexican Standards (see options).

Specifications subject to change without notice.

Optimax® Parabolic Light Control System

PMO 2'x4'

2 Lamps
18 Cells



ENERGY

- Luminaire Efficacy Rating (LER) and Annual Energy Cost/1000 Lumens:

  2-lamp LER.FP (LS louver) = 54. Annual energy cost = $4.44. Based on 32W T8 lamps, 2850 lumen lamp and electronic ballast with ballast factor = .88 and input watts = 62.

Calculated in accordance with NEMA standard LE-5.

PHOTOMETRICS

Calculated using the zonal cavity method in accordance with IESNA LM41 procedure. Floor reflectances are 20%.
Lamp configurations shown are typical. Full photometric data on these and other configurations available upon request.

2PMO GB 2 32 18LS
Report LTL 6028 – Lumens per lamp = 2900
S/MH (along) 1.2 S/MH (across) 1.3
Coefficient of Utilization

Ceiling		80%			70%			50%	
Wall	70%	50%	30%	70%	50%	30%	50%	30%	10%
0	80	80	80	78	78	78	75	75	75
1	76	74	72	74	72	71	70	68	67
2	72	68	65	70	67	64	65	62	60
3	67	62	59	66	61	58	60	57	54
4	63	57	53	62	56	53	55	52	49
5	59	52	48	58	52	47	50	47	44
6	55	48	43	54	48	43	47	43	40
7	51	44	39	50	43	39	42	38	35
8	47	40	35	46	39	35	38	34	31
9	44	36	31	43	35	31	35	30	27
10	41	33	28	40	32	28	32	27	24

Zonal Lumens Summary

Zone	Lumens	%Lamp	%Fixture
0-30	1675	28.9	43.0
0-40	2728	47.0	70.0
0-60	3896	67.2	100.0
0-90	3898	67.2	100.0
90-180	0	0	0
0-180	3898	67.2	100.0

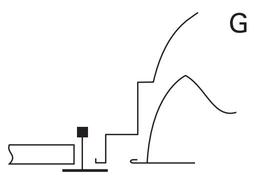
Luminance Summary - cd/m²

Angle	0	45	90
45	1839	3096	3582
55	76	832	574
65	0	0	0
75	0	0	0
85	0	0	0

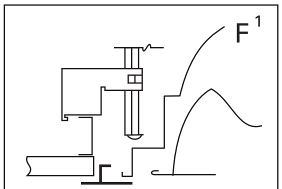
MOUNTING DATA

Continuous row mounting of flanged units requires CRE and CRM trim options (see Options).

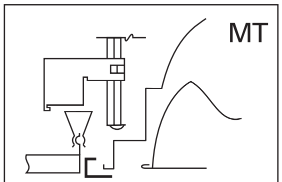
Ceiling Type	Appropriate Trim Type
Exposed grid tee	**G**
Concealed grid tee	**G, ST**
Concealed Z-spline	**F, MT**
Metal pan (consult factory)	**MT**
Screw slot (consult factory)	**ST**
Acoustical tile, plaster, or plasterboard on rigid support parallel to lamps	**F**



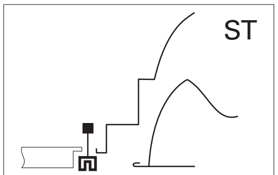
Lay-in Grid (exposed or concealed grid)



Overlapping Flanged Trim with swing-gate hangers



Modular Fit-In Trim with swing-gate hangers

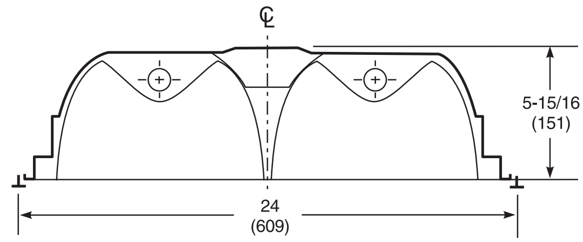


Screw or bolt slot grid

NOTES:
1 Recommended rough-in dimensions for F trim fixtures 24"x48" (Tolerance is +1/4", -O"). Swing-gate range 1" to 3-1/4", span 23-1/2" to 26-5/16".

DIMENSIONS

Inches (millimeters). Subject to change without notice.



ORDERING INFORMATION

Example: **2PMO G B 2 32 18LD 120 GEB**

2PMO ___ ___ ___ ___ ___ ___ ___ ___

Series
- **2PMO** Optimax Light Control System, 2' wide

Trim type
- **G** Grid
- **F** Overlapping flanged
- **MT** Modular fit-in
- **ST** Screw slot

Air function
- **A** Air supply/return (slots in side trim)
- **H** Heat removal (through lamp cavity, dampers available)
- **D** Combination A & H
- **B** Static (no air function, matching appearance)

Number of lamps
- **2**
- Not included.

Lamp type
- **32** 32W T8 (48")
- **40** 40W T12 (48")

Number of cells
- **18** 2 rows of 9

Louver finish
- **LD** Low iridescent diffuse silver
- **LS** Low iridescent specular silver

Voltage
- **120, 277, 347, MVOLT** [1]
- Others available.

Options
- **GEB** Electronic ballast, ≤20% THD
- **GEB10IS** Electronic ballast, ≤10% THD, Instant Start
- **GEB10RS** Electronic ballast, ≤10% THD, Rapid Start
- **EL** Emergency battery pack (nominal 300 lumens)
- **PWS1836** 6' prewire, 3/8" dia., 18-gauge, 3 wires
- **LST** Tandem fixture pairs (shared ballasts)
- **GLR** Internal fast-blow fuse
- **GMF** Internal slow-blow fuse
- **LP__** Lamped, specify lamp type and color
- **CRE** Flanged trim for continuous row mounting (end)
- **CRM** Flanged trim for continuous row mounting (middle)
- **HRD** Heat-removal dampers
- **APB** Air-pattern control blades (A and D models only)
- **PAF** Painted after fabrication (white enamel)
- **JP10** Palletized and stretch-wrapped without individual cartons (10 per), G and MT trim only
- **CSA** Listed and labeled to comply with Canadian Standards
- **NOM** Listed and labeled to comply with Mexican Standards

NOTES:
1 MVOLT available with GEB10IS only.

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www.lithonia.com • IN CANADA: 1100 50TH AVE., LACHINE, QUEBEC H8T 2V3

Catalog Number	Type
Appendix V-1	

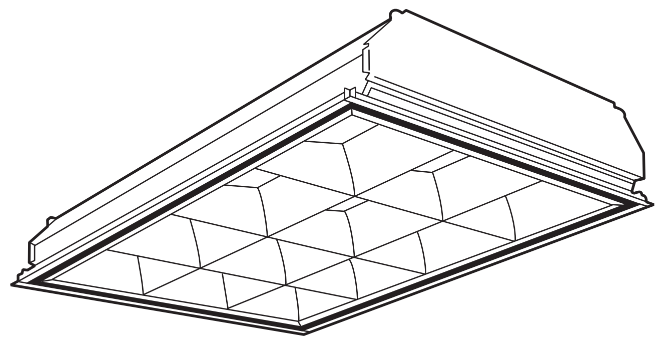
FEATURES

- Full family of light controlling parabolic luminaires designed to control screen glare in VDT open office environments.
- Efficiently delivers appropriate illumination level for paper-based tasks.
- Models available to meet IES RP-1 preferred luminance criteria for office lighting systems in VDT applications.
- Choice of diffuse or specular louvers utilize the latest developments in louver finishing for minimized louver iridescence. Ideal for use with triphosphor lamps.
- Black reveal provides floating louver appearance, conceals optional air supply slots.
- Overlapping flange and modular ceiling trims factory installed with standard swing-gate hangers or field convertible with optional trim and hanger kits.
- Optional heat-removal dampers and air-pattern control blades allow airflow control.
- T-hinges die-formed for maximum strength. Latches spring-loaded, concealed in reveal.
- Guaranteed for one year against mechanical defects in manufacture.

Optimax® Parabolic Light Control System

PMO 2'x2'

3 Lamps
12 Cells



SPECIFICATIONS

BALLAST — Thermally protected, resetting, Class P, HPF, non-PCB, UL listed, CSA certified ballast is standard. Energy-saving and electronic ballasts are sound rated A. Standard combinations are CBM approved and conform to UL 935.

WIRING & ELECTRICAL — Fixture conforms to UL 1570 and is suitable for damp locations. AWM, TFN or THHN wire used throughout, rated for required temperatures.

MATERIALS — Housing formed from cold-rolled steel. Louvers formed from anodized aluminum. No asbestos is used in this product.

FINISH — Five-stage iron-phosphate pretreatment ensures superior paint adhesion and rust resistance. Painted parts finished with high-gloss, baked white enamel.

LISTING — UL listed and labeled. Listed and labeled to comply with Canadian and Mexican Standards (see options).

Specifications subject to change without notice.

PHOTOMETRICS

Calculated using the zonal cavity method in accordance with IESNA LM41 procedures. Floor reflectances are 20%. Lamp configurations shown are typical. Full photometric data on these and other configurations available upon request.

2PMO G B 3 U31 12LS
Report LSI 7565
S/MH (along) 1.2 (across) 1.5
Coefficient of Utilization

Ceiling	80%			70%			50%		
Wall	70%	50%	30%	70%	50%	30%	50%	30%	10%
1	68	66	65	67	65	64	63	61	60
2	64	61	59	63	60	58	58	56	54
3	60	56	53	59	55	52	54	51	49
4	57	52	48	56	51	48	50	47	44
5	53	47	43	52	47	43	46	42	40
6	50	44	39	49	43	39	42	39	36
7	46	40	36	46	39	35	39	35	32
8	43	36	32	42	36	32	35	31	29
9	40	33	29	39	32	28	32	28	25
10	37	30	26	36	30	26	29	25	23

Zonal Lumens Summary

Zone	Lumens	%Lamp	%Fixture
0-30	2300	27.4	45.3
0-40	3708	44.2	73.0
0-60	5066	60.3	99.8
0-90	5074	60.4	100.0
90-180	0	0	0
0-180	5074	60.4	100.0

Luminance Summary - cd/m²

Angle	Along	45	Across
45	6831	7240	4997
55	1391	1672	96
65	24	9	9
75	0	0	7
85	0	0	23

2PMO G B 3 CF40 12LS
Report LSI 7534
S/MH (along) 1.3 (across) 2.1
Coefficient of Utilization

Ceiling	80%			70%			50%		
Wall	70%	50%	30%	70%	50%	30%	50%	30%	10%
1	71	70	68	70	68	67	66	64	63
2	67	64	61	66	63	60	61	59	57
3	63	59	56	62	58	55	56	54	52
4	60	54	50	58	54	50	52	49	47
5	56	50	46	55	49	45	48	44	42
6	52	46	42	51	45	41	44	41	38
7	49	42	38	48	42	37	41	37	34
8	45	38	34	44	38	34	37	33	30
9	42	35	30	41	34	30	34	30	27
10	39	32	27	38	31	27	31	27	24

Zonal Lumens Summary

Zone	Lumens	%Lamp	%Fixture
0-30	2730	28.9	45.7
0-40	4495	47.6	75.2
0-60	5973	63.2	99.9
0-90	5978	63.3	100.0
90-180	0	0	0
0-180	5978	63.3	100.0

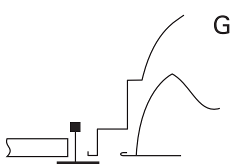
Luminance Summary - cd/m²

Angle	Along	45	Across
45	7814	8833	3649
55	1654	1309	80
65	8	8	8
75	0	0	0
85	0	0	0

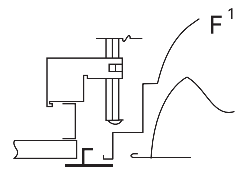
MOUNTING DATA

Continuous row mounting of flanged units requires CRE and CRM trim options (see Options).

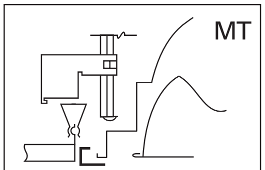
Ceiling Type	Appropriate Trim Type
Exposed grid tee	**G**
Concealed grid tee	**G, ST**
Concealed Z-spline	**F, MT**
Metal pan (consult factory)	**MT**
Screw slot (consult factory)	**ST**
Acoustical tile, plaster, or plasterboard on rigid support parallel to lamps	**F**



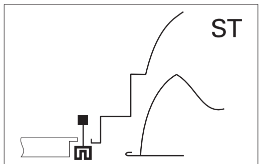
Lay-in Grid (exposed or concealed grid)



Overlapping Flanged Trim with swing-gate hangers



Modular Fit-In Trim with swing-gate hangers



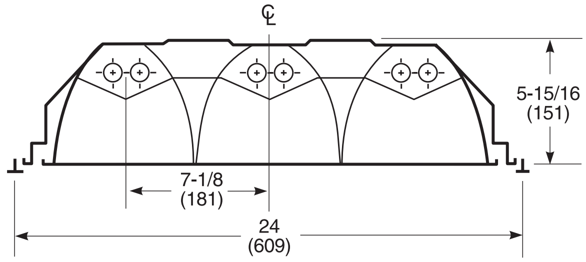
Screw or bolt slot grid

NOTES:

1 Recommended rough-in dimensions for F trim fixtures 24" x 24" (Tolerance is +1/4", -O"). Swing-gate range 1" to 4-3/16", span 23-1/2" to 26-5/16".

DIMENSIONS

Inches (millimeters). Subject to change without notice.



ORDERING INFORMATION

Example: **2PMO G B 3 17 12LD 120 GEB**

2PMO ___ ___ **3** ___ ___ ___ ___

Series

2PMO Optimax Light Control System, 2' wide

Trim type

- **G** Grid
- **F** Overlapping flanged
- **MT** Modular fit-in
- **ST** Screw slot

Air function

- **A** Air supply/return (slots in side trim)
- **H** Heat removal (through lamp cavity, dampers available)
- **D** Combination A & H
- **B** Static (no air function, matching appearance)

Number of lamps

3

Not included.

Lamp type

- **17** 17W T8 (24")
- **20** 20W TS T12 (24")
- **U31** 31W T8 U lamp (24")
- **CF40** 40W RS CF (24")

Number of cells

12 3 rows of 4

Louver finish

- **LD** Low iridescent diffuse silver
- **LS** Low iridescent specular silver

Voltage

120, 277, 347, MVOLT[1]

Others available.

Options

- **1/3** One 3-lamp ballast
- **GEB** Electronic ballasts, ≤20% THD
- **GEB10IS** Electronic ballast, ≤10% THD, Instant Start
- **GEB10RS** Electronic ballast, ≤10% THD, Rapid Start
- **EL** Emergency battery pack (nominal 300 lumens; see Life Safety Section)
- **GLR** Internal fast-blow fuse
- **GMF** Internal slow-blow fuse
- **PWS1836** 6' prewire, 3/8" dia., 18-gauge, 3 wires
- **LP__** Lamped, specify lamp type and color
- **HRD** Heat-removal dampers
- **APB** Air-pattern control blades (A & D models only)
- **CRE** Flanged trim for continuous row mounting (end)
- **CRM** Flanged trim for continuous row mounting (middle)
- **PAF** Painted after fabrication (white enamel)
- **CSA** Listed and labeled to comply with Canadian Standards
- **NOM** Listed and labeled to comply with Mexican Standards
- **JP16** Palletized & stretch-wrapped (16 per), G and MT trim only

NOTE:

1 MVOLT available with GEB10IS only.

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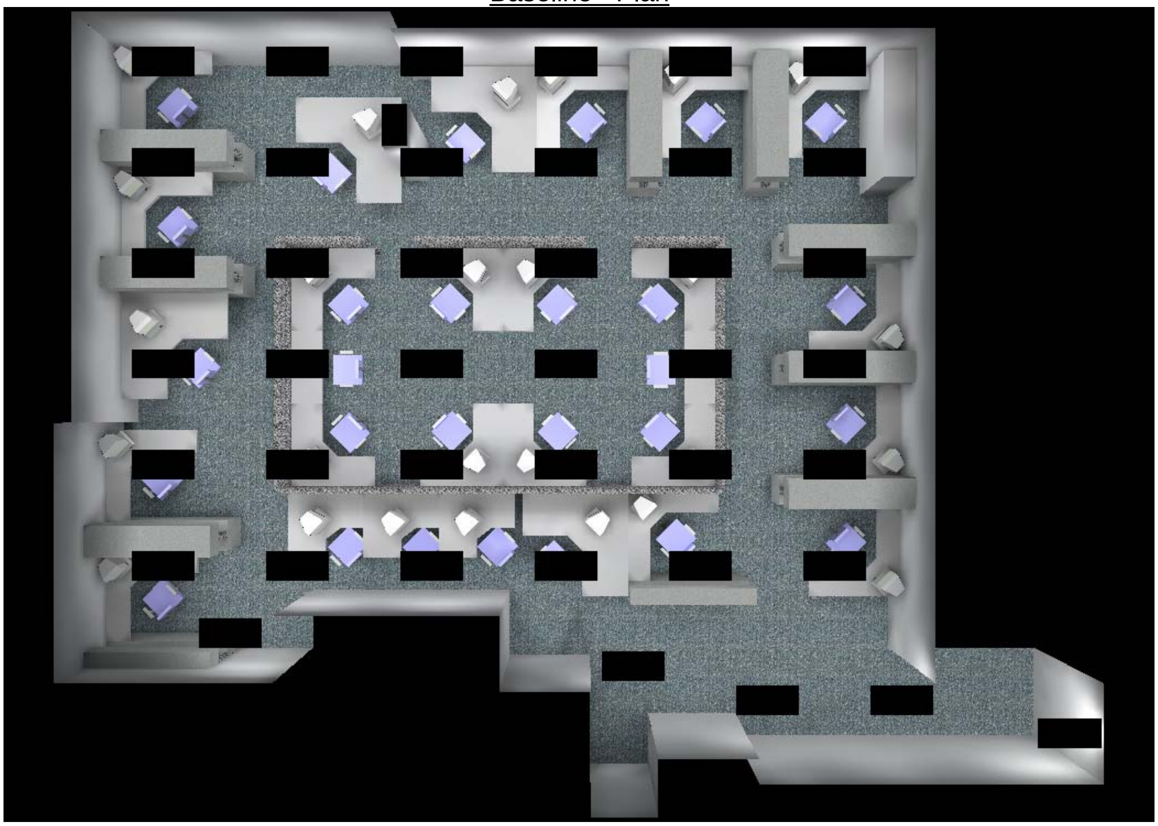
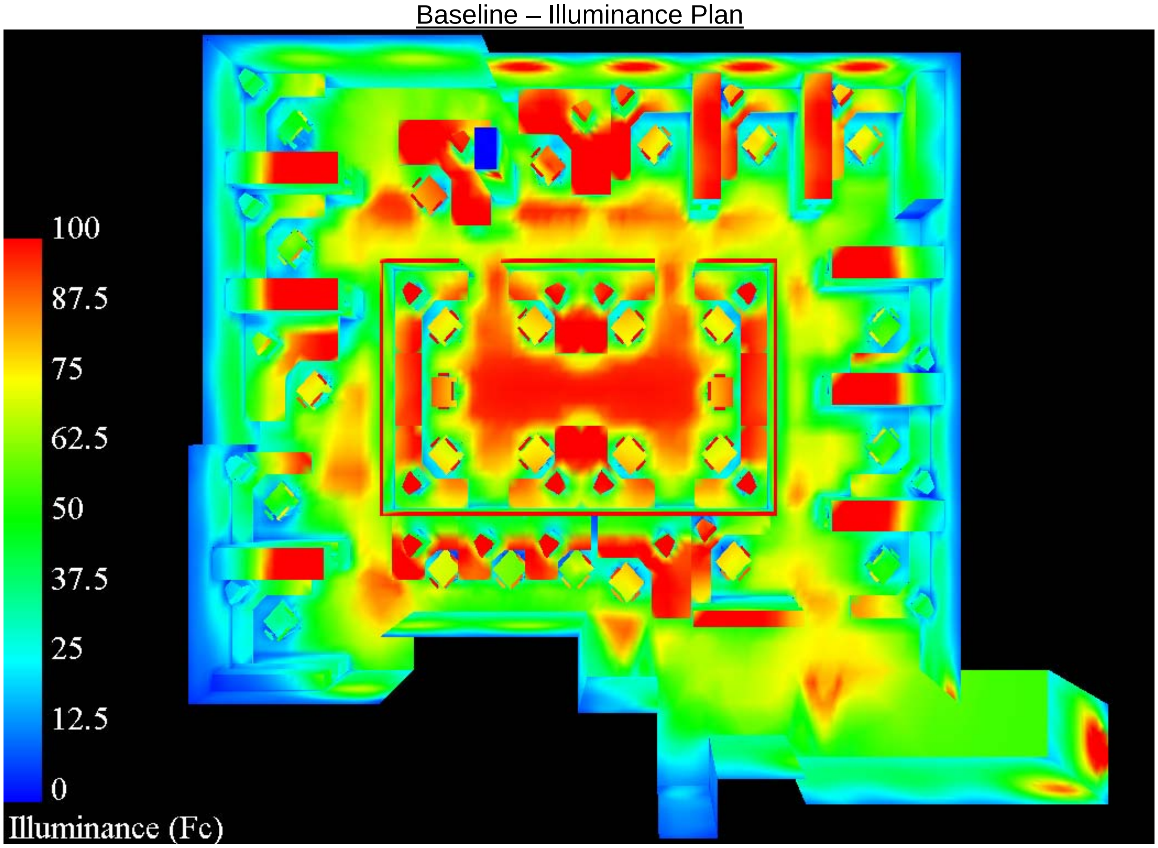
Appendix V-2 – AGI32 Renderings

Baseline - Plan



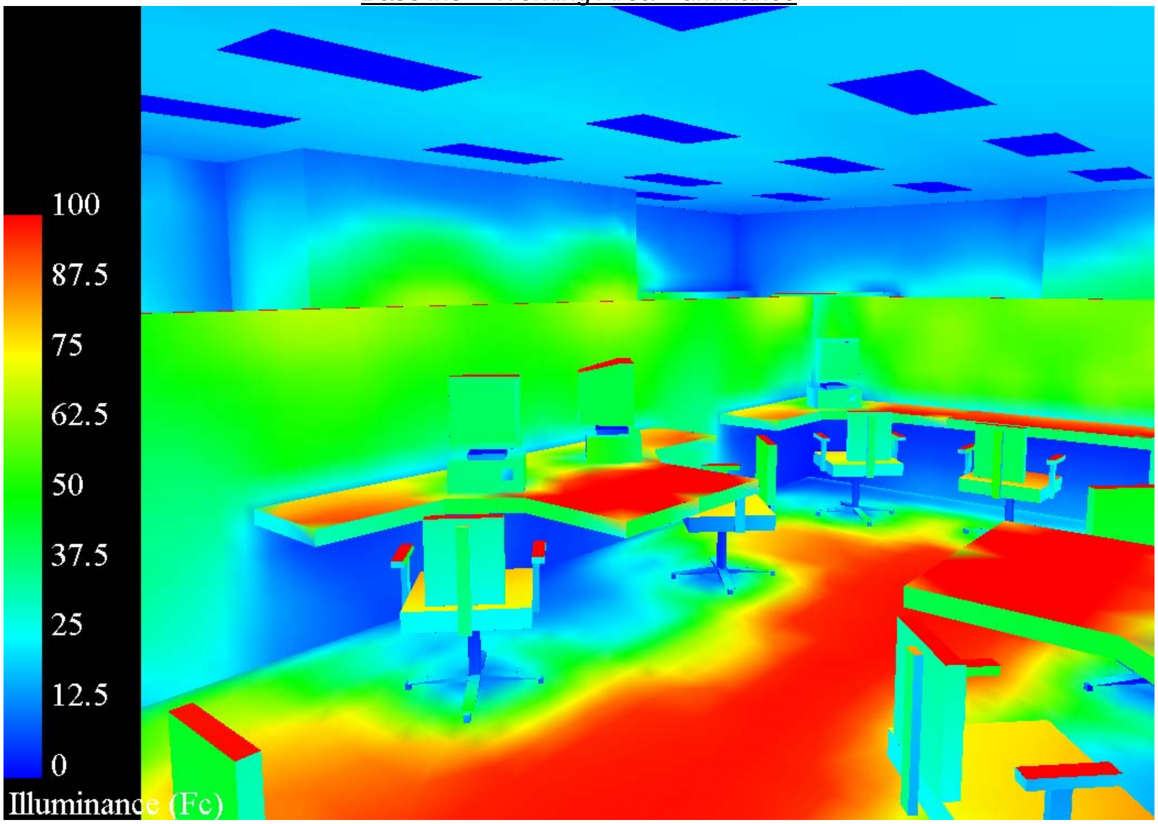
Baseline – Illuminance Plan



Appendix V-2 – AGI32 Renderings

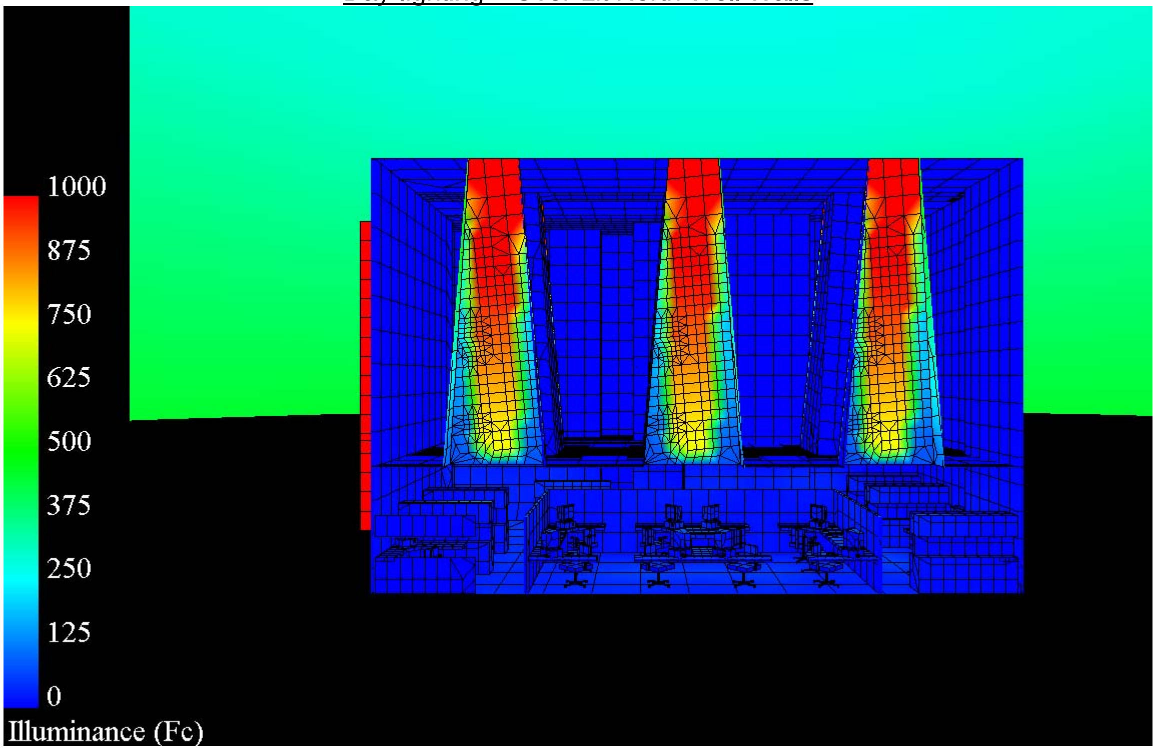
Baseline – Working Area

Baseline – Working Area Illuminance

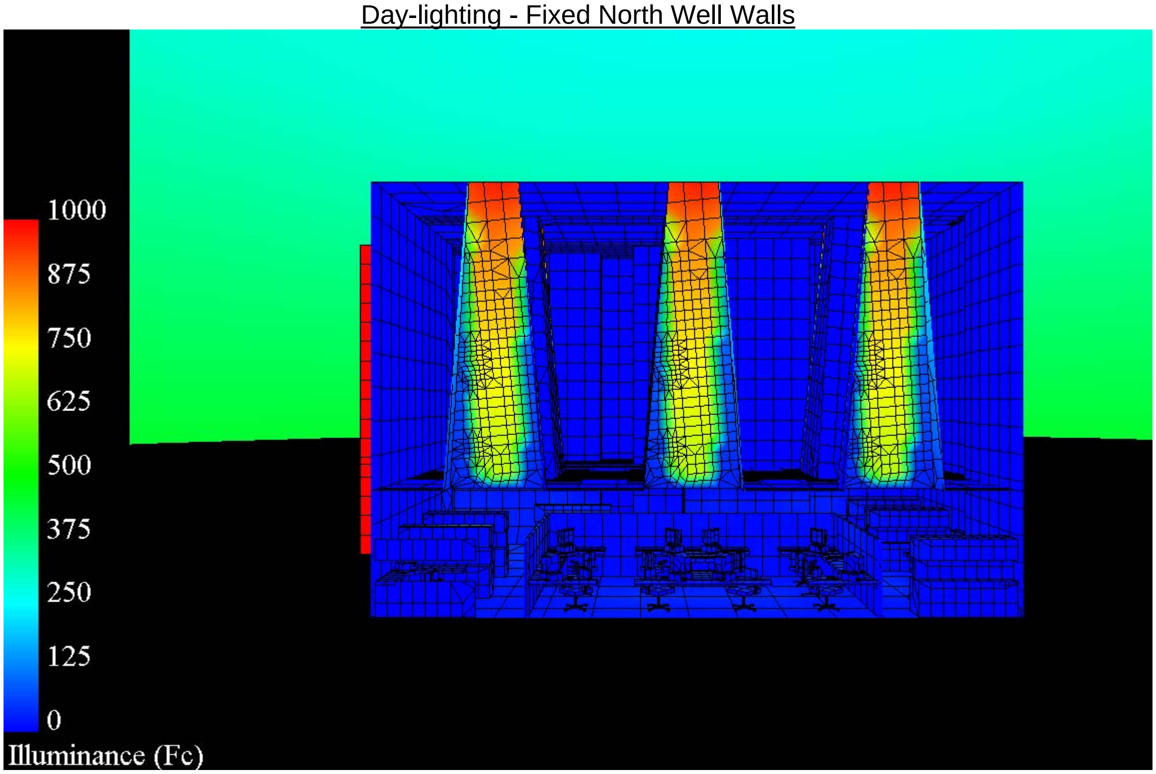


Appendix V-2 – AGI32 Renderings

Day-lighting – Over-Lit North Well Walls



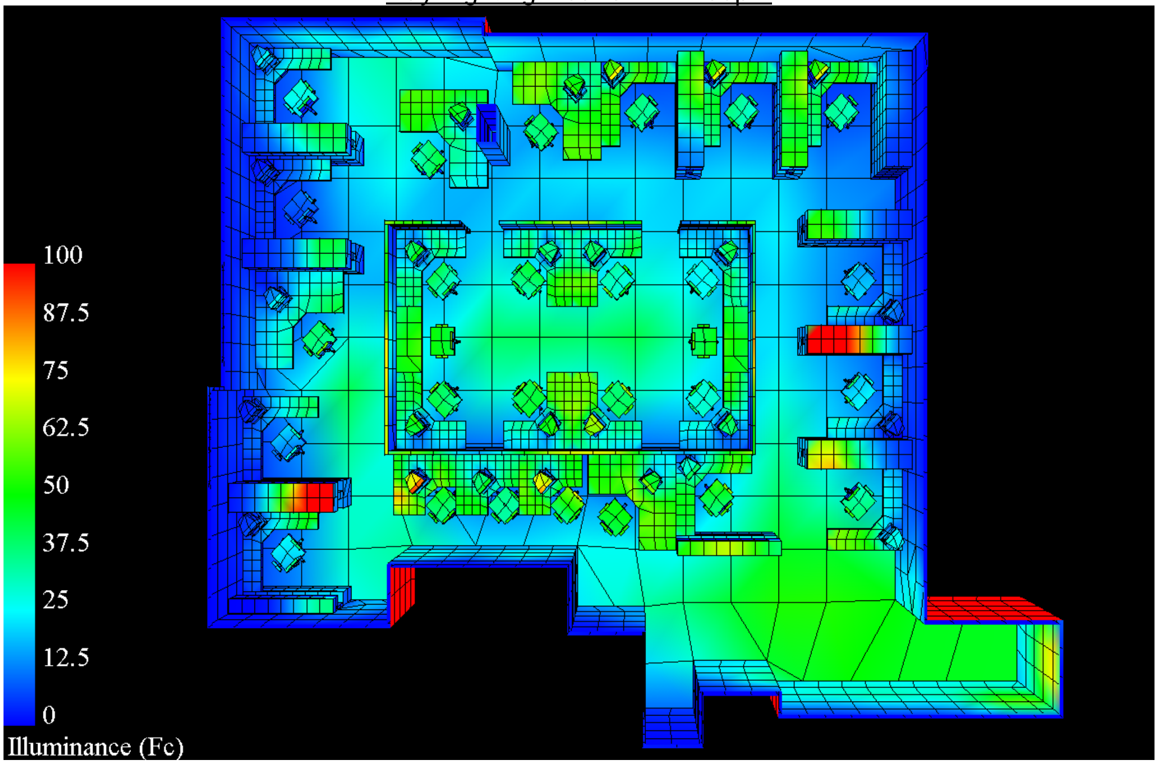
Day-lighting - Fixed North Well Walls



Appendix V-2 – AGI32 Renderings

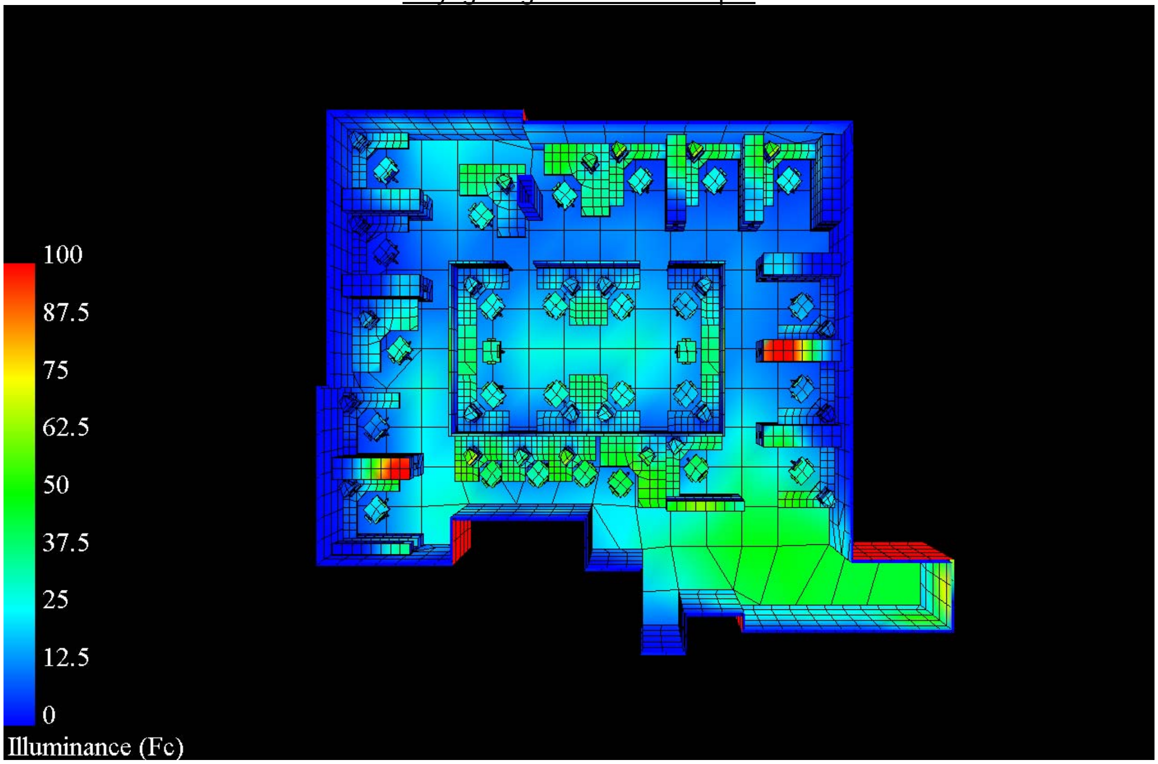
Day-lighting – June 21 11:00am

Day-Lighting – June 21 12:00pm

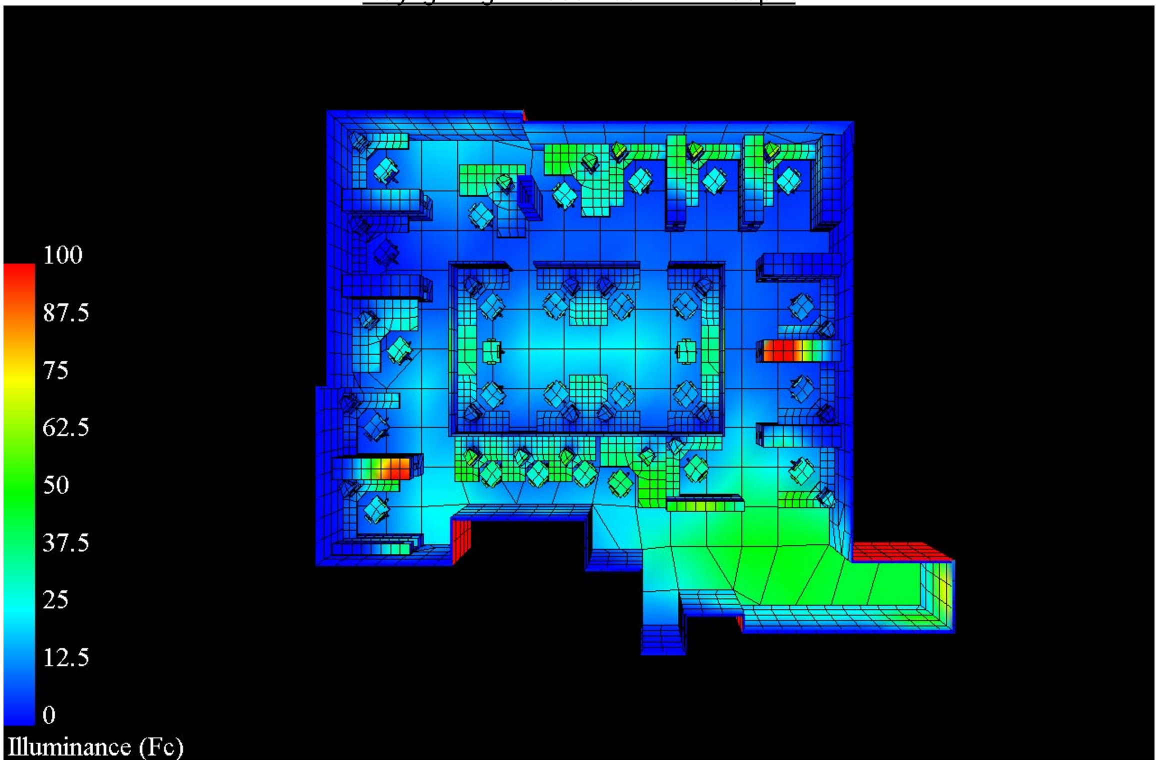


Appendix V-2 – AGI32 Renderings

Daylighting – June 21 3:00pm

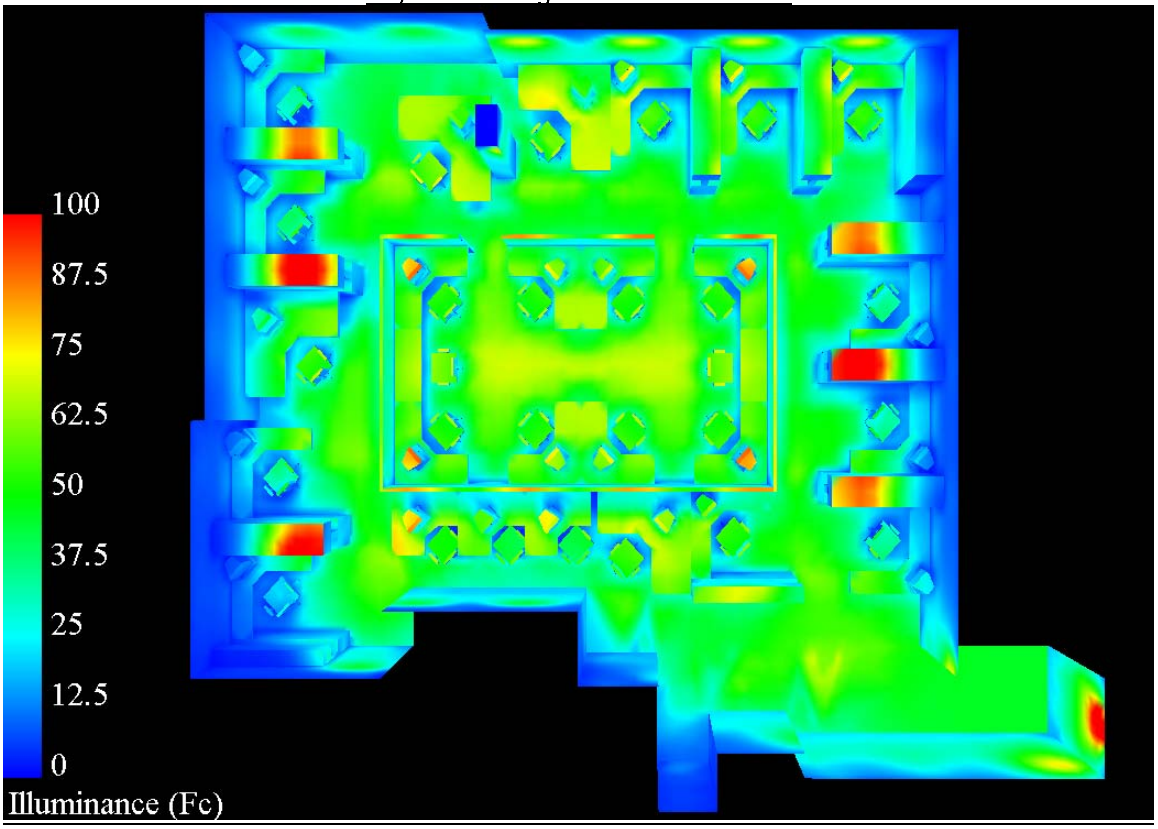


Daylighting – December 21 12:00pm

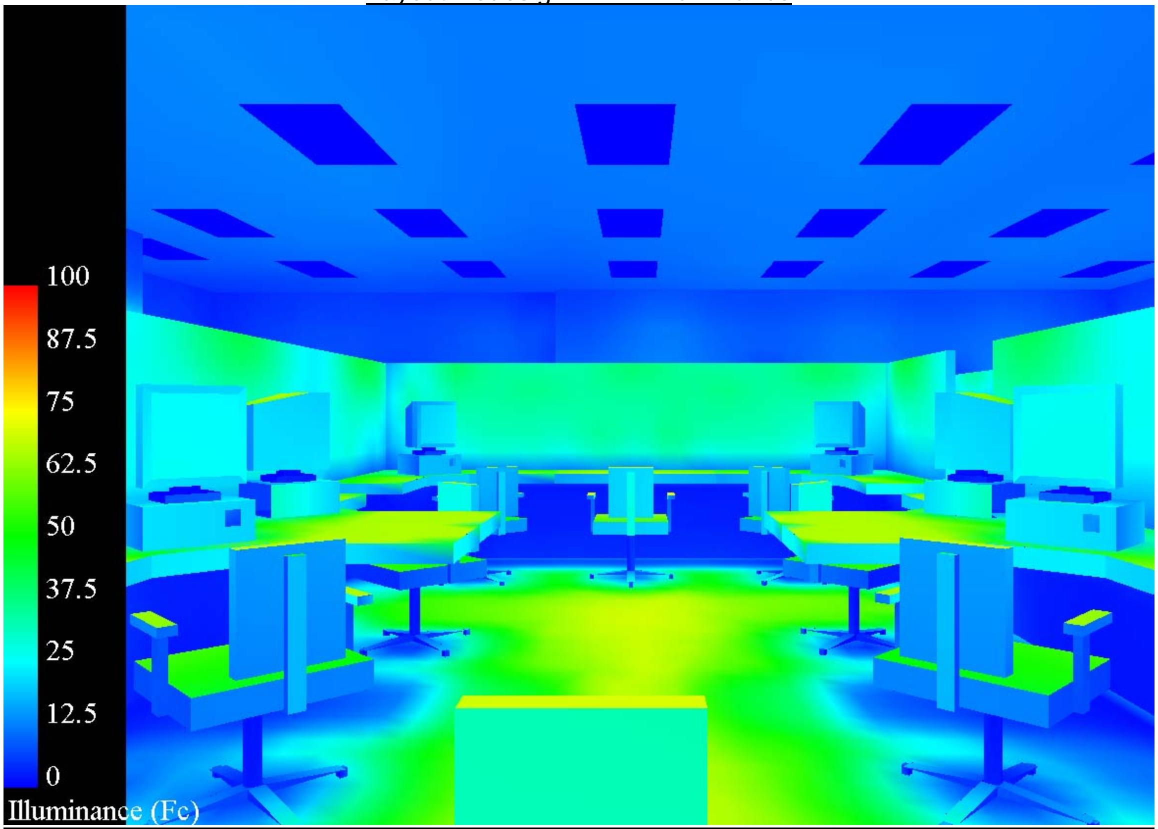


Appendix V-2 – AGI32 Renderings

Layout Redesign – Illuminance Plan

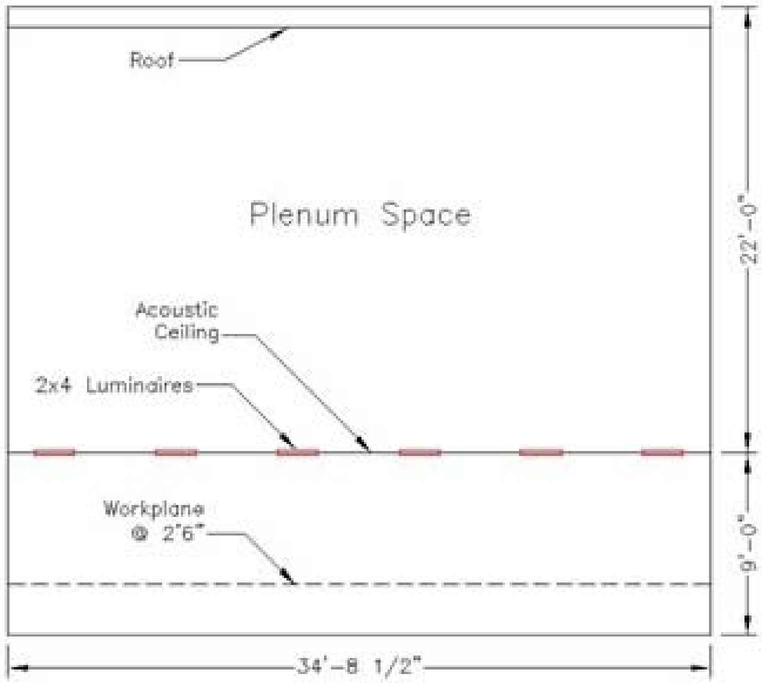


Layout Redesign – VDT Illuminance

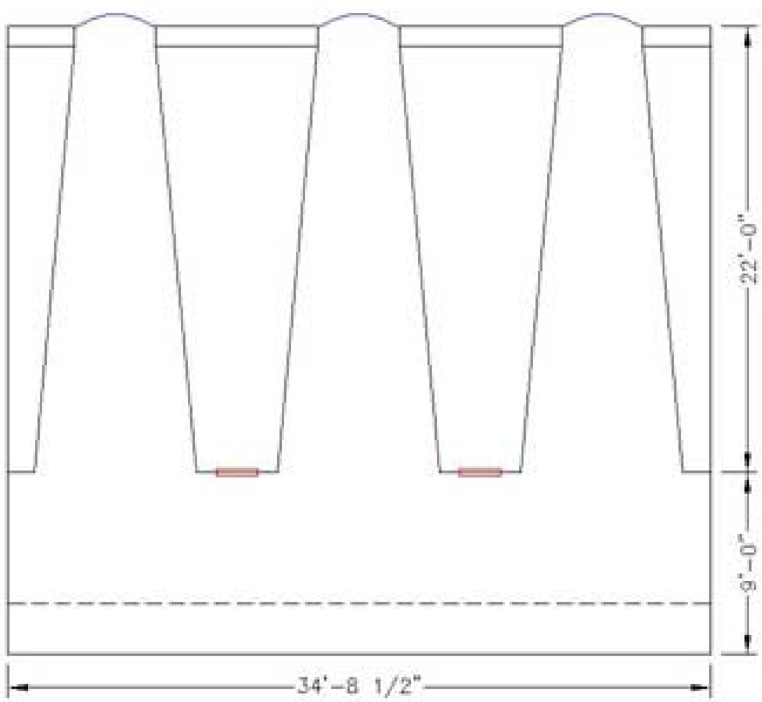


Appendix V-3 – CAD Design

Early Schematic



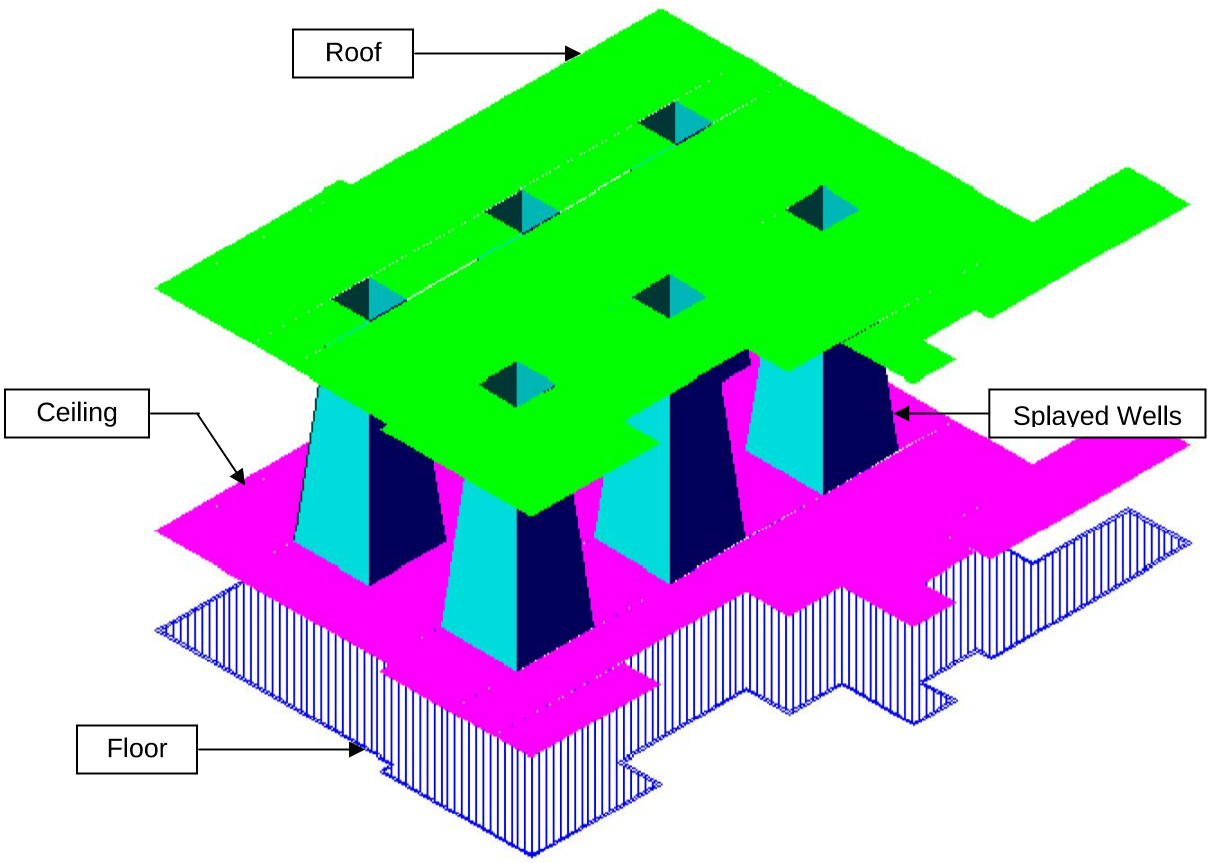
Existing Section



Daylighting Redesign

Appendix V-3 – CAD Design

Skylight Wells in 3D CAD



Appendix V-4

Quick Cost Comparison											
	# of Days	# of Days Total	hours/day of daylighting	dl hours	normal hours	kW dl	kW norm	kWh dl	kWh norm	$/kWh	Spent per year
New Design	204	365	6	872	1988	1.779	3.224	1551	6410	$0.04	$ 318.43
Base Case	0	365	n/a	n/a	2860	n/a	3.608	n/a	10319	$0.04	$ 412.76
				dl hours are x (52x5)/365							

Appendix V-5 – Sky Data For Philadelphia

				cloudiness (days/month)			
	Day	Sunrise	Sunset	clear	partly	cloudy	Days to Daylight
Jan	21	7:18	17:06	7	8	16	15
Feb	21	6:46	17:43	7	7	14	14
Mar	21	6:02	18:14	8	8	15	16
Apr	21	6:13	19:46	7	9	14	16
May	21	5:40	20:15	6	11	14	17
Jun	21	5:32	20:33	7	11	12	18
Jul	21	5:50	20:24	7	12	12	19
Aug	21	6:18	19:48	8	11	11	19
Sep	21	6:48	18:59	10	9	11	19
Oct	21	7:18	18:12	11	9	12	20
Nov	21	6:53	16:40	7	9	14	16
Dec	21	7:19	16:39	7	8	15	15

Sunrise and sunset from http://aa.usno.navy.mil/data/docs/RS_OneDay.html

Cloudiness from http://www.cityratings.com

Appendix VI-1 - Pricing Calculations

City	Philadelphia	
State	Pennsylvania	
Material Index	100.1	
Installation Index	122.6	
System Size	600	tons

	Number	GPM	HP	Material	Installation	Total	Basis
System Pump	1	1200	20	$ 3,200.00	$ 580.00	$ 3,914.28	20 HP Pump
Chiller Pump	3	400	3	$ 1,975.00	$ 315.00	$ 7,089.50	5 HP Pump
Ice Tank Pump	1	731	5	$ 1,975.00	$ 315.00	$ 2,363.17	5 HP Pump
Condenser Pump	1	1800	15	$ 2,750.00	$ 535.00	$ 3,408.66	15 HP Pump

	$/ton Mat.	$/ton Install	Material	Installation		Basis
Cooling Tower	$ 49.00	$ 6.37	$ 29,400.00	$ 3,840.00	$ 34,137.24	Vertical Gear Drive

Steel Pipe								
Piping	Diameter	Length	$/length (mat)	$/length (inst)	Material Index	Installation index	Height Index	Cost
S/R Chiller - Roof	10.0	64.00	$ 53.50	$ 36.50	100.1	122.6	100	$ 6,291.36
CHWP-1	10.0	110.00	$ 53.50	$ 36.50	100.1	122.6	140	$ 12,782.23
CHWP-2	8.0	61.25	$ 53.50	$ 36.50	100.1	122.6	140	$ 7,117.38
CHWP-3	8.0	61.25	$ 35.00	$ 31.00	100.1	122.6	140	$ 5,404.91
CHWP-4	8.0	61.25	$ 35.00	$ 31.00	100.1	122.6	140	$ 5,404.91
CHWP-5	8.0	61.25	$ 35.00	$ 31.00	100.1	122.6	140	$ 5,404.91
CHWP-6	8.0	61.25	$ 35.00	$ 31.00	100.1	122.6	140	$ 5,404.91
CHWP-7	8.0	61.25	$ 35.00	$ 31.00	100.1	122.6	140	$ 5,404.91
CHWP-8	8.0	61.25	$ 35.00	$ 31.00	100.1	122.6	140	$ 5,404.91
CHWP-9	6.0	61.25	$ 22.00	$ 27.00	100.1	122.6	140	$ 4,187.34
CHWP-10	6.0	61.25	$ 22.00	$ 27.00	100.1	122.6	140	$ 4,187.34
CHWP-11	5.0	61.25	$ 22.00	$ 27.00	100.1	122.6	140	$ 4,187.34
CHWP-12	4.0	61.25	$ 20.00	$ 20.50	100.1	122.6	140	$ 3,381.38
CHWP-13	4.0	61.25	$ 6.70	$ 12.50	100.1	122.6	140	$ 1,724.90
CHWP-14	3.0	61.25	$ 6.70	$ 12.50	100.1	122.6	140	$ 1,724.90
S/R Chiller - CT	12.0	64.00	$ 53.50	$ 36.50	100.1	122.6	100	$ 6,291.36
								$ 84,305.00

Cellular Glass: 0 water vapor transmission								
Piping	Diameter	Length	$/length (mat)	$/length (inst)	Material Index	Installation index	Height Index	Cost
S/R Chiller - Roof	10.0	64.00	$ 12.35	$ 14.30	100.1	122.6	100	$ 1,913.23
CHWP-1	10.0	110.00	$ 12.35	$ 14.30	100.1	122.6	140	$ 4,059.76
CHWP-2	8.0	61.25	$ 11.95	$ 12.50	100.1	122.6	140	$ 2,046.79
CHWP-3	8.0	61.25	$ 11.95	$ 12.50	100.1	122.6	140	$ 2,046.79
CHWP-4	8.0	61.25	$ 11.95	$ 12.50	100.1	122.6	140	$ 2,046.79
CHWP-5	8.0	61.25	$ 11.95	$ 12.50	100.1	122.6	140	$ 2,046.79
CHWP-6	8.0	61.25	$ 11.95	$ 12.50	100.1	122.6	140	$ 2,046.79
CHWP-7	8.0	61.25	$ 11.95	$ 12.50	100.1	122.6	140	$ 2,046.79
CHWP-8	8.0	61.25	$ 11.95	$ 12.50	100.1	122.6	140	$ 2,046.79
CHWP-9	6.0	61.25	$ 9.25	$ 10.00	100.1	122.6	140	$ 1,618.42
CHWP-10	6.0	61.25	$ 9.25	$ 10.00	100.1	122.6	140	$ 1,618.42
CHWP-11	5.0	61.25	$ 7.85	$ 8.35	100.1	122.6	140	$ 1,359.12
CHWP-12	4.0	61.25	$ 6.50	$ 7.70	100.1	122.6	140	$ 1,208.02
CHWP-13	4.0	61.25	$ 6.50	$ 7.70	100.1	122.6	140	$ 1,208.02
CHWP-14	3.0	61.25	$ 5.80	$ 6.25	100.1	122.6	140	$ 1,012.66
S/R Chiller - CT	12.0	64.00	$ 19.60	$ 15.60	100.1	122.6	100	$ 2,479.69
								$ 30,804.87

Ice Tank ton hours	2982
$/ton hour	$ 110
Ice Tank total	$ 328,020

$/Chiller	$ 101,000
# of Chillers	3
Chiller Total	$ 303,000