Senior Thesis
Final Report

City of Hope: Amini Medical Center
Duarte, CA

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Architectural Engineering
Mechanical Option

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City of Hope Amini Medical Center

Duarte, California

General Building Data

- 3 Story Above Ground Facility
- 59,800 ft²; All New Construction
- Occupancy: Clinic, Lab & Moderate Hazard Storage
- Design-Bid-Build Project Delivery
- Construction Dates: 6/11/07 - 1/22/09
- Attempting LEED Gold Certification

Project Team

- Owner: City of Hope
- Architect & Engineers: EwingCole
- CM & GC: DPR Construction Inc.

Structural

- Steel Frame Construction
- Cast-In-Place Foundation Wall & Spread Footers
- Ground Floor: 6" Concrete Slab on Grade Over 8" Aggregate and Subgrade
- Floors 1-3: 5-1/2" Concrete Slab (115psf) on Composite Metal Deck with Typ. W16x26 Framing
- Roof: 5-1/4" Concrete Slab (115psf) on Composite Metal Deck with Typ. W16x26 Framing

Architecture

- Limestone Veneer and Stucco façade
- Large curtain wall system with 1" vision glass and 1" spandrel glass on North and West exterior walls
- Exterior walls are 1-HR fire rated with 6" Thermafiber insulation; R-3.8/in.
- 6 ft. projecting canopy distinguishes main entrance
- Aluminum air foil sunshades provided above all vision glass
- An elevator and a staircase are provided on both the North and South ends of the building

Electrical

- 12.47 KV Normal Power feeder to 1500 KVA transformer serving the main switchboard
- 2000 Amp Main Power Switchboard with 1126 KVA connected power
- 4160 V Emergency Power feeder to 750 KVA transformer serving Emergency power switchboard
- 1200 Amp Emergency Power Switchboard with 818 KVA connected power
- 4 high voltage panels serving the building; 480/277V
- 18 low voltage panels serving the building: 208/120V
- Remote disconnect provided for roll up generator
- Typ. lighting fixture throughout is a 2x4 recessed troffer with three(3) F32T8 lamps

Mechanical

- Central Campus cooling and heating plants provide chilled water and high pressure steam to serve the facility
- Two(2) 20 HP pumps (one stand-by) distribute 42F chilled water to 5 Custom Rooftop Air Handling Units and 9 Fan Coil Units for cooling
- Three(3) rooftop Air Handlers provide 1483 MBH cooling for Lab and Office spaces on the first two floors
- Nine(9) fan coil units provide 360 MBH cooling to computer/mech. rooms and other specialty rooms
- Two(2) pressure reducing stations convert 6020 lbs/hr of high pressure steam to low pressure steam
- A 1768 MBH heat exchanger on the roof converts low pressure steam to 160 F hot water for the building
- CV and VAV terminal units control quantity of air to occupied spaces

PENNSTATE

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http://www.engr.psu.edu/ae/thesis/portfolios/2009/cdb162/index.htm

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EXECUTIVE SUMMARY

The Amini Medical Center is the newest addition to the City of Hope Campus located in the suburbs of Los Angeles, CA. The community's main functions include cancer research, treatment and education. As a part of this community, the Amini Center is responsible for blood collection, analysis, processing, transfusion, and storage.

To accommodate the campus' needs, central heating and cooling plants with spare capacity for expansion were designed. The Amini Center's design utilizes the central steam and chilled water plants to run rooftop air-handling units (AHUs) and space fan coil units (FCUs) throughout the 3-story building.

Because little information could be obtained about the campus' central plants, the mechanical redesign starts with sizing chillers and pumps for the building's primary chilled water loop; making the Amini Center's cooling plant independent from the campus. The chiller and pump sizes mentioned here then become the baseline system for which my design is compared.
(With this design change, an analysis of the roofing structure was performed to evaluate the changes needed by adding the chiller equipment loads to the roof.)

The existing primary loop of the building now contains a single air-cooled chiller with constant volume pumps. The system supplies water at 42 ^{o}F for use by the AHUs and FCUs.

The objective of my redesign was to reduce the annual operating costs with a system that doesn't have extreme first cost numbers. To try and accomplish my objective, ice storage systems were researched because they can bring down the annual operating costs of a building by shifting the on-peak load with high energy costs to off-peak hours where energy is cheaper.

Through the several ice storage technologies, I chose to design an internal melt ice-on-coil system. This closed system runs 25% ethylene glycol at 23 ^{o}F through coils in a water storage tank during non-peak hours to create ice. To discharge this stored capacity, the glycol solution, at a higher temperature, is pumped through the storage container where it rejects heat to the ice.

When designing ice storage systems it is very important to know the building load profile and the control strategy for chiller operation. Three control strategies were researched and designed for this report, full storage, load leveling partial storage, and demand limiting partial storage.

In the end, the full storage strategy produced the largest equipment with the highest first cost and close to highest return. The demand limiting scenario was in middle on equipment size and cost while having the least annual savings. The load leveling system seemed to fit this building the best with a first cost just $59,000 over the existing system but savings of $137,000 the first year of operation. Please note, the annual savings recorded included a special program rate offered by the Amini Center's utility company for providing a load shifting technology.

To help reduce the power consumed by the Amini Center, a lighting analysis and redesign was performed in an attempt to reduce the lighting power densities while maintaining the work plain light levels prescribed by the *Illuminating Engineering Society of North America* (IESNA).

Existing Conditions

The Amini Medical Center is the newest addition to the City of Hope Campus located in the suburbs of Los Angeles, CA. The community's main functions include cancer research, treatment and education. As a part of this community, the Amini Center is responsible for blood collection, analysis, processing, transfusion, and storage. To accommodate the building functions, Ewing Cole has designed a 3 story, 60,000 square foot complex situated on the East side of campus.

Architectural

The Amini Center consists of limestone veneer and stucco facades with two story glass curtain walls spanning the North and West exposures. Sixteen and fifteen foot floor to floor heights were designed to accommodate the numerous systems to be installed in the ceiling plenums. The main entrance is marked by a 6 ft. overhang to help distinguish it from other building entrances. The interior zoning of the space flows well for the building's multiple functions. Stairs and elevators are located at both ends of the building connected by a wide central corridor on all floors. This design allows zones to be set up on the East and West sides of the central corridor without interrupting the flow of personnel and incoming patients.

Glass: Viracon 1" insulated glass, VE1-2M with dot frit pattern.

Typ. Wall 1: 2" Stone veneer, 1" Airspace, WP membrane over 5/8" Dens Glas Fire Resistive Sheathing, 6" 16 GA Met Stud @ 16" O.C. with R-19 Batt, and 5/8" GWB-Type 'X'

Typ. Wall 2: 7/8" Stucco over WP membrane, 5/8" Dens Glas Fire Resistive Sheathing, 6" 16 GA Met Stud @ 16" O.C. with R-19 Batt, and 5/8" GWB-Type 'X'

Spandrel Curtain Wall: Glass, 2" 8# Mineral Wool, 3 5/8" Met Stud @ 16: O.C. R-17 Insulation, and 5/8" GWB-Type 'X'

Roof: 60MIL RFG Membrane, 1/4" Dens Deck Cover Board, 6" Rigid Insulation, 5/8" Gyp. Brd. Exterior Sheathing, Metal Deck, Spray Fire Proofing

Structural

The general classification for the Amini facility is a steel framed building. The building has a cast-in-place foundation wall with spread footers supporting steel columns. Steel beams and girders, with moment connections for seismic support, connect to the columns creating a frame at each floor level and roof to support the floor/roof loads.

The ground floor is a 6" concrete slab over an 8" aggregate and subgrade. The floors of the building are a 5 1/2" concrete slab over a composite metal deck with a typical W16X26 framing running north to south and W16x26 & W14x22 framing running west to east on the West and East sides respectively. The roof consists of a 3 1/4" light concrete slab over a 2" composite metal deck within the bays where the large mechanical units are located. The remaining roof consists of 3" 20 GA. Metal roof deck. The framing of the roof consists of mainly W21x44 beams supporting the areas with concrete above and W14x22 beams supporting the remaining roof structure.

Electrical/Lighting

The main power service to the Amini Center is 12.47 KV feeder to a 1500 KVA transformer. The 1500 KVA transformer serves the main 2000 Amp switchboard with a connected load calculated at 1126 KVA. An emergency back-up power service is also provided to the building for critical spaces. A 4160 V emergency power feeder is stepped down with a 750 KVA transformer which serves the 1200 Amp emergency power switchboard. The emergency power switchboard has a connected load calculated at 818 KVA. The emergency power for this building connects to 3 automatic transfer switches which serve the building's Life Safety equipment, Critical Equipment like the stem cell freezers, and Other Equipment like the air handlers and blood storage coolers. The building is also equipped with the capability of plugging in a roll up generator in cases of prolonged power interruption.

Fluorescent lighting fixtures are the primary sources of light throughout the building. Typical Lab spaces and offices contain 4', 2 lamp, T5 HO fixtures. Common rooms like copy areas and break rooms contain 2x4, 3 lamp, T8 fixtures. The bathrooms and hallways contain triple tube compact fluorescent downlights. Mechanical, Electrical, and other unoccupied rooms contain 4', 2 lamp, T8 fixtures. All fixtures throughout the building operate at 277 V and have electronic ballasts.

Heating Plant & Building Heating System

<u>Heating Plant</u>

What is known about the central plant for this project is that there is high pressure steam (HPS) and steam condensate return piping (PCR) available to serve this the Amini Center. The specifics of the central plant, i.e. steam boiler capacities and types, were not attainable. Even the size of the existing steam and condensate pipes could not be obtained.

<u>Building Heating System</u>

The Amini Center converts available high pressure steam (125 psig) into hot water for the building to use. The connection points to the existing steam and condensate lines are located on the South side of the building. Because of this, a mechanical room was created on the South wall of the first floor to accommodate some of the necessary equipment and piping; this room is the location where a 4" HPS and a 2" PCR enter/leave the building.

Due to concerns for running high pressure steam throughout the building, the HPS is reduced to medium pressure steam (MPS), for a domestic water heater, and low pressure steam (LPS) to run to a heat transfer package on the roof. In order to accomplish this, two pressure reducing valves (PRV) are located in the mechanical room to reduce the HPS first down to 25 psig MPS then down again to the 15 psig LPS. The MPS is taken to the Domestic water heater in the mechanical room and heats the domestic water loop from 40 degrees to 140 degrees. The LPS line is taken up to a heat transfer package (HTP) on the roof which heats the hot water loop and pumps the hot water to the air distribution systems (AHUs, and reheat coils).

Cooling Plant & Building Cooling System

<u>Cooling Plant</u>

The central cooling plant serving the Amini Center, and many other buildings, has a little more information available then the heating plan did. The central plan is composed of three centrifugal water cooled chillers and one steam absorption chiller. The system is a primary/secondary system providing chilled water for a good portion of the campus. The plant capacity is a nominal 7,150 Tons supplying a primary loop of 13,104 gpm and a secondary loop of 12,600 gpm. The points of connection for the Amini Center are 12" chilled water supply (CHWS) and 12" chilled water return (CHWR) lines located at the South end of the building.

<u>Building Cooling System</u>

Like the heating system for the building, the CHWS & CHWR lines enter/leave the facility in the mechanical room on the first floor. 6" CHWS & CHWR lines were designed to tap the primary loop and serve the Amini Center with 42 ^{o}F water. Two 20 Hp pumps located in the first floor mechanical room provide circulation of the chilled water to the AHU and FCU cooling coils throughout the building.

The bulk of the 1st and 2nd floors of the facility are served by three custom, water cooled, Air Handling Units (AHUs) located on the roof. Small horizontal, water cooled, Fan Coil Units (FCUs), located in the ceiling plenums, serve the remaining areas not being served by an AHU. The areas served by the AHUs are broken down as follows: AHU-1 serves the Stem Cell Lab and support areas located on the 1st floor. AHU-2 serves the Blood Processing area and the Cryogen Freezer on the 1st floor. All remaining spaces on the 1st and 2nd floors are served by AHU-3. Two future AHUs are shown on the drawings to serve the third floor future office area.

Due to their lack of relevance to the remaining portion of this report, please refer to Technical Assignment 3 for further information regarding the Amini Center's existing airside systems.

Existing System Modifications/Loads

The design of the entire system for the Amini Medical Center appears to be an efficient design based on the information available. Having a central plant increases the equipment and pump sizes on the primary loop of a chilled water system, which, in turn, tends to increase overall efficiency. However, because the information for the central plant was not attainable for this study, the existing chilled water system was modified to provide a baseline comparison.

Existing System Modifications

The Amini facility's chilled water system was removed from the City of Hope central plant and provided with its own primary chilled water loop. For this baseline model, air-cooled chillers, constant volume primary pumps, and their layout were designed. Energy and cost data were then evaluated. The system was assumed to be primary/secondary, with the secondary system remaining the same as designed. The primary system contains two, full capacity, air-cooled chillers located on the roof. One chiller acts as a stand-by in case the initial chiller fails. The same situation is also designed for the pumps, one active, one stand-by.

Existing System Load Estimations

To aid in determining the cooling loads required for the Amini Medical Center, the Trane Trace 700 program was utilized. Due to the third floor remaining vacant on the construction documents, load estimations for office space were input to generate accurate plant sizing.

The building envelope loads, occupancy loads, lighting loads, plug loads, ventilation air loads, climatic data, and schedules were input into the program using the construction documents as a reference.

Building Envelope Input:

The Amini Center building envelope consisted of three typical wall types and one specific glazing type. The u-values entered into the program for these wall types and glazing values can be viewed below. Refer to the "Existing Conditions" section above for a detailed breakdown of these wall and glazing types.

Construction	U-Value Btu/h*ft2*F	SC
Stone Wall	0.043	-
Fire/Stucco Wall	0.039	-
Spandrel Glass Wall	0.045	-
Glazing	0.26	0.43

Table 3.1

Occupancy Input:

Occupancy for each room was taken from the Architectural drawings. Maximum load was assumed to be the maximum number of chairs or seating locations in each room. Occupancy assumed for the 3rd floor Office Area was assumed to be 125 sf/person. Each person was assumed to give off 250 Btu's sensible heat and 200 Btu's latent heat per hour.

Lighting Input:

Lighting for each space on the first two floors was taken to be the designed lighting from the construction documents. The 3rd floor lighting power was taken from ASHRAE 90.1-2007, allowable power density for office plan, 1.1 W/sf.

Plug Loads Input:

Plug load, or room equipment heat load for this building was estimated on a room by room basis. Due to the assortment of equipment in lab areas and IT rooms, a general W/ft^2 load was input after estimating the total load in each room. For general office areas, I estimated the equipment heat loads for computers, printers, copiers, etc. based on values estimated in the Fundamentals Handbook. Refer to the Table below for some general equipment loads that were assumed in the first and second floor office spaces.

Equipment	Heat Load Watts	Equipment	Heat Load Watts
Computer	155	Refrigerator	300
Desktop Printer	100	Microwave	300
Copier	400	Toaster	100
Fax Machines	100	Coffee Maker	200

Table 3.2

The plug loads for the third floor were estimated at 3 W/sf.

Ventilation Air Input:

Supply air for each room was input based on the construction documents. In doing so, each AHU and FCU ventilation percentage was also input based on the minimum outdoor air (OA) quantity listed on the drawing schedules. The 3rd floor units ventilation was input based on the ASHRAE 62.1-2007; 5 cfm/person & 0.06 cfm/sf.

Climate Data Input:

The Amini Medical is being constructed in Duarte, California, a suburb of Los Angeles. For this estimation the Trace program is equipped with regional weather data from around the world. The weather data selected for this project was Pasadena, Ca, 10 miles from the building site. Design conditions for this region are as follows:

Indoor Conditions			Outdoor Conditions							
Summer		Winter	Summer		Winter	Clearness		Ground Reflectance		CO2 Level
DB	RH	DB	DB	WB	DB	Summer	Winter	Summer	Winter	PPM
72	50	72	95	68	29	1.05	0.95	0.2	0.2	400

Table 3.3

Modified Existing System Load Results

After gathering all the information listed above, the Trane Trace program was used to determine all building loads. The resulting airside unit peak loads can be can be seen in Table 3.4.

Unit	Unit Peak Loads (From Trace)		Unit	Unit Peak Loads (From Trace)	
	Total MBH	Sensible MBH		Total MBH	Sensible MBH
AHU-1	275.0	165.3	AHU-2	530.3	432.0
AHU-3	809.2	677.1	FCU-1-1	5.3	5.1
FCU-1-2	17.8	17.6	FCU-1-3	42.8	42.6
FCU-1-4	7.9	7.7	FCU-1-5	88.5	71.2
FCU-2-1	47.8	47.4	FCU-2-2	5.3	4.9
FCU-2-3	3.1	2.9	FCU-2-4	5.4	5.0
3rd Flr West	271.9	251.3	3rd Flr East	251.0	229.9

Table 3.4

Chiller Loads:

Because peak unit sizing will result in an over sized chiller plant, the building block load was assembled. For the Amini Center occupancy and location, the highest block load is seen in August. Chart 3.1 below shows the August design day cooling load profile; showing a maximum block load of 174.9 Tons. From this information, the chiller was selected.

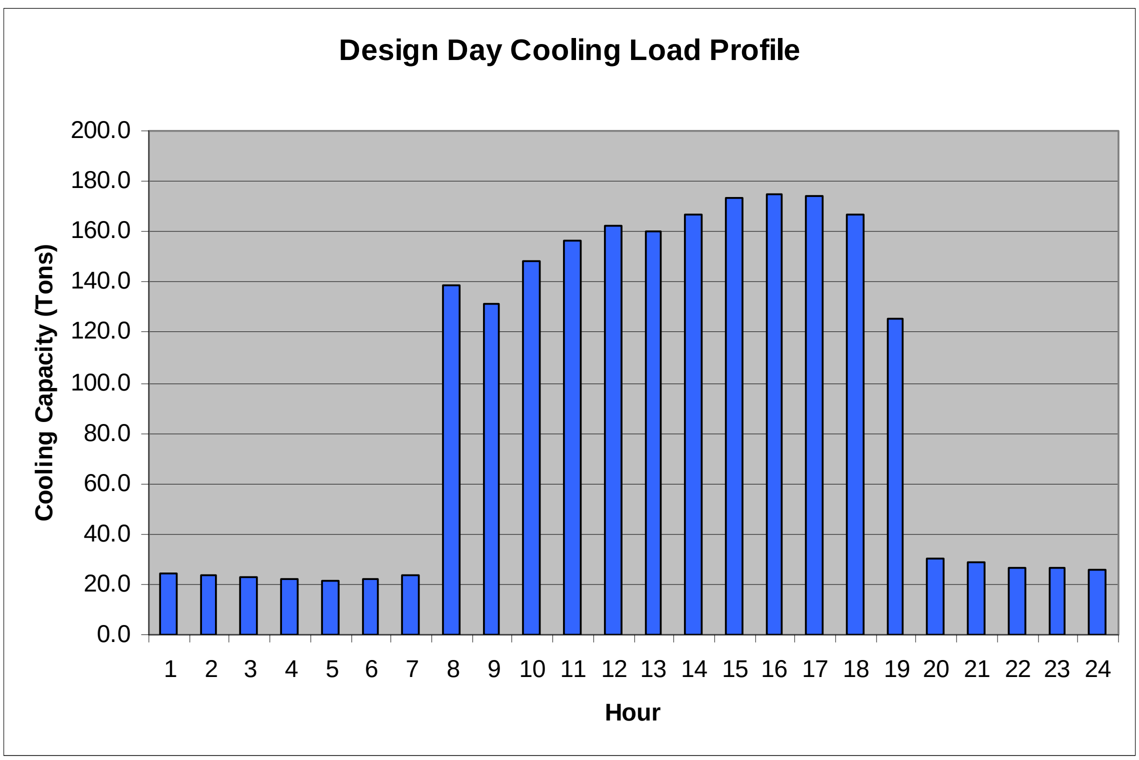

Chart 3.1

Searching through the Trane Catalog for an acceptable chiller resulted in a 185 Ton RTAC unit, which, after derating for climate conditions, resulted in a cooling capacity of 174.8 Tons. Matching the 15 degree delta T of the secondary loop resulted in a primary loop flow of 296 gpm. (GPM = (Nominal Tons*24)/Delta T; for water) Reviewing the tables and data from the Trane catalog gave the energy rate and pressure drop for the chiller. The table below, Table 3.5, shows a summary of the chiller and modified primary loop characteristics.

185 Ton Initial Chiller Selection (Assumed Existing)										
EER	CHWS (deg F)	CHWR (deg F)	dT (deg F)	Flow Rate (GPM)	PD (ft. H2O)	Cap. (Tons)	Input (KW)	KW/Ton	Primary/Secondary Loop Liquid	Chiller Nominal Tonnage
9.5	42	57	15	296	7	174.8	203.5	1.1642	Water	185

Table 3.5

Pump Loads:

Knowing the flow rate of the primary loop was the first step in sizing the primary pumps. Creating a the layout of the primary system along with the piping layout was the next step before calculating the pressure drop needed for the pump sizes. Refer to Appendix A for the chiller and pump locations selected for the baseline design.

For these modifications, the mechanical room was enlarged to provide adequate room for the primary system pumps. The total enlarging gained 125 sf for the mechanical room. The chase for the primary piping was also enlarged taking an extra 2 sf from the second and third floors.

The pressure drop (PD) calculations for this system loop can be seen in Appendix A sheet 3; 53 ft H_2O. With the PD and the flow rate of the system, the Bell and Gossett catalog was used to select two end suction pumps. Table 3.6 shows the characteristics of the pumps.

GPM	PD	Bell & Gossett Selection				
		Model	RPM	HP	Efficiency	Frame
296	53	2.5 BB	1750	7.5	71%	213T

Table 3.6

Modified System Energy Analysis

Using all the information from the load analysis and the newly selected equipment, an annual energy analysis was performed on the building.

Please Note: the airside systems and heating plant used for analysis are the same systems described in Technical Assignment 2. Please refer to that assignment for additional information regarding the inputs of those systems and units because they will not be described in this report.

Cooling Plant Modifications

Because the Amini Center was taken off the central campus cooling plant for this report, the newly selected chillers and pumps were input into the Trace program for analysis. The analysis assumes one chiller and one pump will be working to satisfy the loads of the building. The chiller and pump efficiencies were also input to account for the system energy consumption.

Utility Inputs

With the exception of the heating equipment and coils, the building is run entirely on electricity. For this analysis the heating plant was kept as is and input as purchased steam, with no actual cost to the Amini Center.

For the Electric rates, the building's supplier, Southern California Edison (SCE) posted their commercial rates on their website. The following tables give a breakdown of the electric rates, and the time of day schedule used for analysis.

Elec. Demand ($/KW)		
Summer (Jun. - Sept.)	Winter (Oct. - May)	Rate
$10.36	$10.36	Off-Peak
$15.60	$10.36	Mid-Peak
$25.84	-	Peak

Elec. Consumption ($/KWH)		
Summer	Winter	Rate
$0.135	$0.139	Off-Peak
$0.172	$0.174	Mid-Peak
$0.199	-	Peak

Table 4.1

<table>
<tr><th colspan="5">Utility Schedule</th></tr>
<tr><th></th><th>Time</th><th>Hour</th><th>Summer</th><th>Winter</th></tr>
<tr><td rowspan="12">AM</td><td>12:00 - 1:00</td><td>1</td><td rowspan="8">OFF-PEAK</td><td rowspan="8">OFF-PEAK</td></tr>
<tr><td>1:00 - 2:00</td><td>2</td></tr>
<tr><td>2:00 - 3:00</td><td>3</td></tr>
<tr><td>3:00 - 4:00</td><td>4</td></tr>
<tr><td>4:00 - 5:00</td><td>5</td></tr>
<tr><td>5:00 - 6:00</td><td>6</td></tr>
<tr><td>6:00 - 7:00</td><td>7</td></tr>
<tr><td>7:00 - 8:00</td><td>8</td></tr>
<tr><td>8:00 - 9:00</td><td>9</td><td rowspan="4">MID-PEAK</td><td rowspan="13">MID-PEAK</td></tr>
<tr><td>9:00 - 10:00</td><td>10</td></tr>
<tr><td>10:00 - 11:00</td><td>11</td></tr>
<tr><td>11:00 - 12:00</td><td>12</td></tr>
<tr><td rowspan="12">PM</td><td>12:00 - 1:00</td><td>13</td><td rowspan="6">PEAK</td></tr>
<tr><td>1:00 - 2:00</td><td>14</td></tr>
<tr><td>2:00 - 3:00</td><td>15</td></tr>
<tr><td>3:00 - 4:00</td><td>16</td></tr>
<tr><td>4:00 - 5:00</td><td>17</td></tr>
<tr><td>5:00 - 6:00</td><td>18</td></tr>
<tr><td>6:00 - 7:00</td><td>19</td><td rowspan="5">MID-PEAK</td></tr>
<tr><td>7:00 - 8:00</td><td>20</td></tr>
<tr><td>8:00 - 9:00</td><td>21</td></tr>
<tr><td>9:00 - 10:00</td><td>22</td><td rowspan="3">OFF-PEAK</td></tr>
<tr><td>10:00 - 11:00</td><td>23</td></tr>
<tr><td>11:00 - 12:00</td><td>24</td><td>OFF-PEAK</td></tr>
</table>

Table 4.2

Annual Energy Consumption / Cost

Tables 4.3, 4.4 and 4.5 on the following pages give a breakdown of the annual energy usage and cost associated to the Amini Center.

The complex's energy usage is dominated by the plug load, lighting, and space cooling. Knowing the locale and the building occupancy, a cooling dominated building is understandable. Over a year it is estimated that the Amini Center will consume 7.4 billion BTUs, resulting in a cost of over $533 thousand dollars. When taking a closer look at the monthly energy costs, the on-peak time period, 6 hours each weekday between June and September (5% of yearly hours), accounts for 20% of the yearly energy costs. A small amount of time in which the demand load rate increase skyrockets the monthly bill. Overall the facility is operating around $10/sq. ft. (excluding the cost for heating).

Energy Cost Budget – Baseline AC Chiller System

Note: The percentage displayed for the "Proposed/ Base %" column of the base case is actually the percentage of the total energy consumption.

* Denotes the base alternative for the ECB study.

		* Alt-1 Baseline AC Chiller		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Lighting - Conditioned	Electricity	942.2	13	258
Space Heating	Electricity	1.4	0	0
	Purchased Steam	198.6	3	249
Space Cooling	Electricity	1,572.9	21	682
Pumps	Electricity	241.1	3	52
Heat Rejection	Electricity	170.5	2	75
Fans - Conditioned	Electricity	536.3	7	213
Receptacles - Conditioned	Electricity	3,697.2	50	663
Stand-alone Base Utilities	Electricity	27.4	0	6
Total Building Consumption		7,387.7		

		* Alt-1 Baseline AC Chiller
Total	Number of hours heating load not met Number of hours cooling load not met	31 5

	* Alt-1 Baseline AC Chiller	
	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	7,189.1	533,070
Purchased Steam	198.6	0
Total	7,388	533,070

Table 4.3

—— Monthly Energy Consumption ——

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 1	**Baseline AC Chiller**												
Electric													
On-Pk Cons. (kWh)	0	0	0	0	0	60,986	59,893	69,063	58,323	0	0	0	248,264
Off-Pk Cons. (kWh)	68,416	63,535	66,566	72,695	72,162	66,999	82,530	74,472	76,549	73,446	67,610	73,018	857,999
Mid-Pk Cons. (kWh)	88,924	83,597	102,955	92,411	105,809	57,943	55,540	65,791	54,142	109,295	96,794	86,920	1,000,122
On-Pk Demand (kW)	0	0	0	0	0	507	546	545	536	0	0	0	546
Off-Pk Demand (kW)	406	420	418	425	442	472	510	507	496	465	427	412	510
Mid-Pk Demand (kW)	444	460	460	468	485	484	519	523	508	503	472	453	523
Purchased Steam													
On-Pk Cons. (therms)	0	0	0	0	0	47	41	47	40	0	0	0	175
Off-Pk Cons. (therms)	159	105	78	50	26	23	24	22	26	28	63	141	745
Mid-Pk Cons. (therms)	135	105	116	94	100	51	46	54	48	101	104	113	1,066
On-Pk Demand (therms/hr)	0	0	0	0	0	1	1	1	1	0	0	0	1
Off-Pk Demand (therms/hr)	2	2	1	1	1	1	1	1	1	1	1	2	2
Mid-Pk Demand (therms/hr)	1	1	1	1	1	1	1	1	1	1	1	1	1

—— Monthly Utility Costs ——

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative 1													
Electric													
On-Pk Cons. ($)	276	276	276	276	276	12,424	12,206	14,033	11,894	276	276	276	52,762
Off-Pk Cons. ($)	9,800	9,120	9,542	10,396	10,321	9,347	11,450	10,359	10,640	10,500	9,688	10,440	121,605
Mid-Pk Cons. ($)	15,785	14,856	18,232	16,393	18,730	10,219	9,807	11,566	9,567	19,338	17,158	15,435	177,086
On-Pk Demand ($)	0	0	0	0	0	13,098	14,121	14,089	13,846	0	0	0	55,154
Off-Pk Demand ($)	4,207	4,348	4,325	4,407	4,574	4,890	5,280	5,249	5,138	4,813	4,428	4,266	55,924
Mid-Pk Demand ($)	4,602	4,765	4,762	4,848	5,021	7,553	8,097	8,162	7,928	5,216	4,891	4,693	70,538
Total ($):	34,670	33,365	37,137	36,320	38,922	57,531	60,961	63,458	59,014	40,142	36,440	35,111	533,070
Monthly Total ($):	34,670	33,365	37,137	36,320	38,922	57,531	60,961	63,458	59,014	40,142	36,440	35,111	533,070

Building Area = 53,101 ft²

Utility Cost Per Area = 10.04 $/ft²

Mechanical System Redesign (Depth Study)

The main objective of my system redesign is to reduce the overall system operating cost while maintaining a first cost that is comparable to the existing "modified" design. As a result of reducing the cost, I believe the redesigned system will also reduce the energy consumption of the building. In order to achieve these objectives, an ice storage system was researched and designed to off-set the peak cooling loads.

Introduction to Ice Storage

During the summer months, cooling demand introduces a large load on electrical companies. As a result, many electric companies have rate structures that correspond to the peak/off-peak periods, refer to tables 4.1 and 4.2 for the Amini Center's rate structures. Lower rates are available for energy consumption during non-peak periods, while high rates are incurred during the peak consumption times. In order to take advantage of the off-peak rates, storage technology is available to shift the on-peak cooling capacities to off-peak hours.

Ice Storage System:

There are several technologies available to take advantage of the cool storage concept; some include chilled water storage, eutectic salts, and the topic of this report, ice storage. There are also several ice storage systems available, but for the Amini Center I chose to study an internal melt ice-on-coil system. This system seems to be very popular in ice storage design according to the BAC Ice Chiller Application Guide.

The system works by chilling a secondary coolant, 25% ethylene glycol in this case, to below freezing temperatures and running the coolant through coils submerged in water in a storage tank. The low temperature coolant will begin to form ice around the coils, creating the cooling storage capacity. To discharge the cooling capacity, a control scheme is set up to turn down or turn off the chillers during high cost hours and the now warmer coolant will run through the storage unit coils rejecting the heat to the ice that has been formed. Refer to Figure 5.1 for an illustration of the system charging and discharging. Figure borrowed from ASHRAE Design Guide for Cool Thermal Storage.

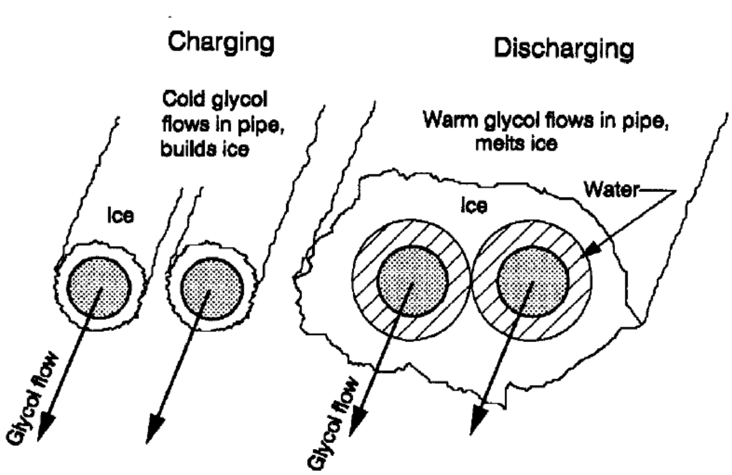

Figure 5.1

For the Amini Center, the redesign will be supplying the storage tank with 23 ^{o}F ethylene glycol during the charging cycle. 38 ^{o}F ethylene glycol will then be pumped to the air systems through out the building. Figure 5.2 and 5.3 show the flow diagrams for the existing system and the redesigned ice storage system for this analysis.

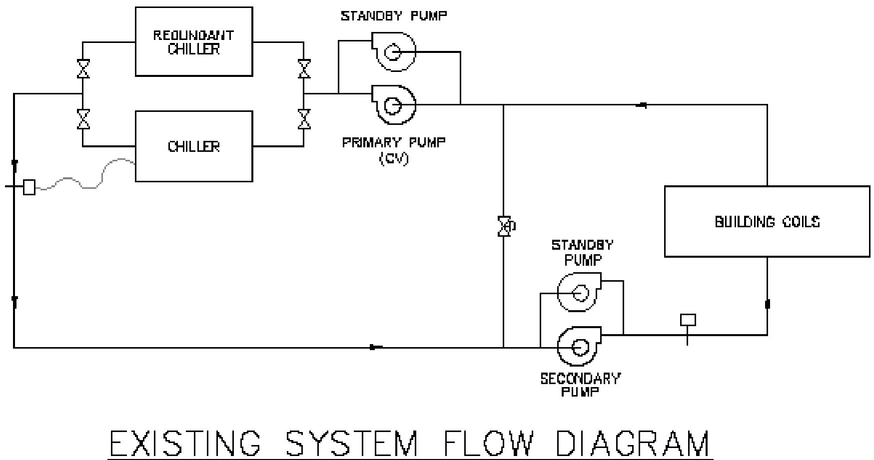

Figure 5.2

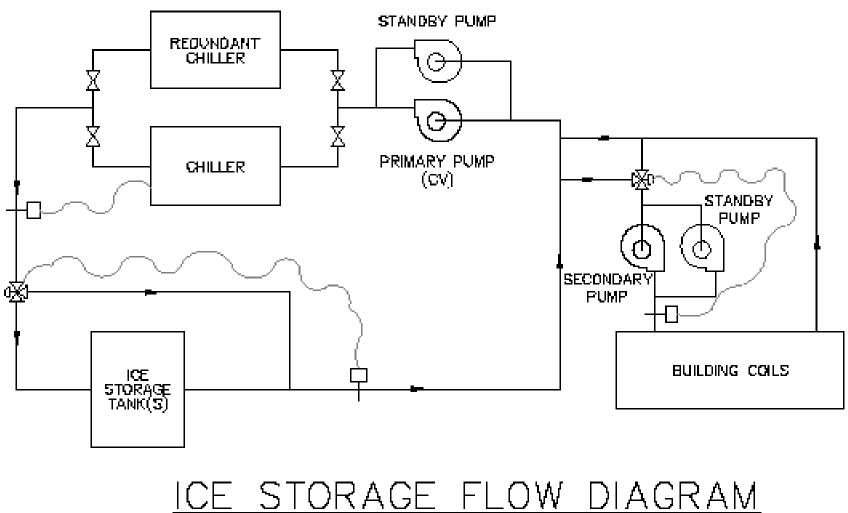

Figure 5.3

As seen in the ice storage flow diagram, the chiller will be positioned upstream of the storage tanks in this design. Positioning the chiller in this location allows the chiller to maintain the discharge temperature and operate more efficiently due to the higher evaporator temperatures. The ice storage diagram also shows the secondary loop connected directly to the primary loop without the use of a heat exchanger. This means that the secondary loop will need to account for the different heat transfer and flow characteristics of a 25% glycol solution compared to water.

Chiller Operation

Ice storage systems are typically classified by the amount of on-peak load they shift to off-peak hours. The three main classifications include full storage, load leveling partial storage, and demand limiting partial storage. The operating strategies and their effect on the Amini center design are discussed in the following sections. Refer to Figures 5.4, 5.5 and 5.6 for illustrations these basic operating strategies. Figures are borrowed from ASHRAE Design Guide for Cool Thermal Storage.

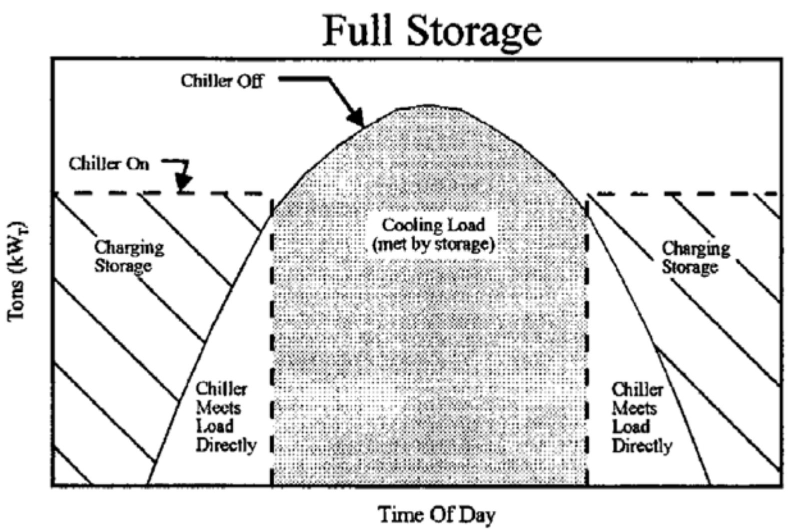

Figure 5.4

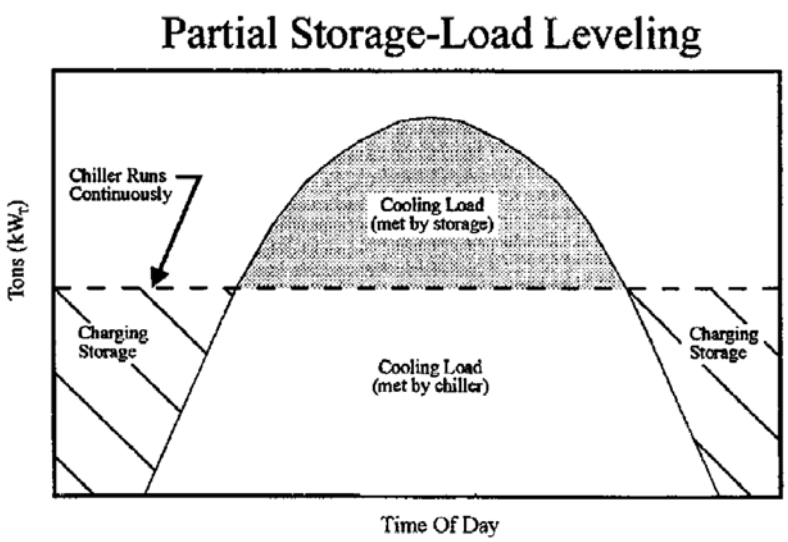

Figure 5.5

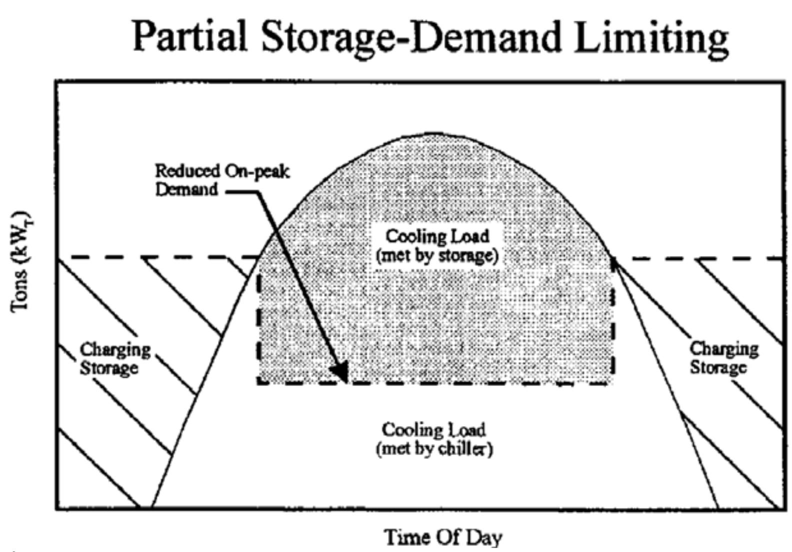

Figure 5.6

Full Storage

A full storage strategy will take the entire on-peak load and move it to non-peak hours. During off-peak hours, the chiller runs at full capacity meeting the building loads and storing the remaining capacity in the ice tank. During the on-peak hours the chiller is shut down, and the building loads are met from the capacity collected in the storage tank.

Load Profile/Schedule

To refresh your memory, the load profile for the cooling design day of the Amini Center is seen below in figure 5.7:

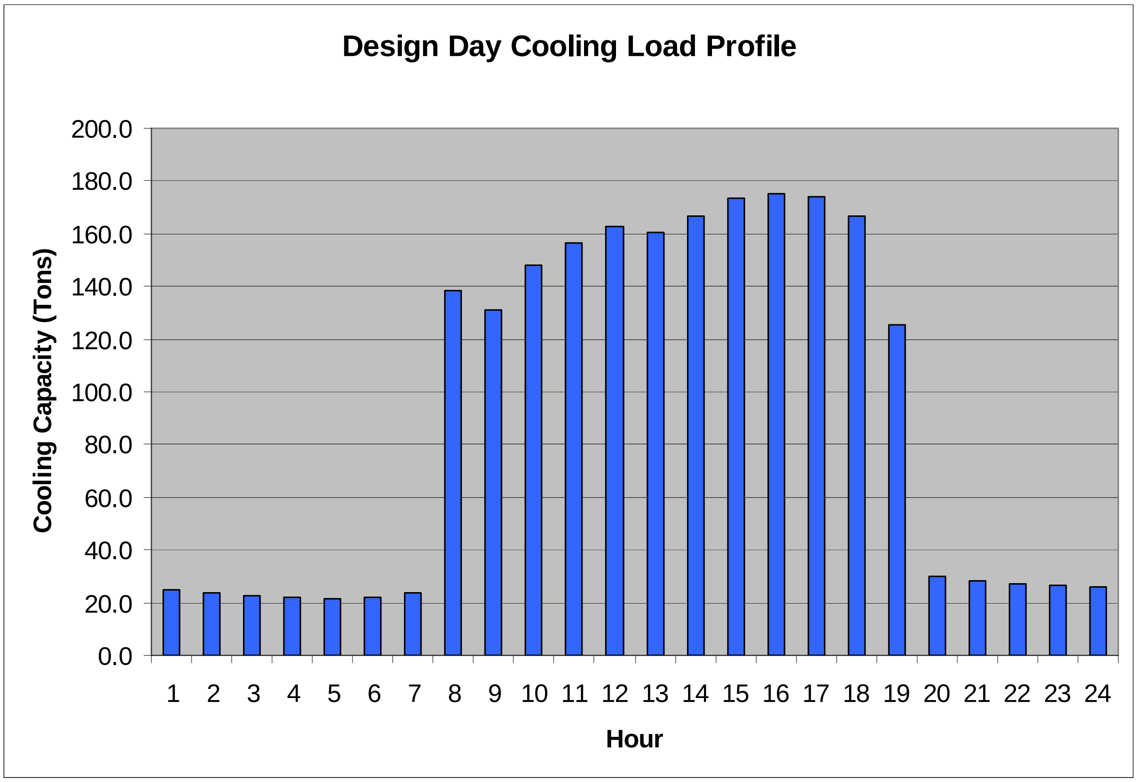

Figure 5.7

When comparing the load profile against the utility rate schedule (refer to Table 4.2) reasonable estimations needed to be made for selecting how the chiller will operate. Because of the load profile, and the necessity for 24/7 cooling, the chiller in this design will never operate in a "charging storage only" mode. The chiller with a full storage strategy will only operate in the following modes; Satisfy Load & Charge Storage, Satisfy Load, and Discharge.

After some personal debate, the chiller cooling modes were set as you seen in Table 5.1. I believe this was the best operating strategy for the full storage scenario. This strategy allowed a 12 hour charging process instead of a quicker 8-10 process to allow for the storage capacity derating due to the building loads.

COH Full Storage Scenario				
Hour	Clg (Tons)	Cooling Mode	Summer	Winter
1	24.7	Satisfy Load & Charge	OFF-PEAK	OFF-PEAK
2	23.6	"		
3	22.8	"		
4	22.0	"		
5	21.5	"		
6	22.0	"		
7	23.5	"		
8	138.5	Satisfy Load		
9	131.1	"	MID-PEAK	MID-PEAK
10	148.1	"		
11	156.4	"		
12	162.5	"		
13	160.3	Discharging	PEAK	
14	166.7	"		
15	173.4	"		
16	175.1	"		
17	174.0	"		
18	166.9	"		
19	125.2	"	MID-PEAK	
20	29.9	Satisfy Load & Charge		
21	28.5	"		
22	26.9	"		OFF-PEAK
23	26.6	"		
24	25.8	"	OFF-PEAK	

Table 5.1

Equipment Sizing

With the following chiller modes laid out, a ratio of the chiller capacity in those modes compared to the nominal capacity needed to be selected. After much research, a 25% ethylene glycol solution in Trane air-cooled chillers would produce the following capacity ratios in each chiller mode.

- Satisfy Load: 85% Nominal Capacity
- Satisfy Load and Charge Storage: 70% Nominal Capacity
- Discharge: 0% Nominal Capacity

Using the equations in the Ashrae Design Guide for Cool Thermal Storage for quick chiller and storage tank selections resulted in a nominal chiller capacity of 172 Tons and a storage capacity of 1142 Ton-hours. Refer to Appendix B for sizing calculations.

Because packaged chillers don't come in a nominal 172 Ton capacity, the 170 ton unit initially was selected. After quickly running the calculations with the 170 Ton unit, it was seen that it would not work for the scenario explained here. Therefore, the Trane nominal 185 Ton RTAC unit, which has ice making capabilities, was selected. Refer to Table 5.2 for the characteristics of the selected chiller. As you can see, the chilled water supply temperature has been reduced to 38F and the Delta T has increase to 20 degrees. With this information and the specific heat and specific gravity of 25% ethylene glycol, the flow rate through the chiller has been calculated.

185 Ton Chiller Selection (Full Storage Scenario)										
EER	CHWS (deg F)	CHWR (deg F)	dT (deg F)	Flow Rate (GPM)	PD (ft. H2O)	Cap. (Tons)	Input (KW)	KW/Ton	Primary/Secondary Loop Liquid	Chiller Nominal Tonnage
9.5	38	58	20	232	4.5	158.9	193	1.2146	25% Ethylene Glycol	185

Table5.2

When comparing the chillers actual capacity to the design day loads, the chiller cannot meet the load needed in the 12th hour of a design day (162.5 Tons). Because the difference is small and many assumptions were made on the loads and sizes, the capacity difference will be ignored for the cost analysis. If actually designing the system however, this difference should not be ignored. Table 5.3 shows the breakdown of the performance requirements.

Full Storage Design Requirements Needed (185 Ton Trane Chiller)			
Hour	Total System Load (Tons)	Non-Storage System Load (Tons)	Thermal Storage System Load (Tons)
1	25	126	-101
2	24	126	-102
3	23	126	-103
4	22	126	-104
5	22	126	-105
6	22	126	-104
7	23	126	-103
8	139	139	0
9	131	131	0
10	148	148	0
11	156	156	0
12	163	163	0
13	160	0	160
14	167	0	167
15	173	0	173
16	175	0	175
17	174	0	174
18	167	0	167
19	125	0	125
20	30	126	-96
21	29	126	-97
22	27	126	-99
23	27	126	-99
24	26	126	-100
		Total (Ton-hrs)	1142
		Storing (Ton-hrs)	1089

Table 5.3

With this chiller, a storage capacity of 1142 Ton-hours is needed. Looking through the BAC storage units, two TSU-594M (594 Ton-hour capacity) will be needed.

With the equipment selections and loop flow rate calculated, the pressure drop is the only thing needed to size the pumps. In order to get a proper pressure drop calculation the layout of the equipment needs to be anticipated. Due to the size of the ice storage units, the layout designed has the units below grade outside the mechanical room. Please refer to Appendix B for the layout of the system with ice storage and the pressure drop calculations. For this scenario the pressure drop through the primary loop was 54.5 ft. H_2O.

With the PD and the flow rate of the system, the Bell and Gossett catalog was used to select two end suction pumps. Table 5.4 shows the characteristics of the pumps.

GPM	PD	Bell & Gossett Selection				
		Model	RPM	HP	Efficiency	Frame
232	54.5	2.5 BB	1750	5	74%	184T

Table 5.4

Load Leveling Partial Storage

A partial storage strategy will take a portion of the on-peak load and transfer it to off-peak hours. The load not transferred to off-peak hours will be met by the chiller. In a load leveling system, the chiller operates at full capacity on a design day. When the building load is less then the chiller capacity (during non-peak hours), the chiller will store the excess capacity in the ice tank. When the building load is in excess of the chiller capacity (usually during on-peak hours), the stored capacity will discharge to supplement the chiller.

Load Profile/Schedule

The load profile for the building can be viewed in the full Storage section above, Figure 5.1.

For this strategy, certain aspects of the schedule were weighed against the utility rate schedule and iterations were calculated which resulted in the cooling mode schedule as seen in table 5.5.

Equipment Sizing

Because the chillers in this design will not operate in a “charging only” mode as mentioned above, a load leveling strategy on the Amini Center consists of only two cooling modes, Satisfy Load & Charge, and Satisfy Load & Discharge. The same capacity ratios apply:

- Satisfy Load & Charge: 70% Nominal Capacity
- Satisfy Load & Discharge: 85% Nominal Capacity

Using the equations in the Ashrae Design Guide for Cool Thermal Storage resulted in a nominal chiller capacity of 117 Tons and a storage capacity of 685 Ton-hours. Refer to Appendix C for sizing calculations.

A Trane nominal 125 Ton RTAA unit, with ice making capabilities, was selected. Refer to Table 5.6 for the characteristics of the selected chiller. As you can see, the chilled water supply temperature has been reduced to 38F and the Delta T has increase to 20 degrees as it was in the full storage scenario. With this information and the specific heat and specific gravity of 25% ethylene glycol, the flow rate through the chiller has also been calculated.

When comparing the chillers actual capacity to the design day loads, the chiller selected meets the necessary capacities needed for the design day. Table 5.7 shows the breakdown of the performance requirements.

<table>
<tr><th colspan="5">COH Load Leveling Scenario</th></tr>
<tr><th>Hour</th><th>Clg (Tons)</th><th>Cooling Mode</th><th>Summer</th><th>Winter</th></tr>
<tr><td>1</td><td>24.7</td><td>Satisfy Load & Charge</td><td rowspan="8">OFF-PEAK</td><td rowspan="8">OFF-PEAK</td></tr>
<tr><td>2</td><td>23.6</td><td>"</td></tr>
<tr><td>3</td><td>22.8</td><td>"</td></tr>
<tr><td>4</td><td>22.0</td><td>"</td></tr>
<tr><td>5</td><td>21.5</td><td>"</td></tr>
<tr><td>6</td><td>22.0</td><td>"</td></tr>
<tr><td>7</td><td>23.5</td><td>"</td></tr>
<tr><td>8</td><td>138.5</td><td>Satsify Load & Discharge</td></tr>
<tr><td>9</td><td>131.1</td><td>"</td><td rowspan="4">MID-PEAK</td><td rowspan="13">MID-PEAK</td></tr>
<tr><td>10</td><td>148.1</td><td>"</td></tr>
<tr><td>11</td><td>156.4</td><td>"</td></tr>
<tr><td>12</td><td>162.5</td><td>"</td></tr>
<tr><td>13</td><td>160.3</td><td>"</td><td rowspan="6">PEAK</td></tr>
<tr><td>14</td><td>166.7</td><td>"</td></tr>
<tr><td>15</td><td>173.4</td><td>"</td></tr>
<tr><td>16</td><td>175.1</td><td>"</td></tr>
<tr><td>17</td><td>174.0</td><td>"</td></tr>
<tr><td>18</td><td>166.9</td><td>"</td></tr>
<tr><td>19</td><td>125.2</td><td>"</td><td rowspan="5">MID-PEAK</td></tr>
<tr><td>20</td><td>29.9</td><td>Satisfy Load & Charge</td></tr>
<tr><td>21</td><td>28.5</td><td>"</td></tr>
<tr><td>22</td><td>26.9</td><td>"</td><td rowspan="3">OFF-PEAK</td></tr>
<tr><td>23</td><td>26.6</td><td>"</td></tr>
<tr><td>24</td><td>25.8</td><td>"</td><td>OFF-PEAK</td></tr>
</table>

Table 5.5

120 Ton Chiller Selection (Load Leveling Partial Storage Scenario)										
EER	CHWS (deg F)	CHWR (deg F)	dT (deg F)	Flow Rate (GPM)	PD (ft. H2O)	Cap. (Tons)	Input (KW)	KW/Ton	Primary/Secondary Loop Liquid	Chiller Nominal Tonnage
9.3	38	58	20	157	5.75	106.1	128.7	1.2130	25% Ethylene Glycol	125

Table 5.6

Partial Storage (Load Leveling) Design Requirements (125 Ton Chiller)			
Hour	Total System Load (Tons)	Non-Storage System Load (Tons)	Thermal Storage System Load (Tons)
1	25	84	-59
2	24	84	-60
3	23	84	-61
4	22	84	-62
5	22	84	-63
6	22	84	-62
7	23	84	-61
8	139	102	37

9	131	102	29
10	148	102	46
11	156	102	54
12	163	102	61
13	160	102	58
14	167	102	65
15	173	102	71
16	175	102	73
17	174	102	72
18	167	102	65
19	125	102	23
20	30	84	-54
21	29	84	-55
22	27	84	-57
23	27	84	-57
24	26	84	-58
		Total Storage(Ton-hrs)	654
		Storing (Ton-hrs)	-710

Table 5.7

With this chiller, a storage capacity of 654 Ton-hours is needed. In the 12 hour charging cycle, the chiller is capable of storinga total of 710 tons capacity. Looking through the BAC storage units, one TSU-761M (761 Ton-hour capacity) will be needed.

The layout and method for this system is similar to the full storage with certain changes; lower flow, one storage container, and smaller piping size. Please refer to Appendix C for the layout of the system with ice storage and the pressure drop calculations. For this scenario the pressure drop through the primary loop was calculated at 56.6 ft. H_2O.

With the PD and the flow rate of the system, the Bell and Gossett catalog was used to select two end suction pumps. Table 5.8 shows the characteristics of the pumps.

GPM	PD	Bell & Gossett Selection				
		Model	RPM	HP	Efficiency	Frame
157	56.6	2BC	1750	5	67%	184T

Table 5.8

Demand Limiting Partial Storage

Similar to the load leveling system, a demand limiting system will shift only part of the on-peak load to off-peak hours. The difference between the demand limiting and load leveling occurs during the on-peak hours. The chiller in the demand limiting system will be controlled to run at part load, 45% for this study, and have the storage tank make up the remaining load. During the non-peak hours, if the chiller capacity exceeds building load, the chiller will store the excess capacity. If the chiller capacity is less then the building load, the storage unit will supplement the chiller.

Load Profile/Schedule

The load profile for the building can be viewed in the full Storage section above, Figure 5.1.

Once again, certain aspects of the schedule were weighed against the utility rate schedule and iterations were calculated which resulted in the cooling mode schedule as seen in table 5.9.

COH Demand Limiting Scenario				
Hour	Clg (Tons)	Cooling Mode	Summer	Winter
1	24.7	Satisfy Load & Charge	OFF-PEAK	OFF-PEAK
2	23.6	"		
3	22.8	"		
4	22.0	"		
5	21.5	"		
6	22.0	"		
7	23.5	"		
8	138.5	Satisfy Load & Discharge		
9	131.1	"	MID-PEAK	MID-PEAK
10	148.1	"		
11	156.4	"		
12	162.5	"		
13	160.3	45% Chiller Cap. & Discharge	PEAK	
14	166.7	"		
15	173.4	"		
16	175.1	"		
17	174.0	"		
18	166.9	"		
19	125.2	"	MID-PEAK	
20	29.9	Satisfy Load & Charge		
21	28.5	"		
22	26.9	"		OFF-PEAK
23	26.6	"		
24	25.8	"	OFF-PEAK	

Table 5.9

Equipment Sizing

Because the chillers in this design will not operate in a “charging only” mode as mentioned previously, a load leveling strategy on the Amini Center consists of three cooling modes, Satisfy Load & Charge, and Satisfy Load & Discharge, and 45% Capacity & Discharge. The capacity ratios are as follows:

- Satisfy Load & Charge: 70% Nominal Capacity
- Satisfy Load & Discharge: 85% Nominal Capacity
- 45% Chiller Cap. & Discharge: 45% Nominal Capacity

Using the equations in the Ashrae Design Guide for Cool Thermal Storage resulted in a nominal chiller capacity of 138 Tons and a storage capacity of 859 Ton-hours. Refer to Appendix D for sizing calculations.

A Trane nominal 140 Ton RTAC unit, with ice making capabilities, was selected. Refer to Table 5.10 for the characteristics of the selected chiller. As you can see, the chilled water supply temperature has been reduced to 38F and the Delta T has increase to 20 degrees as it was in the other storage scenarios. With this information and the specific heat and specific gravity of 25% ethylene glycol, the flow rate through the chiller has also been calculated.

140 Ton Chiller Selection (Demand Limiting Partial Storage Scenario)										
EER	CHWS (deg F)	CHWR (deg F)	dT (deg F)	Flow Rate (GPM)	PD (ft. H2O)	Cap. (Tons)	Input (KW)	KW/Ton	Primary/Secondary Loop Liquid	Chiller Nominal Tonnage
9.3	38	58	20	176	7	120.7	147.5	1.2220	25% Ethylene Glycol	140

Table 5.10

When comparing the chillers actual capacity to the design day loads, the chiller selected meets the necessary capacities needed for the design day. Table 5.11 shows the breakdown of the performance requirements.

Demand Limiting Partial Storage Design Requirements (140 Ton Chiller)			
Hour	Total System Load (Tons)	Non-Storage System Load (Tons)	Thermal Storage System Load (Tons)
1	25	98	-73
2	24	98	-74
3	23	98	-75
4	22	98	-76
5	22	98	-77
6	22	98	-76
7	23	98	-75
8	139	119	20
9	131	119	12
10	148	119	29
11	156	119	37
12	163	119	44
13	160	63	97
14	167	63	104
15	173	63	110
16	175	63	112
17	174	63	111
18	167	63	104
19	125	63	62
20	30	98	-68
21	29	98	-69
22	27	98	-71
23	27	98	-71
24	26	98	-72
		Total (Ton-hrs)	842
		Storing (Ton-hrs)	-878

Table 5.11

With this chiller, a storage capacity of 654 Ton-hours is needed. In the 12 hour charging cycle, the chiller is capable of storinga total of 710 tons capacity. Looking through the BAC storage units, tw0 TSU-476M (476 Ton-hour capacity) will be needed.

The layout and method for this system is similar to the full storage with certain changes; lower flow and smaller piping size. Please refer to Appendix D for the layout of the system with ice storage and the pressure drop calculations. For this scenario the pressure drop through the primary loop was calculated at 66.9 ft. H_2O.

With the PD and the flow rate of the system, the Bell and Gossett catalog was used to select two end suction pumps. Table 5.12 shows the characteristics of the pumps.

GPM	PD	Bell & Gossett Selection				
		Model	RPM	HP	Efficiency	Frame
176	66.9	2BC	1750	5	70%	184T

Table 5.12

Redesigned System Energy Analysis

Using all the information from the load analysis and the newly selected equipment, an annual energy analysis was performed on the building for each of the ice storage scenarios.

Cooling Plant Modifications

Besides changing the chiller and pump sizes for each scenario another assumption was made for the ice making process and input into the Trace program.

To create low temperature coolant for the ice making process, a chiller will need to work harder to produce the low supply temperature. Because of this, each chiller was given a 1.3 KW/Ton ice making consumption. With the Chiller and pump sizes changing for each ice storage scenario, Table 6.1 summarizes the plant changes that were input into the Trace program.

System	dT (deg F)	Flow Rate (GPM)	Cap. (Tons)	Input (KW)	Normal Oper. (KW/Ton)	Ice Making (KW/Ton)	Chiller Nominal Tonnage	Pump PD (ft H2O)	Pump HP	Pump (Eff%)
Existing Sys	15	296	174.8	203.5	1.1642	-	185	53	7.5	71
Full Storage	20	232	158.9	193	1.2146	1.30	185	54.5	5	74
Load Leveling	20	157	106.1	128.7	1.2130	1.30	125	56.6	5	67
Demand Limiting	20	176	120.7	147.5	1.2220	1.30	140	66.9	5	70

Table 6.1

Utility Inputs

The utilities analyzing the ice storage systems are the same utilities from the modified design analysis. Please refer to that section of the report for the inputs other then the utility rates shown again in Table 6.2.

Amini Center Input Rate Structure				
Utility	**Customer Charge**		**Rate**	
Electric Demand	275.69	$/month		
On Peak (Oct. - May)			-	-
Mid Peak (Oct. - May)			10.36	$/KW
Off Peak (Oct. - May)			10.36	$/KW
On Peak (Jun. - Sept.)			25.84	$/KW
Mid Peak (Jun. - Sept.)			15.6	$/KW
Off Peak (Jun. - Sept.)			10.36	$/KW
Electric Consumption				
On Peak (Oct. - May)	-		-	-
Off Peak (Oct. - May)	-		0.139	$/kwh
Mid Peak (Oct. - May)	-		0.174	$/kwh
On Peak (Jun. - Sept.)	-		0.199	$/kwh
Off Peak (Jun. - Sept.)	-		0.172	$/kwh
Mid Peak (Jun. - Sept.)	-		0.135	$/kwh

* Rates are based on SCE rate schedule
Table 6.2

Annual Energy Consumption / Cost

The annual energy consumption outputs and costs for each ice storage scenario and the existing scenario can be viewed in appendices.

A summary of the energy and cost savings for each scenario is summarized in Table 6.3.

System	Consumption (kWh)			Demand (kW)			Annual Cost ($)	Annual Savings
	Peak	Off-Peak	Mid-Peak	Peak	Off-Peak	Mid-Peak		
Existing Sys	248,264	857,999	1,000,122	546	510	523	$533,070	$0
Load Leveling	224,302	857,853	983,472	464	451	456	$508,744	$24,326
Full Storage	161,397	983,472	936,168	329	513	524	$500,247	$32,823
Demand Limiting	207,183	885,248	1,003,749	432	472	478	$511,303	$21,767

Table 6.3

By switching to an ice storage system, the annual on-peak demand loads for the building were able to be reduced by 40% for the full storage system, 15% for the load leveling system, and 20% for the demand limiting system. These reductions reduced the annual energy cost for each system by 6.16%, 4.6%, and 4.08% respectively.

Utility Incentives

The above cost savings are for the cooling system differences only. Other cost savings can be received by incentive programs offered by the utility supplier, Southern California Edison. According to their website, the utility company offers two programs that the Amini Center qualifies for.

The first program, CPP-GCCD, offers rate discounts for peak periods for customers who shift their on-peak loads to off-peak hours. In this case, each ice storage program researched qualifies for this incentive. The claim of this incentive is elimination of on-peak and mid-peak demand charges. With this incentive, the utility rates are reduced to those shown in table 6.4.

Amini Center Input Rate Structure				
Utility	**Customer Charge**		**Rate**	
Electric Demand				
On Peak (Oct. - May)	256.19	$/month	-	-
Mid Peak (Oct. - May)			0	$/KW
Off Peak (Oct. - May)			10.36	$/KW
On Peak (Jun. - Sept.)			0	$/KW
Mid Peak (Jun. - Sept.)			0	$/KW
Off Peak (Jun. - Sept.)			10.36	$/KW
Electric Consumption				
On Peak (Oct. - May)	-		-	-
Off Peak (Oct. - May)	-		0.139	$/kwh
Mid Peak (Oct. - May)	-		0.174	$/kwh
On Peak (Jun. - Sept.)	-		0.199	$/kwh
Off Peak (Jun. - Sept.)	-		0.172	$/kwh
Mid Peak (Jun. - Sept.)	-		0.135	$/kwh

* Rates are based on SCE rate schedule with CPP incentive
Table 6.4

A summary of the cost savings for each scenario with the CPP incentive is summarized in Table 6.5. As it is seen, the cost savings increases in each scenario by 25.6% for the full storage system, 25.8% for the load leveling system, and 24.8% for the demand limiting system. A much larger and more attractive percentage for any building owner.

Another program offered, PLS program, provides design, installation, and on going maintenance for the load shifting equipment; another incentive that provides even more savings for the system through the years. With these incentives, an ice storage system is an extremely attractive option for this building.

System	Consumption (kWh)			Demand (kW)			Annual Cost ($)	Annual Savings
	Peak	Off-Peak	Mid-Peak	Peak	Off-Peak	Mid-Peak		
Existing Sys	248,264	857,999	1,000,122	546	510	523	$533,070	$0
Load Leveling	224,302	857,853	983,472	464	451	456	$395,718	$137,352
Full Storage	161,397	983,472	936,168	329	513	524	$396,679	$136,391
Demand Limiting	207,183	885,248	1,003,749	432	472	478	$400,928	$132,142

Table 6.5

Systems First Cost Analysis

The savings shown from the systems annual energy consumption are not the only costs that make a design feasible. First cost is an important aspect to building owners. In order to analyze the first cost impacts, the existing system costs were evaluated also. To evaluate the systems, the contractor's bid was consulted, along with the means catalog. Tables 7.1 thru 7.4 show the first costs associated with the existing system and the revised ice storage systems. Some of the main differences in the systems include obviously the storage units and the costs associated with having them below grade. Other cost changes include chiller sizing, pipe sizing, and the extra controls associated with a ice storage system.

Baseline First Costs					
Description	Product Total	Units	Quantity	Cost/Unit	Sub-Total
Chiller incl. Labor + O&P (185 Ton)	1	EA	2	$118,500.00	$237,000
CHW Piping - 5" incl. Labor + O&P	574	LF	1	$70.00	$40,180
CHW 90 deg Fittings - 5" incl. Labor + O&P	1	EA	24	$370.00	$8,880
CHW 45 deg Fittings - 5" incl. Labor + O&P	1	EA	1	$455.00	$455
CHW Tee Fittings - 5" incl. Labor + O&P	1	EA	6	$655.00	$3,930
CHW Piping Insulation - 2" on 5"d incl. Labor + O&P	574	LF	1	$14.00	$8,036
Valves incl. Labor + O&P	1	LS	1	$4,800.00	$4,800
Control Valve incl. Labor + O&P	1	EA	1	$1,225.00	$1,225
Vibration/Seismic Restraints incl. Labor + O&P	1	LS	1	$4,000.00	$4,000
CHW Pump - 300 gpm @ 7.5 Hp incl. Labor + O&P	1	EA	2	$3,950.00	$7,900
Trace Wiring incl. Labor + O&P	40	LF	1	$2.50	$100
DDC Controls	1	LS	1	$12,000.00	$12,000
Electrical - CHWP Hook-up	1	EA	2	$1,750.00	$3,500
Electrical - Chiller Hook-up	1	EA	2	$2,500.00	$5,000
Pipe Testing - 500-1000 LF	1	EA	1	$1,750.00	$1,750
Water Balancing (Pumps)	1	EA	2	$1,700.00	$3,400
Water Chemical Treatment	1	LS	1	$5,000.00	$5,000
Commissioning	1	TC	1	0.75%	$2,603.67

	Total:	$349,760
Escalation:	15%	$402,224

Table 7.1

Full Storage First Costs					
Description	Product Total	Units	Quantity	Cost/Unit	Sub-Total
Chiller incl. Labor + O&P (185 Ton)	1	EA	2	$118,500.00	$237,000
CHW Piping - 5" incl. Labor + O&P	721	LF	1	$70.00	$50,470
CHW 90 deg Fittings - 5" incl. Labor + O&P	1	EA	47	$370.00	$17,390
CHW 45 deg Fittings - 5" incl. Labor + O&P	1	EA	1	$455.00	$455
CHW Tee Fittings - 5" incl. Labor + O&P	1	EA	13	$655.00	$8,515
CHW Piping Insulation - 2" on 5"d incl. Labor + O&P	721	LF	1	$14.00	$10,094
Valves incl. Labor + O&P	1	LS	1	$6,000.00	$6,000
Control Valve incl. Labor + O&P	1	EA	2	$1,885.00	$3,770
Vibration/Seismic Restraints incl. Labor + O&P	1	LS	1	$4,500.00	$4,500

CHW Pump - 232 gpm @ 5.0 Hp incl. Labor + O&P	1	EA	2	$3,825.00	$7,650
DDC Controls	1	LS	1	$15,000.00	$15,000
Electrical - CHWP Hook-up	1	EA	2	$1,750.00	$3,500
Electrical - Chiller Hook-up	1	EA	2	$2,500.00	$5,000
Excevation and Hauling	413	CY	1	$20.18	$8,341
Gravel Fill incl. Labor + O&P	744	SF	1	$0.45	$335
Formwork SOG incl. Labor + O&P	110	LF	1	$4.35	$479
Formwork Walls incl. Labor + O&P	1560	SFCA	1	$6.65	$10,374
Concrete SOG incl. Labor + O&P	744	SF	1	$3.41	$2,537
Concrete Walls incl. Labor + O&P	39	CY	1	$25.50	$1,006
Steel Beam incl. Labor + O&P	28	LF	1	$51.00	$1,428
Steel Grating incl. Labor + O&P	744	SF	1	$15.00	$11,160
Ethylene Glycol	2040	GAL	1	$10.05	$20,502
Ice Storage Units	1	EA	2	$74,500.00	$149,000
Pipe Testing - 500-1000 LF	1	EA	1	$1,750.00	$1,750
Water Balancing (Pumps)	1	EA	2	$1,700.00	$3,400
Commissioning	1	TC	1	0.75%	$4,347.41
				Total:	$584,003
			Escalation:	15%	$671,603

Table 7.2

Demand Limiting Partial Storage First Costs					
Description	Product Total	Units	Quantity	Cost/Unit	Sub-Total
Chiller incl. Labor + O&P (140 Ton)	1	EA	2	$93,000.00	$186,000
CHW Piping - 4" incl. Labor + O&P	721	LF	1	$48.50	$34,969
CHW 90 deg Fittings - 4" incl. Labor + O&P	1	EA	47	$240.00	$11,280
CHW 45 deg Fittings - 4" incl. Labor + O&P	1	EA	1	$278.00	$278
CHW Tee Fittings - 4" incl. Labor + O&P	1	EA	13	$360.00	$4,680
CHW Piping Insulation - 2" on 4"d incl. Labor + O&P	721	LF	1	$13.00	$9,373
Valves incl. Labor + O&P	1	LS	1	$5,500.00	$5,500
Control Valve incl. Labor + O&P	1	EA	2	$1,885.00	$3,770
Vibration/Seismic Restraints incl. Labor + O&P	1	LS	1	$4,500.00	$4,500
CHW Pump - 176 gpm @ 5.0 Hp incl. Labor + O&P	1	EA	2	$3,700.00	$7,400
DDC Controls	1	LS	1	$15,000.00	$15,000
Electrical - CHWP Hook-up	1	EA	2	$1,750.00	$3,500
Electrical - Chiller Hook-up	1	EA	2	$2,500.00	$5,000
Excevation and Hauling	353	CY	1	$20.18	$7,130
Gravel Fill incl. Labor + O&P	636	SF	1	$0.45	$286
Formwork SOG incl. Labor + O&P	102	LF	1	$4.35	$444
Formwork Walls incl. Labor + O&P	1440	SFCA	1	$6.65	$9,576
Concrete SOG incl. Labor + O&P	636	SF	1	$3.41	$2,169
Concrete Walls incl. Labor + O&P	36	CY	1	$25.50	$921
Steel Beam incl. Labor + O&P	28	LF	1	$51.00	$1,428

Steel Grating incl. Labor + O&P	636	SF	1	$15.00	$9,540
Ethylene Glycol	1525	GAL	1	$10.05	$15,326
Ice Storage Units	1	EA	2	$61,000.00	$122,000
Pipe Testing - 500-1000 LF	1	EA	1	$1,750.00	$1,750
Water Balancing (Pumps)	1	EA	2	$1,700.00	$3,400
Commissioning	1	TC	1	0.75%	$3,489.15
				Total:	$468,709
			Escalation:	15%	$539,015

Table 7.3

Load Leveling Partial Storage First Costs					
Description	Product Total	Units	Quantity	Cost/Unit	Sub-Total
Chiller incl. Labor + O&P (125 Ton)	1	EA	2	$85,000.00	$170,000
CHW Piping - 4" incl. Labor + O&P	693	LF	1	$48.50	$33,611
CHW 90 deg Fittings - 4" incl. Labor + O&P	1	EA	38	$240.00	$9,120
CHW 45 deg Fittings - 4" incl. Labor + O&P	1	EA	1	$278.00	$278
CHW Tee Fittings - 4" incl. Labor + O&P	1	EA	9	$360.00	$3,240
CHW Piping Insulation - 2" on 4"d incl. Labor + O&P	693	LF	1	$13.00	$9,009
Valves incl. Labor + O&P	1	LS	1	$5,200.00	$5,200
Control Valve incl. Labor + O&P	1	EA	2	$1,885.00	$3,770
Vibration/Seismic Restraints incl. Labor + O&P	1	LS	1	$4,500.00	$4,500
CHW Pump - 157 gpm @ 5.0 Hp incl. Labor + O&P	1	EA	2	$3,700.00	$7,400
DDC Controls	1	LS	1	$15,000.00	$15,000
Electrical - CHWP Hook-up	1	EA	2	$1,750.00	$3,500
Electrical - Chiller Hook-up	1	EA	2	$2,500.00	$5,000
Excevation and Hauling	269	CY	1	$20.18	$5,426
Gravel Fill incl. Labor + O&P	484	SF	1	$0.45	$218
Formwork SOG incl. Labor + O&P	91	LF	1	$4.35	$396
Formwork Walls incl. Labor + O&P	1275	SFCA	1	$6.65	$8,479
Concrete SOG incl. Labor + O&P	484	SF	1	$3.41	$1,650
Concrete Walls incl. Labor + O&P	36	CY	1	$25.50	$921
Steel Beam incl. Labor + O&P	28	LF	1	$51.00	$1,428
Steel Grating incl. Labor + O&P	484	SF	1	$15.00	$7,260
Ethylene Glycol	1339.6	GAL	1	$10.05	$13,463
Ice Storage Units	1	EA	1	$84,000.00	$84,000
Pipe Testing - 500-1000 LF	1	EA	1	$1,750.00	$1,750
Water Balancing (Pumps)	1	EA	2	$1,700.00	$3,400
Commissioning	1	TC	1	0.75%	$2,985.14
				Total:	$401,003
			Escalation:	15%	$461,154

Table 7.4

Mechanical Redesign Summary

In order to reduce the operating costs for the Amini Center, an ice storage system was investigated and designed to shift the on-peak cooling loads to off-peak hours. Three ice storage systems, each with its own control strategy, were designed and evaluated against a primary secondary chiller system with no storage. Each system designed was the primary loop of a primary secondary system, and each systems secondary loop was modeled identically.

Each storage system evaluated was designed as an internal melt ice-on-coil with 25% ethylene glycol coolant pumped throughout the entire system. Due to the glycol solution, capacity deratings and flow changes needed to be accounted for.

Full Storage

The full storage system design took all the on-peak load and shifted to non-peak hours. In order to do this, a chiller with the same capacity as the existing system (185 Tons) needed to be designed. The storage capacity required for this system was also the largest of the systems evaluated at 1150 Ton-hours. The layout of the system did not take up any additional floor space compared to the existing system modeled. The chiller footprint and piping sizes also remained the same. The only additional space required was a pit to house the storage tanks. The full storage system produced just under the largest annual savings but had the highest first cost of the systems evaluated.

Load Leveling Partial Storage

The load leveling design used a smaller, 125 Ton chiller to off-set only part of the on-peak design day load. With the smaller chiller, a smaller pump and reduced flow were also calculated. The storage container sized for the load leveling system was also the smallest unit of the three scenarios needing 655 Ton-hours. The load leveling system like the full storage required no additional floor space. Compared to the other systems, this one required the least additional space due to the reduced equipment sizes. This system produced the largest annual savings and had the cheapest first cost of the ice storage systems.

Demand Limiting Partial Storage

This system chiller and storage capacities ended up in between the other two ice storage systems. This 140 Ton chiller and 850 Ton-hour storage system also had reduced piping sizes compared to the existing and full storage systems. Like the other systems, no additional floor space was required. Compared to the existing system, the weight of the units on the building is reduced with the small equipment sizing. The cost for this system was greater then the load leveling and produced the least amount in annual savings.

Table 8.1 below summarizes the total first year costs to install and operate each system.

System	Building Consumption (10^6 BTUs/yr)	First Cost ($)	Annual Cost ($)	Total Cost ($)
Existing Sys	7,388	$402,224	$533,070	935,294
Load Leveling	7,249	$461,154	$395,718	856,872
Full Storage	7,326	$671,603	$396,679	1,068,282
Demand Limiting	7,353	$539,015	$400,928	939,943

Table 8.1

Mechanical Redesign Discussion

Many factors need to be accounted for when designing a chilled water system, not to mention one with ice storage. Changes to temperature or the cooling fluid can affect the efficiency and performance of equipment significantly. First cost and annual energy costs also play an important role in determining the feasibility of a design. In this study design, all these factors were taken into account in determining the validity of an ice storage system for the Amini Medical Center.

Remember, removing the building's cooling system from the central plant and providing an independent air-cooled chiller was the base system. In keeping that setup of the air-cooled chiller, an ice storage system was then installed to see the effects of shifting loads from on-peak hours.

The disadvantages of providing the ice storage system included the following.

- Physical space for the storage tanks
- The need for the less efficient glycol solution
- Added controls and piping

The advantages of having the system included:

- Annual savings by shifting loads
- Smaller chillers, piping and pump sizes for 2 of the scenarios
- Slight savings in energy consumption
- Eligibility for utility incentives
- Lower CHWS temperature

With the lower CHWS temperature, additional savings are possible by providing cold air distribution and reducing piping, duct and fan sizes in the secondary loop. A first cost and annual energy savings might be possible due to the downsizing.

However it is installed, I do believe that an ice storage system would be of great benefit the Amini Medical Center. For this study, it appears that a load leveling partial storage system would be best suited for this building. Even with the central plant, providing a secondary tap from the mains and providing a smaller chiller to produce ice during the off hours would help off-set some of the building demand loads and reduce their electric bill.

Electrical Breadth

During the past semesters course work of reviewing the existing building systems, it became apparent that the lighting power densities in many rooms of the Amini Center were not at or below the ASHRAE 90.1-2007 stated values. With some of the power densities calculated being very high, I suspected that the lighting levels at the work plain might also be above the prescribed values recommended by the Illuminating Engineering Society of North America (IESNA). I believe that the lighting levels should remain high in the patient areas, where critical tasks like taking blood and performing examinations are done, but areas like the break room and offices could reduce the lighting power densities and lighting levels while still meeting the footcandle requirements for the tasks performed in those areas.

IESNA provides recommendations for the lighting levels based on locations and tasks performed. According to the IESNA lighting design guide, break rooms and office areas require an average of 30 footcandles for normal tasks and an average of 50 footcandles for specialty tasks at the work surface. I will be assuming the areas evaluated will have normal tasks and the work surface will be the desk 2’-6” above the floor.

Existing Lighting Conditions/Modeling

The lighting evaluation concentrated on Work Area 260, Break Room 280, Conference Room 283, and Office 286 since these layouts could be applied to several other areas. Type P (Ledalite 7306-H02-I-N-4-7-2-ED-W), an indirect/direct pendant mounted light fixture with two 54W T5HO lamps, are used in the office areas and conference rooms. Type A3 (Daybrite 2-SP-G-3-32-FA-01---277-EB10I), a 2’x4’ lensed troffer with three 32W T8 lamps, are used in the break room. In addition to the type P fixture in the work room, type C2 (Kramer Lighting KL6-S1-1X32PLT-2-SGC-FF-277), a square 6” downlight with a 32W compact fluorescent lamp, is used for the entrance way into the room. Using a light level modeling software, Visual 2.6, I’ve modeled the illuminance at the work surface areas per the design for the rooms mentioned above. The software takes the manufacturer’s light fixture ies files and uses them to determine each fixtures lighting output.

To start the modeling, I imported the CAD background as a basis for the room layouts and constructed walls in the program to account for light reflected from wall surfaces. Each surface in the program has a reflectance level which was set to the default level of flat paint, 0.30. The measured lighting zone is offset at 2’-6” from the floor, which is the same as the work surface. After creating the fixture and room layout, I assigned the corresponding ies file to each fixture. At this time the the program was run and the illuminance values were calculated. Refer to Appendix E for the existing light fixture cut sheets and the calculated illuminance at the work plain for the rooms evaluated. The lighting levels in the open office area and conference room were calculated with an average footcandle 3-4x above the average for the expected tasks in those rooms. The other rooms seemed a little better with average footcande measurements about double that recommended.

Table 10.1 below provides a summary of the fixtures and their output for each room. The wattage and cost per fixture are also shown in Table 10.1 to provide an estimate of the energy used along with first costs expected with the existing design.

*Fixture costs include installation and wiring based from the contractors bid pricing.

Existing Lighting Design												
Room	Area	Fixture P			Fixture A3			Fixture C2			W/SF	$/SF
		Qty.	Watts/Fix.	$/Fix.	Qty.	Watts/Fix.	$/Fix.	Qty.	Watts/Fix.	$/Fix.		
Work Area 260	1125	24	108	$685	0	96	$250	2	32	$335	2.4	$15.2
Break Rm 280	518	0	108	$685	7	96	$250	0	32	$335	1.3	$3.4
Conference Rm 283	614	16	108	$685	0	96	$250	0	32	$335	2.8	$17.9
Office 286	116	2	108	$685	0	96	$250	0	32	$335	1.9	$11.8

Table 10.1

Lighting Redesign

The goal for the redesign is to reduce the wattage per area while keeping the lighting levels above the average 30 footcandles. I switched the pendant mounted P fixtures to a 2'x4' recessed indirect/direct fixture with two 28W T5 lamps (Lithonia 2AV-G-A-2-28T5-MDR-MVOLT-GEB10PS) because it is half the wattage and a more economical fixture. This fixture was expected to reduce the illuminance at the work plain but still remain within the IESNA recommendations. I also redesigned the break room with under cabinet light fixtures (Lithonia UC-24E-120) to illuminate concentrated task areas. Using the software and methods mentioned above for the light level modeling, I modeled the same rooms by using the new fixtures with a new layout. Refer to Appendix F for the new light fixture cut sheets, layout, and the calculated illuminance at the work plain for the rooms evaluated. See Table 10.2 below for the measured lighting levels (footcandles) and total wattage per area. The lighting levels in the open office area and conference room were now calculated with an average footcandle under 2x the average for the expected tasks in those rooms. The other rooms average footcandle measurement ended up between the normal and special task recommendations.

Table 10.2 below provides a summary of the fixtures and their output for each room. The wattage and cost per fixture are also shown in Table 10.2 to provide an estimate of the energy used along with first costs expected with the existing design.

*Fixture costs include installation and wiring based from the contractors bid pricing.

Existing Lighting Design									
Room	Area	Fixture A			Fixture B			W/SF	$/SF
		Qty.	Watts/Fix.	$/Fix.	Qty.	Watts/Fix.	$/Fix.		
Work Area 260	1125	18	56	$450	0	19	$125	0.9	$7.2
Break Rm 280	518	7	56	$450	4	19	$125	0.9	$7.0
Conference Rm 283	614	12	56	$450	0	19	$125	1.1	$8.8
Office 286	116	2	56	$450	0	19	$125	1.0	$7.8

Table 10.2

Conclusions

With the redesign of the lighting as mentioned, the lighting power densities and overall lighting cost per square foot was reduced while remaining within acceptable work plain lighting levels.

Reducing the power densities can be extremely beneficial to the building owner because it can affect many aspects of the building. By reducing the lighting load here, less lighting power is consumed, building cooling loads are then reduced, electrical service and mechanical systems might be downsized, and the first costs and energy savings are also applicable. The future 3rd floor office (18,466 sf) would save (avg. rooms 260 and 286) $6.0/sf = $110,796 in first cost and 1.2 w/sf =22,160 W in energy to run. I believe redesigning the lighting system would be beneficial.

Structural Breadth

Due to the addition of the chillers in all scenarios of the mechanical redesign, increased structural loads needed to be evaluated. For this breadth study, the roofing members (beams and girders) and roof construction, in the bay where the units were added, were evaluated to see if the existing members can effectively hold the newly added weights.

Existing Conditions

The existing roofing structure is a steel framed structure with W14x22 members making up the majority of the supports on the outskirts of a screened mechanical penthouse. The roofing above the W14x22 members consists of only 3", 20 gauge, metal roof deck. The framing under the mechanical penthouse consists mainly of W21x44 members under 3-1/4" light weight concrete on 2" metal decking. For a roof framing plan, refer to Appendix G.

Evaluation Area

Leaving the mechanical air-handling units in their design locations, the best area for the chillers placement was just north in plan of the mechanical penthouse. Refer to Appendix G for chiller locations overlaid on the roof framing plan. As it is seen on the existing framing plan, the concrete roofing structure and mechanical screen do not extend to this area. The redesign will, therefore, need to include the weight extending the concrete on metal deck roofing north to the next bay.

Load Estimation

In determining the total load expected within the bay where the chillers were added, dead load (DL) and live loads (LL) will need to be calculated. Deal loads include the following; the chiller, concrete on roof decking, and the roof construction consisting of roof insulation, vapor barrier, and particle board. Table 11.1 below summarizes the total dead load anticipated by the beams. For this analysis the smallest chiller from the load leveling scenario mentioned in the mechanical depth will be analyzed (136 sf footprint, 9612 lbs). Refer to Appendix C for more chiller information. Concrete on metal deck load was taken from the Vulcraft catalog, 6-1/2" 20 gauge light weight concrete with a clear span of 6 feet. The roofing construction weights were taken from ASCE Standard 7-06.

DL Estimation	
Unit	Load (lb/sf)
120 Ton Chiller	71
Concrete on metal Deck	48
2" Rigid Insul.	3
1/4" Board	0.375
Vapor Membrane	0.7
Misc. MEP Equip (Assumed)	10
Total	133.075

The live load experienced on the roof members was taken from the contract documents, 20 lb/sf. This does seem like a relatively small load, but for the location, snow is not really a factor to include in the live load estimate.

Calculations

Now that the loads have been estimated, the effect on the steel members needs to be calculated. To do this the tributary area for each beam within the bay needs to calculated and the load applied over that area. The three 30 foot, W14x22 beams shown spanning north to south within the 24 foot bay are each going to see the same tributary width of 6 feet. The remaining area will be split with the two beams connecting directly to the columns. The DL seen by those beams is as follows:

(DL) 134 lb/sf * 6 ft = 804 lb/lf = 0.804 k/lf (kips per linear foot)

(LL) 20 lb/sf * 6 ft = 120 lb/lf = 0.12 k/lf (kips per linear foot)

With these values calculated I then used a beam selection software to provide a beam suitable to with stand these loads. The program used, EnerCalc, used the Load Resistance Factor Design (LRFD) method in selecting the beam. The inputs needed were the span of the beam, the dead and live loads per linear foot, and the type of connection which was entered as pinned-pinned. One assumption that was made was that the yield strength (F_y) = 50ksi, which is standard for A992 steel beams.

With all inputs entered, the program produced a W18x40 beam to adequately support the chillers and roofing loads. The maximum moment capacity (M_u) produced by these loads is 135.551 k-ft, which is less than the nominal moment capacity (Phi*M_n = 294 k-ft) of the beam. Compared to the existing W14x22 beam with a Phi*M_n = 123 k-ft, this is a 139% increase. With W21 beams in the next bay over, the W18 beam was assumed to not pose a problem for the depth of the beam. Please refer to Appendix G for the EnerCalc outputs.

To size the girders, it was assumed that the 139% increase could be applied to the moment capacity of the girders. The existing W24x76 girders, Phi*M_n = 750 k-ft, would now have to bear a capacity of Phi*M_n = 1793 k-ft. Searching the Steel Manual for a beam meeting this capacity I came across the lightest being a W36x135. Because of possible depth issues, this beam was not selected and the W24x176 with a Phi*M_n = 1920 k-ft was designed. With the redesign shown in Appendix G, the outer framing was mimicked from the adjacent bay and the screen was enlarged to house the chillers also. The redesigned framing members for this bay are shown as well.

Conclusion

With the addition of the chillers to the roof, the roofing structure experienced some major changes including expanding the concrete and metal decking, the penthouse up sizing, and the upsizing of the roofing beams and maybe columns. Adding equipment to a roofing structure can have significant effect on the building construction and costs. When different scenarios are evaluated, these structural changes need to be evaluated as well in the overall design to provide a proper cost analysis of a system.

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Also, I would like to thank Kevin Parfitt, Moses Ling, and the rest of the Penn State Architectural Engineering Faculty and Staff.

References

EwingCole. 2007. City of Hope: Amini Medical Center Construction Documents and Specifications. EwingCole, Irvine, CA

ASHRAE. 2007, ANSI/ASHRAE, Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., Atlanta, GA.

ASHRAE. 2007, ANSI/ASHRAE, Standard 90.1-2007, Energy Standard for Building Except Low-Rise Residential Buildings. American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., Atlanta, GA

ASHRAE. 2005, 2005 ASHRAE Handbook – Fundamentals. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc., Atlanta, GA 2001.

ASHRAE. 2008, 2008 ASHRAE Handbook – Systems & Equipment. American Society of Heating Refrigeration and Air Conditioning Engineers, Inc., Atlanta, GA 2001.

Parsons, Bob, ed. Design Guide for Cool Thermal Storage. New York: American Society of Heating, Refrigerating & Air Conditioning Engineers, Inc., Atlanta, GA 1994.

BAC. 2001. Ice Chiller Application Guide. Baltimore Aircoil Company, Baltimore, MD

Kirkpatrick & Elleson, Cold Air Distribution System Design Guide. American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., Atlanta, GA 1996.

Doty, PE, Steve. "Designing for Reliability." ASHRAE Journal 50.7 (2008): 22-29.

McQuay Air Conditioning. “Why Change the Chilled Water Temperature Range?” Engineering System Solutions Vol. 14, Dec. 2002.

Trane. User’s Manual: Trace700, Building Energy and Economic Analysis Version 6.0. American Standard, 2005.

AISC. Manual of Steel Construction - Load & Resistance Factor Design Vol. 1. American Institute of Steel Construction, Inc. 1995.

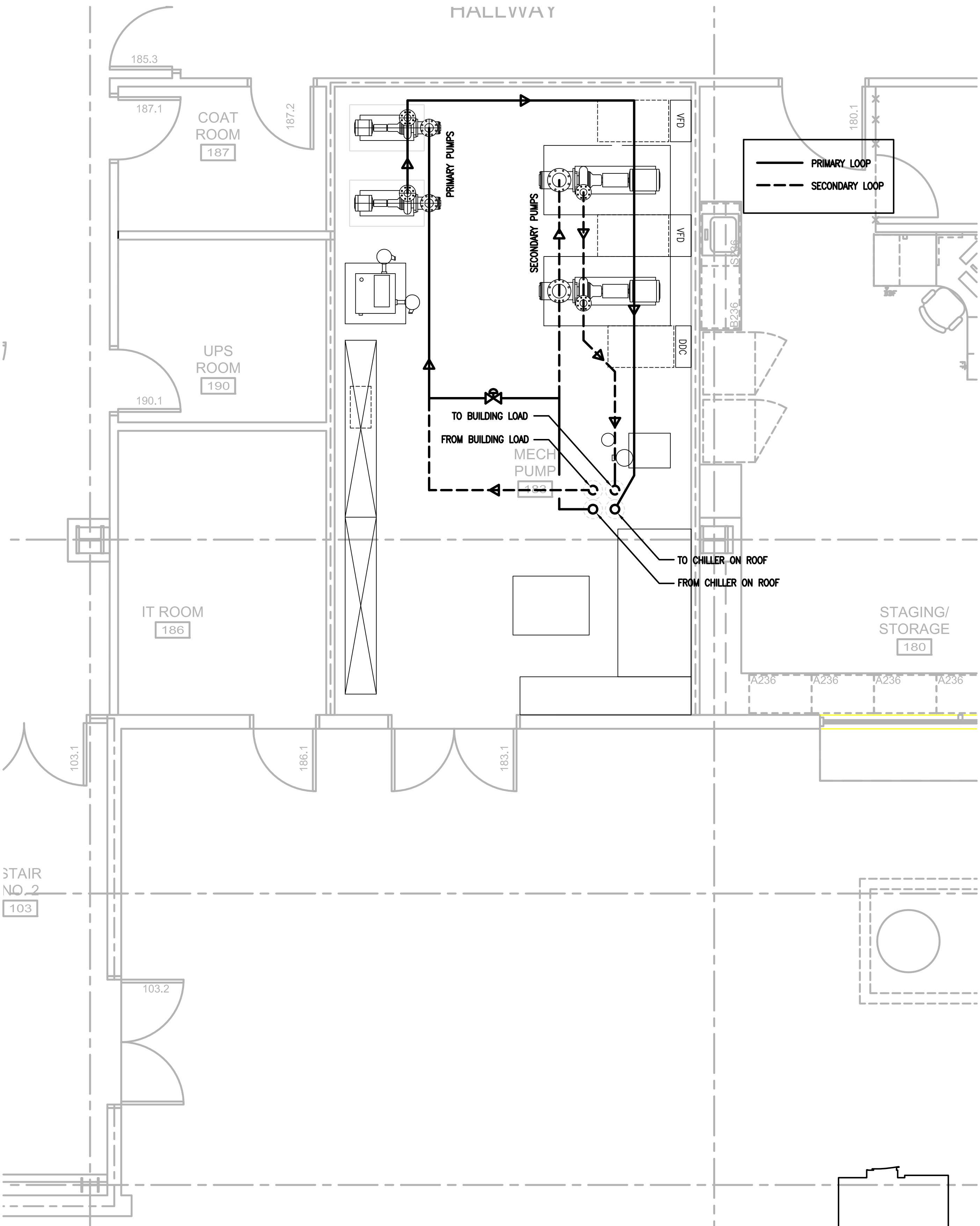
McQuiston, Parker, Spitler. Heating, Ventilating, and Air Conditioning Analysis and Design Fifth Edition. John Wiley & Sons, Inc. 2000.

RSMeans, 2007. Mechanical Cost Data – 30th Annual Edition. Reed Construction Data, Inc. 2006.

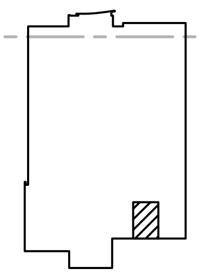
RSMeans, 2007. Building Construction Cost Data – 65th Annual Edition. Reed Construction Data, Inc. 2006.

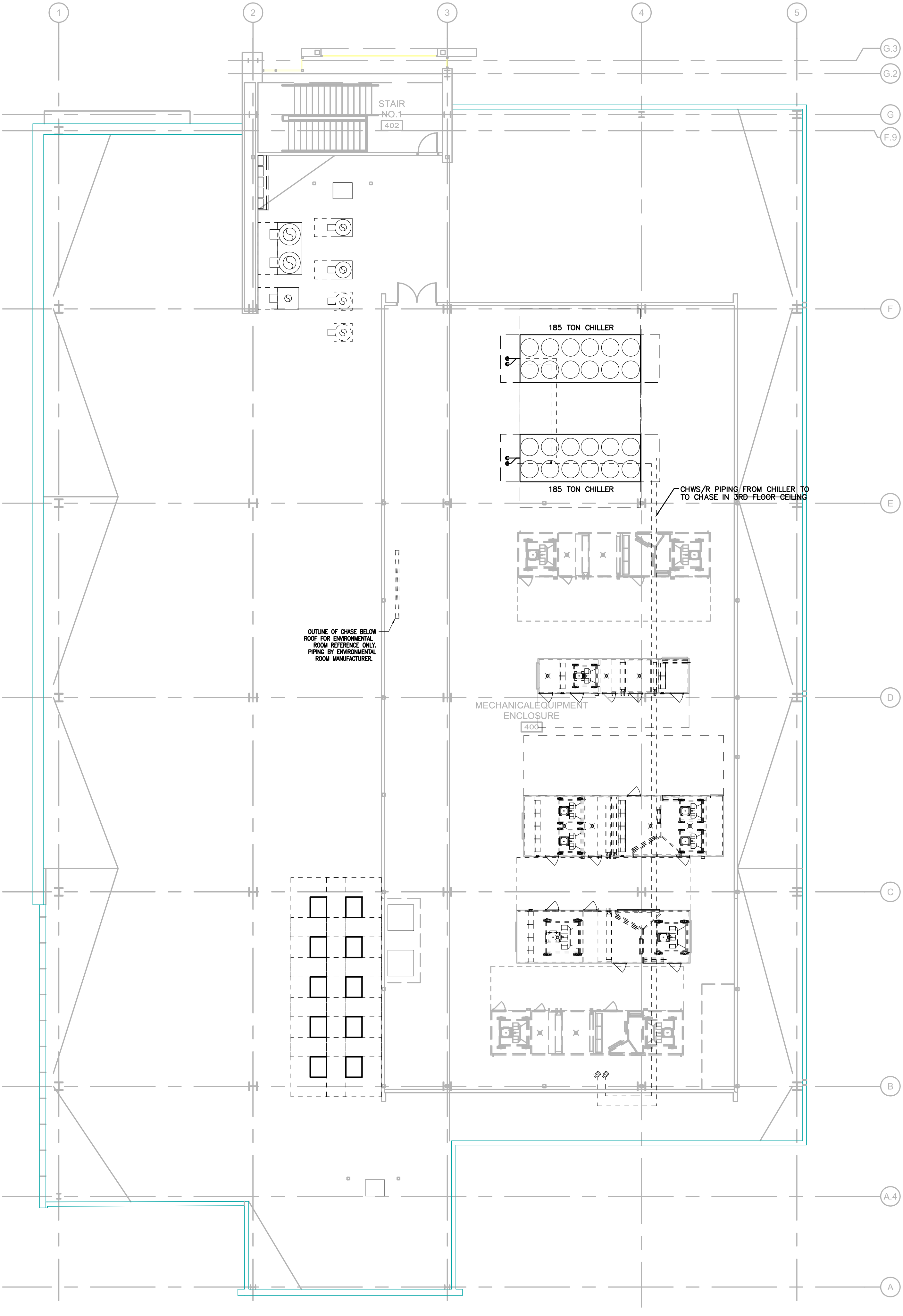
American Society of Civil Engineers. ASCE 7-05: Minimum Design Loads for Buildings and Other Structures. ASCE: Reston, VA, 2006.

Appendix A
Existing Mechanical Design



MECH. RM. LAYOUT – BASELINE SYSTEM





1
2
3
4
5
G.3
G.2
G
F.9
F
E
D
C
B
A.4
A
STAIR
NO.1
402
185 TON CHILLER
185 TON CHILLER
CHWS/R PIPING FROM CHILLER TO
TO CHASE IN 3RD FLOOR CEILING
OUTLINE OF CHASE BELOW
ROOF FOR ENVIRONMENTAL
ROOM REFERENCE ONLY.
PIPING BY ENVIRONMENTAL
ROOM MANUFACTURER.
MECHANICALEQUIPMENT
ENCLOSURE
400

City of Hope
24458
CHW Head Calc
Piping System

Section	Describe Pipe	Flow (gpm)	Pipe Size (in)	Alt Pipe Size (in)	Length (ft)	Tag No.	Fittings Description	No. Fittings	Actual Pressure Drop (ft)	Velocity (fps)	Alt C	Head Loss / 100ft	Fitting Equiv. Length	Pressure Drop (ft)	Total Pressure Drop (ft)
	MECH ROOM					1	NA								
Pump to Chase	Supply	296.0	5			4	Pump		5.0	4.75		2.11		5.00	5.00
		296.0	5		48	2	Straight Pipe			4.75		2.11		1.01	6.01
		296.0	5			12	Long Radius 90 Elbow	4		4.75		2.11	6.73	0.57	6.58
		296.0	5			13	45 Standard Elbow	1		4.75		2.11	6.73	0.14	6.72
		296.0	5			14	Standard Tee-thru flow	1		4.75		2.11	8.41	0.18	6.90
Chase to Pump	Return	296.0	5			12	Long Radius 90 Elbow	4		4.75		2.11	6.73	0.57	7.46
		296.0	5		35	2	Straight Pipe			4.75		2.11		0.74	8.20
		296.0	5			15	Standard Tee-branch flow	3		4.75		2.11	25.2	1.59	9.79
		296.0	5			32	Control Valve (25 ft)		15.0	4.75		2.11		15.00	24.79
Chase	Supply + Return	296.0	5		70	2	Straight Pipe			4.75		2.11		1.47	26.27
3rd Flr	Supply + Return	296.0	5		290	2	Straight Pipe			4.75		2.11		6.11	32.38
		296.0	5			12	Long Radius 90 Elbow	12		4.75		2.11	6.73	1.70	34.08
		296.0	5			15	Standard Tee-branch flow	2		4.75		2.11	25.2	1.06	35.14
		296.0	5			22	Butterfly valve	2		4.75		2.11	18.9	0.80	35.93
Roof	Supply + Return	296.0	5		20	2	Straight Pipe			4.75		2.11		0.42	36.35
		296.0	5			12	Long Radius 90 Elbow	4		4.75		2.11	6.73	0.57	36.92
	Chiller	296.0	5			33	Other		7.0	4.75		2.11		7.00	43.92
			3/4			1	NA								43.92
			3/4			1	NA								43.92

Total Head = 43.92

Safety Factor = 20%

Grand Total = 52.71

* Based on Cameron Hydraulic Data Book.
Small Pipe Add 10% Safety Factor.
Medium to Large Pipe 20% Safety Factor.

Air-Cooled Series R™ Rotary Liquid Chiller

Model RTAC
140 to 500 Tons (60 Hz)
140 to 400 Tons (50 Hz)
Built For the Industrial and Commercial Markets

November 2006

RLC-PRC006-EN

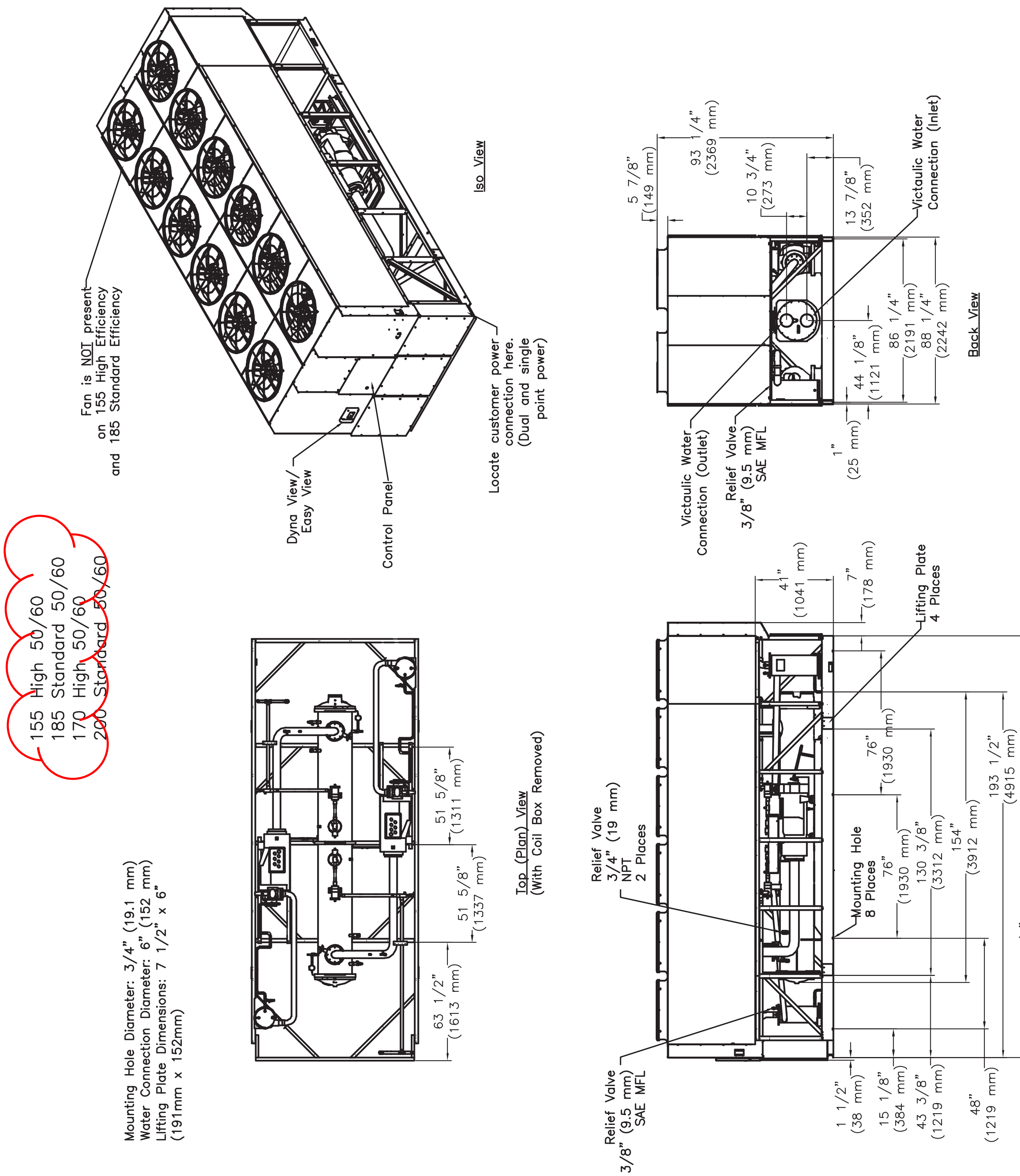
General Data

Table G-1. General data — 140-500 ton 60 Hz units - standard efficiency

Size		140	155	170	185	200	225	250	275	300	350	400	450	500
Type		STD	STD	STD	STD	STD	STD	STD	STD	STD	STD	STD	STD	STD
Compressor														
Quantity (1)		2	2	2	2	2	2	2	3	3	3	4	4	4
Nominal size (tons)									85-	100-	120-	100-100 /	120-120 /	120-120 /
@ 60 Hz		70/70	85/70	85/85	100/85	100/100	120/100	120/120	85/100	100/100	120/100	100-100	100-100	120-120
Evaporator														
Water storage	(gallons)	29	32	33	35	39	38	42	60	65	70	81	84	89
	(liters)	111	121	127	134	146	145	158	229	245	264	306	316	337
2 Pass arrangement														
Minimum flow	(gpm)	193	214	202	217	241	217	241	309	339	375	404	422	461
	(L/s)	12	14	13	14	15	14	15	20	21	24	26	27	29
Maximum flow	(gpm)	709	785	741	796	883	796	883	1134	1243	1374	1483	1548	1690
	(L/s)	45	50	47	50	56	50	56	72	78	87	94	98	107
3 Pass arrangement														
Minimum flow	(gpm)	129	143	135	145	161	145	161	206	226	250	270	282	307
	(L/s)	8	9	9	9	10	9	10	13	14	16	17	18	19
Maximum flow	(gpm)	473	523	494	531	589	531	589	756	829	916	989	1032	1127
	(L/s)	30	33	31	33	37	33	37	48	52	58	62	65	71
Condenser														
Qty of coils		4	4	4	4	4	4	4	8	8	8	8	8	8
Coil length	(inches)	156/156	180/156	180/180	216/180	216/216	252/216	252/252	180/108	216/108	252/108	216/216	252/216	252/252
	(millimeters)	3962/3962	4572/3962	4572/4572	5486/4572	5486/5486	6401/5486	6401/6401	4572/2743	5486/2743	6401/4572	5486/5486	6401/5486	6401/6401
Coil height	(inches)	42	42	42	42	42	42	42	42	42	42	42	42	42
	(millimeters)	1067	1067	1067	1067	1067	1067	1067	1067	1067	1067	1067	1067	1067
Fins/Ft		192	192	192	192	192	192	192	192	192	192	192	192	192
Number of rows		3	3	3	3	3	3	3	3	3	3	3	3	3
Condenser fans														
Quantity (1)		4/4	5/4	5/5	6/5	6/6	7/6	7/7	10/6	12/6	14/6	12/12	14/12	14/14
Diameter	(inches)	30	30	30	30	30	30	30	30	30	30	30	30	30
	(millimeters)	762	762	762	762	762	762	762	762	762	762	762	762	762
Total airflow	(cfm)	77000	84542	92087	101296	110506	119725	128946	147340	165766	184151	221016	239456	257991
	(m^3/hr)	130811	143623	156441	172086	187732	203394	219059	250307	281610	312843	375471	406797	438285
Nominal fan speed	rpm	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140
	rps	19	19	19	19	19	19	19	19	19	19	19	19	19
Tip speed	(ft/min)	8954	8954	8954	8954	8954	8954	8954	8954	8954	8954	8954	8954	8954
	M/S	45	45	45	45	45	45	45	45	45	45	45	45	45
Minimum starting/operating ambient (2)														
Standard unit	(F)	25	25	25	25	25	25	25	25	25	25	25	25	25
	(C)	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9
Low ambient	(F)	0	0	0	0	0	0	0	0	0	0	0	0	0
	(C)	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8
General unit														
Refrigerant		HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a
No. of independent refrigerant circuits		2	2	2	2	2	2	2	2	2	2	2	2	2
% Minimum load		15	15	15	15	15	15	15	15	15	15	15	15	15
Refrigerant charge (1)	(pounds)	165/165	175/165	175/175	215/210	215/215	225/215	225/225	365/200	415/200	460/200	415/415	460/415	460/460
	(kilograms)	75/75	79/75	79/79	98/95	98/98	102/98	102/102	166/91	188/91	209/91	188/188	209/188	209/209
Oil charge (1)	[gallons]	1.5/1.5	1.5/1.5	1.5/1.5	2.1/1.5	2.1/2.1	2.1/2.1	2.1/2.1	4.6/2.1	5.0/2.1	5.0/2.1	5.0/5.0	5.0/5.0	5.0/5.0
	[liters]	6/6	6/6	6/6	6/8	8/8	8/8	8/8	17/8	19/8	19/8	19/19	19/19	19/19

Notes:
1. Data containing information on two circuits shown as follows: CKT 1/CKT 2
2. Minimum start-up/operating ambient based on a 5 mph wind across the condenser

Dimensions



Note:
Add 2" (51mm) to overall width for louvered panels and coil protection.

Minimum clearances are 4 feet to each side of the unit, 2 feet to the end opposite the control panel and National Electric Code Article 110-26 requirements for control panel clearances. Tube pull clearances are given in submittals and the Installation, Operation and Maintenance manual.

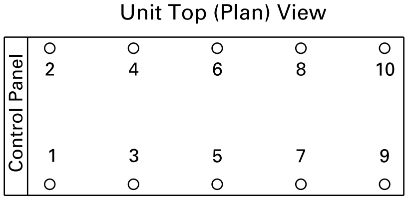
Weights

Table W-1. Aluminum fin unit weights (60 Hz units)

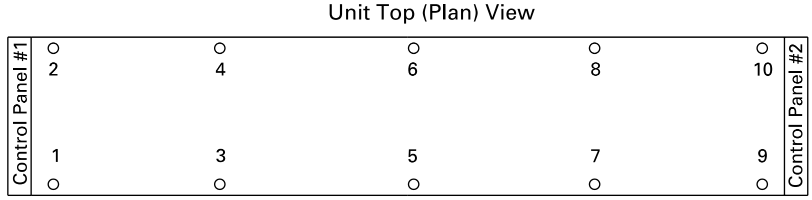
Unit Size	Units	Isolator Location 1	2	3	4	5	6	7	8	9	10	Operating Weight	Shipping Weight
RTAC 140 STD	lbs.	1384	1431	1363	1410	1340	1387	1317	1364	n/a	n/a	10995	10752
	kg	628	649	618	640	608	629	597	619	n/a	n/a	4987	4877
RTAC 140 HIGH	lbs.	1390	1437	1370	1418	1348	1395	1326	1373	n/a	n/a	11057	10780
	kg	630	652	622	643	611	633	601	623	n/a	n/a	5015	4890
RTAC 155 STD	lbs.	1389	1434	1369	1414	1346	1391	1323	1368	n/a	n/a	11034	10769
	kg	630	650	621	641	611	631	600	621	n/a	n/a	5005	4885
RTAC 155 HIGH	lbs.	1578	1630	1545	1598	1494	1547	1443	1496	n/a	n/a	12332	12038
	kg	716	740	701	725	678	702	655	679	n/a	n/a	5594	5460
RTAC 170 STD	lbs.	1391	1439	1372	1420	1350	1398	1328	1375	n/a	n/a	11073	10796
	kg	631	653	622	644	612	634	602	624	n/a	n/a	5023	4897
RTAC 170 HIGH	lbs.	1586	1641	1555	1610	1504	1559	1454	1509	n/a	n/a	12418	12098
	kg	719	744	705	730	682	707	660	685	n/a	n/a	5633	5488
RTAC 185 STD	lbs.	1642	1662	1608	1628	1553	1574	1499	1520	n/a	n/a	12685	12391
	kg	745	754	729	738	705	714	680	689	n/a	n/a	5754	5621
RTAC 185 HIGH	lbs.	1409	1513	1395	1499	1370	1475	1348	1452	1325	1429	14214	13897
	kg	639	686	633	680	622	669	611	659	601	648	6447	6304
RTAC 200 STD	lbs.	1663	1717	1636	1690	1593	1648	1551	1606	n/a	n/a	13104	12784
	kg	754	779	742	767	723	748	704	728	n/a	n/a	5944	5799
RTAC 200 HIGH	lbs.	1487	1537	1468	1519	1435	1486	1405	1456	1375	1425	14593	14247
	kg	674	697	666	689	651	674	637	660	623	646	6619	6462
RTAC 225 STD	lbs.	1483	1554	1466	1536	1435	1505	1406	1477	1378	1448	14687	14370
	kg	673	705	665	697	651	683	638	670	625	657	6662	6518
RTAC 225 HIGH	lbs.	1631	1674	1618	1661	1597	1640	1581	1624	1557	1601	16184	15838
	kg	740	759	734	753	724	744	717	737	706	726	7341	7184
RTAC 250 STD	lbs.	1510	1561	1493	1543	1461	1512	1433	1483	1404	1454	14853	14507
	kg	685	708	677	700	663	686	650	673	637	660	6737	6580
RTAC 250 HIGH	lbs.	1651	1676	1639	1664	1619	1644	1603	1629	1581	1607	16314	15968
	kg	749	760	743	755	734	746	727	739	717	729	7400	7243
RTAC 275 STD	lbs.	2168	1915	2124	1877	2072	1860	2052	1767	1976	1723	19536	18876
	kg	984	870	964	852	941	844	932	802	897	782	8869	8570
RTAC 275 HIGH	lbs.	2060	1819	2124	1877	2191	1950	2272	2083	2385	2183	20944	20266
	kg	935	826	964	852	995	885	1031	946	1083	991	9509	9201
RTAC 300 STD	lbs.	2163	1926	2188	1952	2220	1984	2256	2019	2324	2070	21103	20544
	kg	982	875	993	886	1008	901	1024	917	1055	940	9581	9327
RTAC 300 HIGH	lbs.	2382	2137	2381	2110	2347	2077	2309	2039	2274	2004	22060	22508
	kg	1081	970	1081	958	1066	943	1048	926	1032	910	10015	10219
RTAC 350 STD	lbs.	2134	1897	2203	1967	2291	2055	2389	2153	2526	2290	21904	21450
	kg	969	861	1000	893	1040	933	1085	977	1147	1040	9945	9738
RTAC 350 HIGH	lbs.	2637	2619	2525	2507	2442	2424	2389	2370	2284	2290	24487	23803
	kg	1197	1189	1146	1138	1109	1100	1085	1076	1037	1040	11117	10806
RTAC 400 STD	lbs.	2734	2748	2657	2636	2574	2554	2521	2500	2418	2412	25754	25074
	kg	1241	1248	1206	1197	1169	1160	1145	1135	1098	1095	11692	11383
RTAC 400 HIGH	lbs.	2734	2695	2763	2719	2787	2744	2812	2768	2836	2792	27650	26913
	kg	1241	1224	1254	1234	1265	1246	1277	1257	1288	1268	12553	12219
RTAC 450 STD	lbs.	2751	2751	2694	2694	2637	2637	2581	2581	2524	2524	26373	25678
	kg	1249	1249	1223	1223	1197	1197	1172	1172	1146	1146	11973	11658
RTAC 500 STD	lbs.	2753	2709	2777	2734	2802	2758	2826	2782	2850	2807	27798	27056
	kg	1250	1230	1261	1241	1272	1252	1283	1263	1294	1274	12620	12283

Notes:
1. Operating weight includes refrigerant and water.
2. Shipping weight includes refrigerant.
3. All weights +/- 3%.

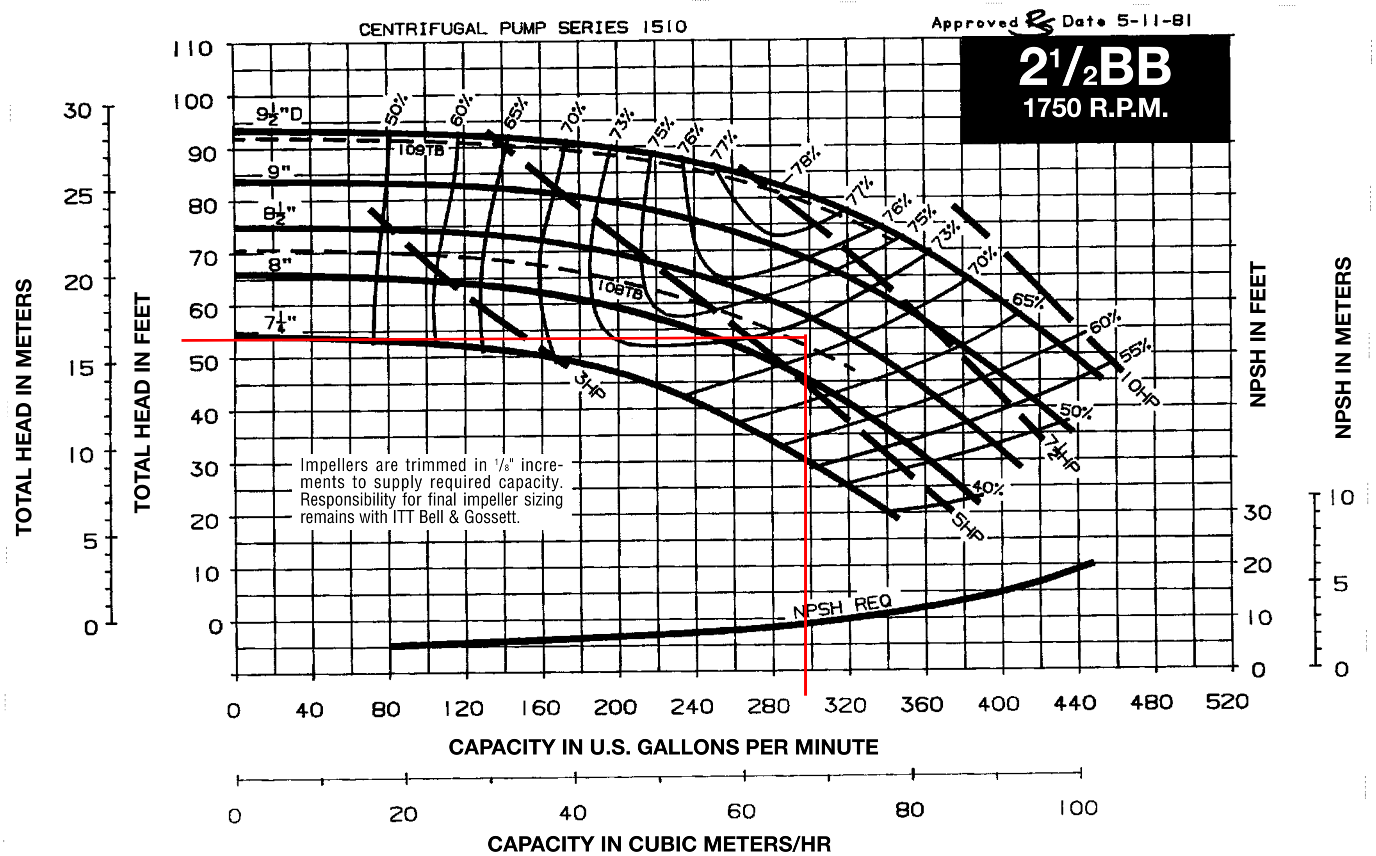
Unit Top (Plan) View

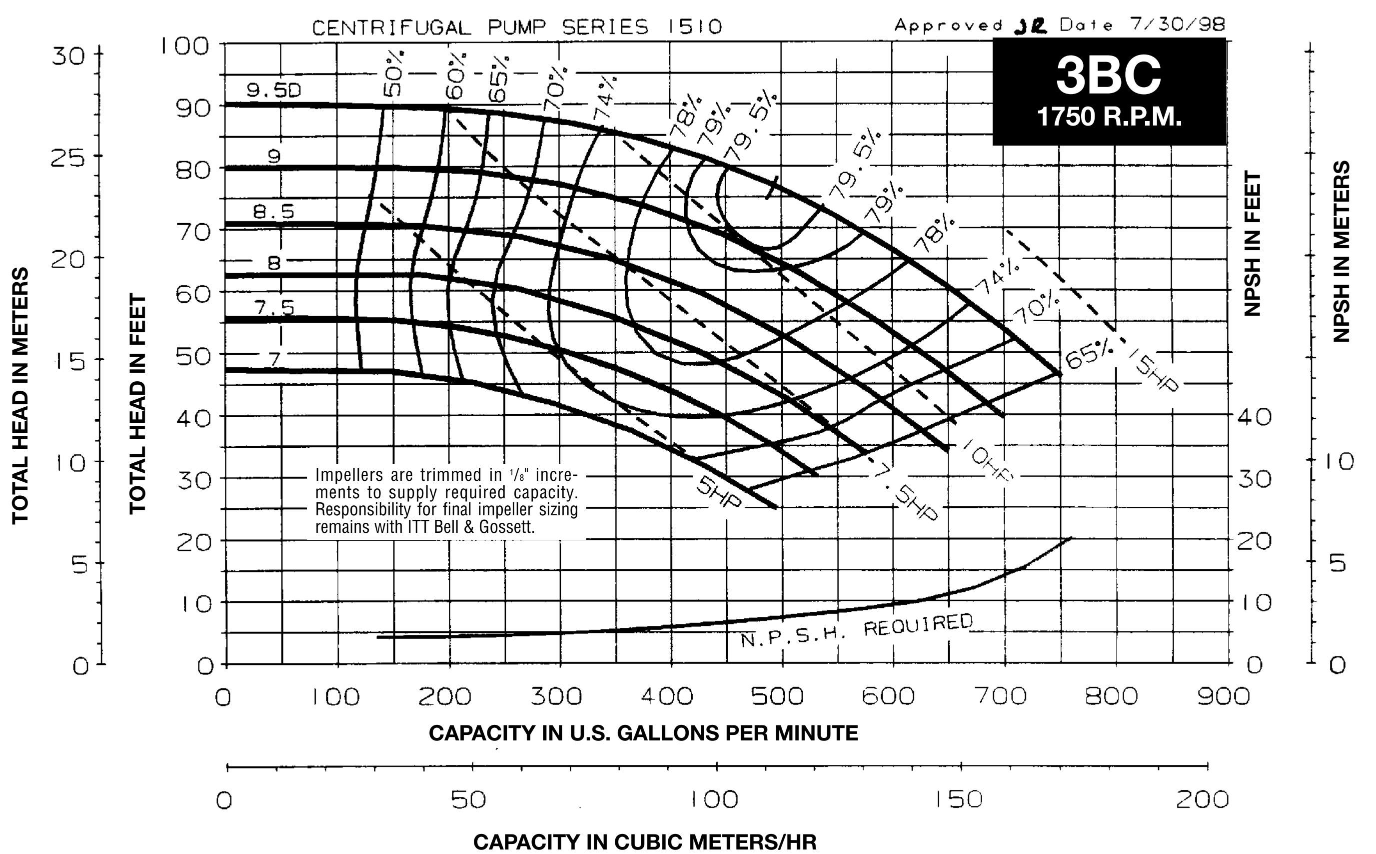


Unit Top (Plan) View



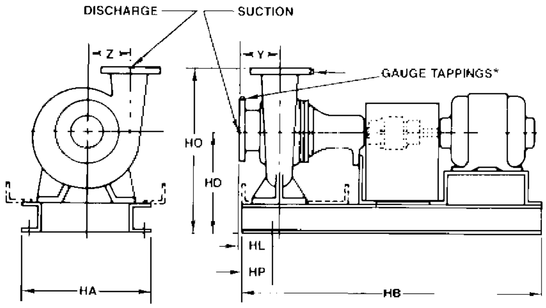
1750 RPM PUMP CURVES





Series 1510 Centrifugal Pumps

Dimensions



*Gauge Tapping Sizes: 1/8" for NPT, 1/4" for Flanged Sizes

Motor Horsepower and Frame Tabulation three phase (Dripproof Enclosure)

Horsepower	Frame @ 1750 RPM	Frame @ 3500 RPM	Horsepower	Frame @ 1750 RPM	Frame @ 3500 RPM
1/2	56		20	256T	254T
3/4	56		25	284T	256T
1	143T		30	286T	284TS
1 1/2	145T		40	324T	286TS
2	145T	145T	50	326T	324TS
3	182T	145T	60	364T	326TS
5	184T	182T	75	365T	364TS
7 1/2	213T	184T	100	404TS	365TS
10	215T	213T	125	—	404TS
15	254T	215T			

DIMENSIONS – INCHES (MM)			STANDARD MECHANICAL SEAL PUMP MODEL 1510, 1510-F								STUFFING BOX CONSTRUCTION PUMP MODEL 1510-PF, 1510-S							
PUMP SIZE DISCHARGE	SUCTION SIZE	MOTOR FRAME SIZE	HA	HB	HD	HL	HO	HP	Y	Z	HA	HB	HD	HL	HO	HP	Y	Z
1 1/4 AC (NPT)	1 1/2 (NPT)	56	12 (305)	28 3/4 (730)	9 3/4 (248)	3 1/8 (79)	14 3/4 (375)	3 (76)	3 1/4 (83)	4 1/2 (114)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	1 3/4 (44)	14 3/4 (375)	3 (76)	3 1/4 (83)	4 1/2 (114)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		1 3/4 (46)												
		213T-215T		34 5/8 (879)								39 3/8 (1000)						
1 1/4 BC (NPT)		143T-145T		31 (787)	10 3/4 (273)	1 13/16 (46)	18 3/4 (476)			5 1/2 (140)		34 5/8 (879)	10 3/4 (273)	1 13/16 (46)	18 3/4 (476)			5 1/2 (140)
		182T-184T																
		213T-215T		39 3/8 (1000)							16 (406)	46 1/2 (1181)	12 (305)	2 15/16 (75)	20 (508)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)	2 15/16 (75)	20 (508)	5 (127)				51 3/4 (1314)						
		284TS-286TS			13 (330)		21 (533)						13 (330)		21 (533)			
1 1/2 AC (NPT)	2 (NPT)	56	12 (305)	28 3/4 (730)	9 3/4 (248)	3 1/16 (78)	15 3/4 (400)	3 (76)	3 1/8 (79)	4 5/8 (117)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	1 11/16 (43)	15 3/4 (400)	3 (76)	3 1/8 (79)	4 5/8 (117)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		1 11/16 (43)												
		213T-215T		34 5/8 (879)								39 3/8 (1000)						
		254T-256T		39 3/8 (1000)	10 3/4 (273)		16 3/4 (425)				16 (406)	46 1/2 (1181)	12 (305)	2 13/16 (71)	18 (457)	5 (127)		
1 1/2 BC (NPT)		143T-145T		31 (787)			17 1/4 (438)			5 3/4 (146)	14 5/8 (371)	34 5/8 (879)	10 3/4 (273)	1 11/16 (43)	17 1/4 (438)	3 (76)		5 3/4 (146)
		182T-184T																
		213T-1750		34 5/8 (879)								39 3/8 (1000)						
		213T-215T-3500		39 3/8 (1000)							16 (406)	46 1/2 (1181)	12 (305)	2 13/16 (71)	18 1/2 (470)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)	2 13/16 (71)	18 1/2 (470)	5 (127)				51 3/4 (1314)						
		284TS-286TS			13 (330)		19 1/2 (495)						13 (330)		19 1/2 (495)			
2 AC	2 1/2	56	12 (305)	28 3/4 (730)	9 3/4 (248)	3 9/16 (90)	16 1/4 (413)	3 (76)	3 1/2 (89)	4 3/4 (121)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	2 3/16 (56)	16 1/4 (413)	3 (76)	3 1/2 (89)	4 3/4 (121)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		2 3/16 (56)												
		213T-215T		34 5/8 (879)							16 (406)	46 1/2 (1181)	11 (279)	3 5/16 (84)	17 1/2 (445)	5 (127)		
		254T-256T		39 3/8 (1000)	10 3/4 (273)		17 1/4 (438)					51 3/4 (1314)	12 (305)		18 1/2 (470)			
2 BC		143T-145T		31 (787)		2 11/16 (68)	17 3/4 (451)		4 (102)	5 7/8 (149)	14 5/8 (371)	34 5/8 (879)	10 3/4 (273)	2 11/16 (68)	17 3/4 (451)	3 (76)	4 (102)	5 7/8 (149)
		182T-184T																
		213T-215T-1750		34 5/8 (879)								39 3/8 (1000)						
		254T-3500		39 3/8 (1000)		3 13/16 (97)		5 (127)			16 (406)	46 1/2 (1181)	12 (305)	3 13/16 (97)	19 (483)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)		19 (483)					51 3/4 (1314)						
		284TS-286TS			13 (330)		20 (508)						13 (330)		20 (508)			
		324TS-326TS			12 (305)		19 (483)						12 (305)		19 (483)			
2 E†	3	182T		42 1/4 (1073)	14 (356)	6 1/2 (165)	22 (559)	5 (127)	5 1/2 (140)	6 1/2 (165)		42 1/4 (1073)	14 (356)	6 1/2 (165)	22 (559)	5 (127)	5 1/2 (140)	6 1/4 (165)
		184T																
		213T																
		215T																
		254T																
		286TS		46 1/2 (1181)		4 1/8 (105)						51 3/4 (1314)		4 1/8 (105)				
		324TS		51 3/4 (1314)														
		326TS																
		364TS	24 (610)	56 (1422)	16 1/2 (419)	4 3/4 (121)	24 1/2 (622)	6 (152)			24 (610)	56 (1422)	16 1/2 (419)	4 3/4 (121)	24 1/2 (622)	6 (152)		
		365TS																
2 G†		213T-215T	16 (406)	46 1/2 (1181)	14 (356)	3 7/8 (98)	23 (584)	5 (127)		7 1/4 (184)	16 (406)	46 1/2 (1181)	14 (356)	3 7/8 (98)	23 (584)	5 (127)		7 1/4 (184)
		254T-256T										51 3/4 (1314)						
		284T		51 3/4 (1314)														
2 1/2 AB		56	12 (305)	28 3/4 (730)	9 3/4 (248)	4 3/8 (111)	15 3/4 (400)	3 (76)	4 1/4 (108)	4 11/16 (119)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	3 (76)	15 3/4 (400)	3 (76)	4 1/4 (108)	4 11/16 (119)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		3 (76)												
		213T-215T		34 5/8 (879)							16 (406)	46 1/2 (1181)	11 (279)	4 1/8 (105)	17 (432)	5 (127)		
		254T-256T		39 3/8 (1000)	10 3/4 (273)		16 3/4 (425)					51 3/4 (1314)	12 (305)					
2 1/2 BB		182T-184T		31 (787)		2 3/4 (70)	17 1/2 (445)		4 (102)	6 (152)	14 5/8 (371)	34 5/8 (879)	10 3/4 (273)	2 3/4 (70)	17 1/2 (445)	3 (76)	4 (102)	6 (152)
		213T-215T		34 5/8 (879)								39 3/8 (1000)						
		284TS-286TS	16 (406)	46 1/2 (1181)	13 (330)	3 7/8 (98)	19 3/4 (502)	5 (127)			16 (406)	51 3/4 (1314)	13 (330)	3 7/8 (98)	19 3/4 (502)	5 (127)		
		324TS-326TS			12 (305)		18 3/4 (476)						12 (305)		18 3/4 (476)			
		346TS		51 3/4 (1314)	13 (330)		19 3/4 (502)						13 (330)		19 3/4 (502)			
3 AC	4	143T-145T	12 (305)	28 3/4 (730)	9 3/4 (248)	4 5/16 (110)	15 3/4 (400)	3 (76)	4 1/8 (105)	5 (127)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	2 15/16 (75)	15 3/4 (400)	3 (76)	4 1/8 (105)	5 (127)
		182T-184T	14 5/8 (371)	31 (787)		2 15/16 (75)												
		215T		39 3/8 (1000)							16 (406)	46 1/2 (1181)	11 (279)	4 1/16 (103)	17 (432)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)	4 1/16 (103)	18 (457)	5 (127)				51 3/4 (1314)	12 (305)		18 (457)			
		284TS-286TS			13 (330)		19 (483)						13 (330)		19 (483)			

These dimensions are not to be used for installation purposes unless certified.
†250 psi (17 bar) available

Maximum Working Pressure 175 psi (12 bar)

Energy Cost Budget / PRM Summary

By META Engineers

Project Name:	Date: April 22, 2009
City:	Weather Data: Pasadena, California (CTZ09)

Note: The percentage displayed for the "Proposed/ Base %" column of the base case is actually the percentage of the total energy consumption.

* Denotes the base alternative for the ECB study.

		* Alt-1 Baseline AC Chiller		
		Energy 10^6 Btu/yr	**Proposed / Base %**	**Peak kBtuh**
Lighting - Conditioned	Electricity	942.2	13	258
Space Heating	Electricity	1.4	0	0
	Purchased Steam	198.6	3	249
Space Cooling	Electricity	1,572.9	21	682
Pumps	Electricity	241.1	3	52
Heat Rejection	Electricity	170.5	2	75
Fans - Conditioned	Electricity	536.3	7	213
Receptacles - Conditioned	Electricity	3,697.2	50	663
Stand-alone Base Utilities	Electricity	27.4	0	6
Total Building Consumption		**7,387.7**		

		* Alt-1 Baseline AC Chiller
Total	**Number of hours heating load not met**	31
	Number of hours cooling load not met	5

	* Alt-1 Baseline AC Chiller	
	Energy 10^6 Btu/yr	**Cost/yr $/yr**
Electricity	7,189.1	533,070
Purchased Steam	198.6	0
Total	**7,388**	**533,070**

MONTHLY ENERGY CONSUMPTION

By META Engineers

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

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 1	**Baseline AC Chiller**												
Electric													
On-Pk Cons. (kWh)	0	0	0	0	0	60,986	59,893	69,063	58,323	0	0	0	248,264
Off-Pk Cons. (kWh)	68,416	63,535	66,566	72,695	72,162	66,999	82,530	74,472	76,549	73,446	67,610	73,018	857,999
Mid-Pk Cons. (kWh)	88,924	83,597	102,955	92,411	105,809	57,943	55,540	65,791	54,142	109,295	96,794	86,920	1,000,122
On-Pk Demand (kW)	0	0	0	0	0	507	546	545	536	0	0	0	546
Off-Pk Demand (kW)	406	420	418	425	442	472	510	507	496	465	427	412	510
Mid-Pk Demand (kW)	444	460	460	468	485	484	519	523	508	503	472	453	523
Purchased Steam													
On-Pk Cons. (therms)	0	0	0	0	0	47	41	47	40	0	0	0	175
Off-Pk Cons. (therms)	159	105	78	50	26	23	24	22	26	28	63	141	745
Mid-Pk Cons. (therms)	135	105	116	94	100	51	46	54	48	101	104	113	1,066
On-Pk Demand (therms/hr)	0	0	0	0	0	1	1	1	1	0	0	0	1
Off-Pk Demand (therms/hr)	2	2	1	1	1	1	1	1	1	1	1	2	2
Mid-Pk Demand (therms/hr)	1	1	1	1	1	1	1	1	1	1	1	1	1

Energy Consumption		
Building	139,126	Btu/(ft2-year)
Source	411,184	Btu/(ft2-year)
Floor Area	53,101	ft2

Environmental Impact Analysis	
CO2	No Data Available
SO2	No Data Available
NOX	No Data Available

MONTHLY UTILITY COSTS

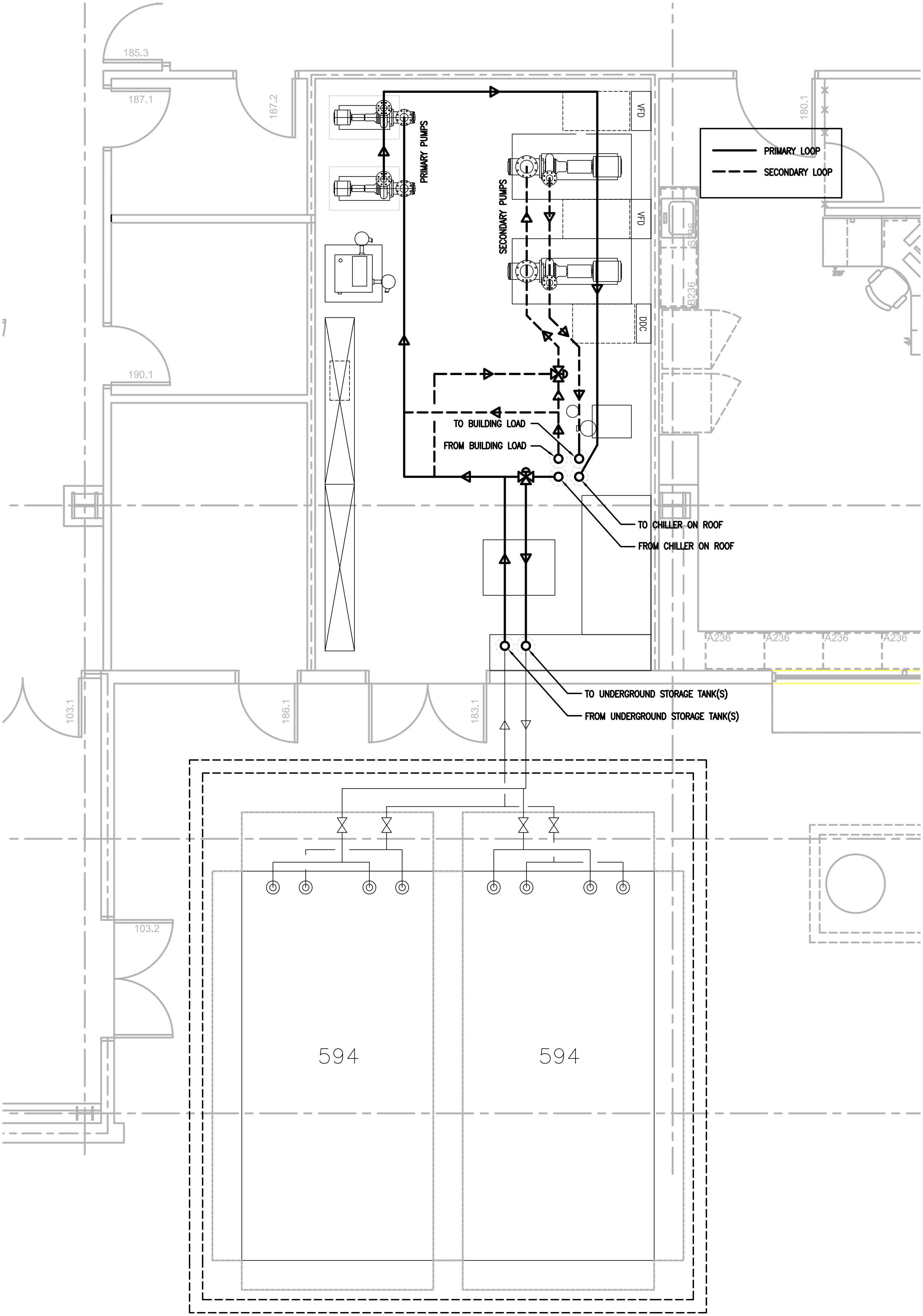
By META Engineers

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Alternative 1													
Electric													
On-Pk Cons. ($)	276	276	276	276	276	12,424	12,206	14,033	11,894	276	276	276	52,762
Off-Pk Cons. ($)	9,800	9,120	9,542	10,396	10,321	9,347	11,450	10,359	10,640	10,500	9,688	10,440	121,605
Mid-Pk Cons. ($)	15,785	14,856	18,232	16,393	18,730	10,219	9,807	11,566	9,567	19,338	17,158	15,435	177,086
On-Pk Demand ($)	0	0	0	0	0	13,098	14,121	14,089	13,846	0	0	0	55,154
Off-Pk Demand ($)	4,207	4,348	4,325	4,407	4,574	4,890	5,280	5,249	5,138	4,813	4,428	4,266	55,924
Mid-Pk Demand ($)	4,602	4,765	4,762	4,848	5,021	7,553	8,097	8,162	7,928	5,216	4,891	4,693	70,538
Total ($):	34,670	33,365	37,137	36,320	38,922	57,531	60,961	63,458	59,014	40,142	36,440	35,111	533,070
Monthly Total ($):	34,670	33,365	37,137	36,320	38,922	57,531	60,961	63,458	59,014	40,142	36,440	35,111	533,070

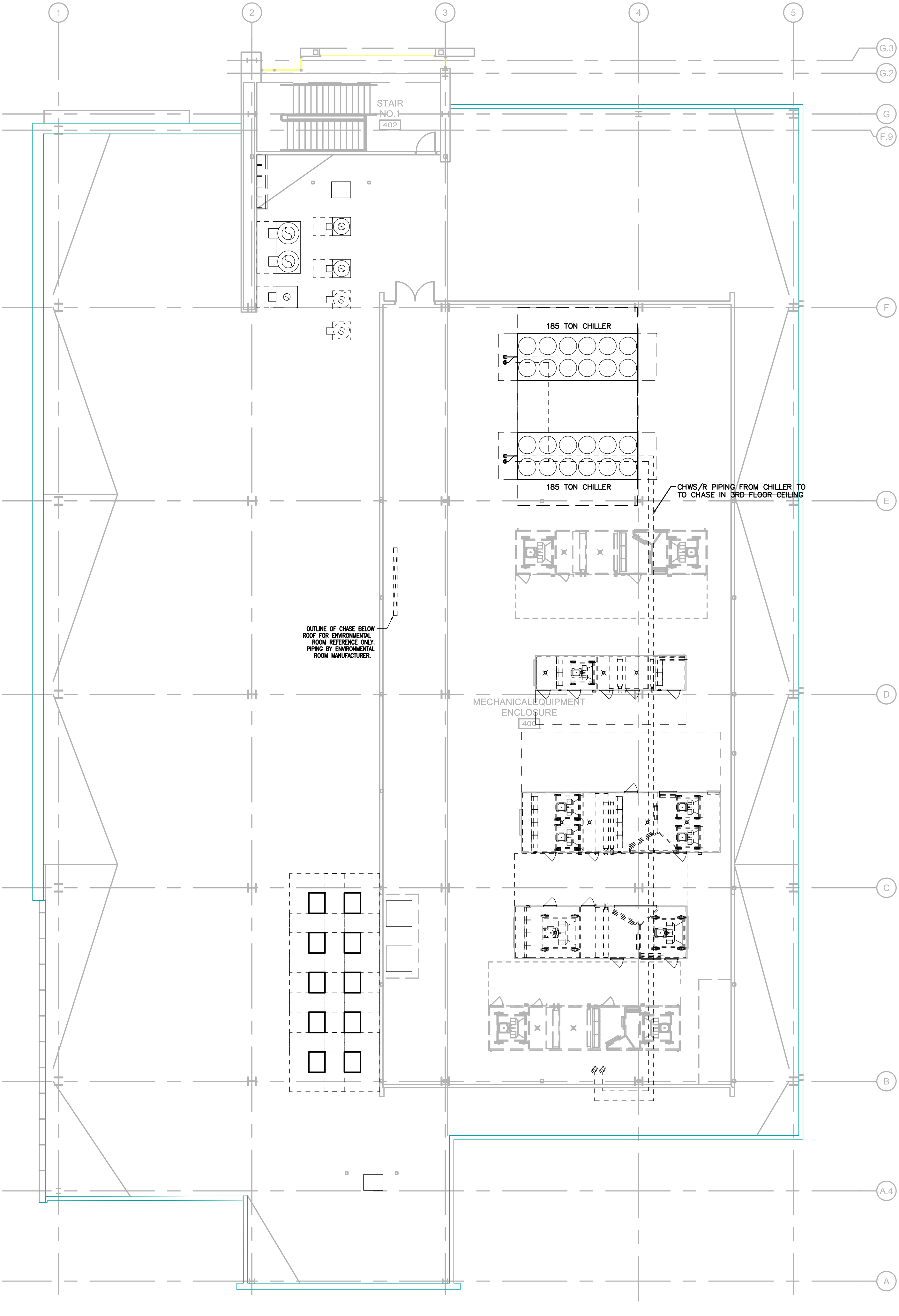
Building Area = 53,101 ft²

Utility Cost Per Area = 10.04 $/ft²

Appendix B
Full Ice Storage Redesign



MECH. RM. LAYOUT – ICE STORAGE SYSTEM


1
2
3
4
5
G.3
G.2
G
F.9
F
E
D
C
B
A.4
A
STAIR
NO.1
402
185 TON CHILLER
185 TON CHILLER
CHWS/R PIPING FROM CHILLER TO
TO CHASE IN 3RD FLOOR CEILING
OUTLINE OF CHASE BELOW
ROOF FOR ENVIRONMENTAL
ROOM REFERENCE ONLY.
PIPING BY ENVIRONMENTAL
ROOM MANUFACTURER.
MECHANICALEQUIPMENT
ENCLOSURE
400

Full Storage Quick Equipment Sizing

Assumptions:

Total Cooling Load = Total Chiller Capacity (1) (No heat or pump losses)

Total Chiller Capacity = $H_{chrg}C_{chrg} + H_{DConp}C_{DConp} + H_{DCoffp}C_{DCoffp}$ (2)

H_{chrg}	hours charging storage
C_{chrg}	capacity when charging storage
H_{DConp}	hours direct cooling during on-peak period
C_{DConp}	capacity when cooling during on-peak period
H_{DCoffp}	hours direct cooling during off-peak period
C_{DCoffp}	capacity when cooling during off-peak period

Quick Chiller Sizing Equation (Combine (1) and (2))

Nominal Chiller Size = Total Cooling Load / ($H_{chrg}CR_{chrg} + H_{DConp}CR_{DConp} + H_{DCoffp}CR_{DCoffp}$) (3)

H_{chrg}	hours charging storage
CR_{chrg}	capacity ratio when charging storage
H_{DConp}	hours direct cooling during on-peak period
CR_{DConp}	capacity ratio when cooling during on-peak period
H_{DCoffp}	hours direct cooling during off-peak period
CR_{DCoffp}	capacity ratio when cooling during off-peak period

Full Storage System $H_{DConp}CR_{DConp} = 0$

COH Assumptions:

Supply 38 deg. solution to load

Chiller Upstream tanks provides 23 deg solution during ice making

COH Nominal Chiller Capacity (3) = 172 Tons

H_{chrg}	12	
CR_{chrg}	0.7	Assumed
H_{DCoffp}	5	
CR_{DCoffp}	0.85	Assumed

Quick Storage Size

Storage Capacity = Total Cooling load - ($TC_{DConp} + TC_{DCoffp} + TH_{DCchrg}$) (4)

TC_{DConp}	total capacity when direct cooling during on-peak	(Ton-hrs)
TC_{DCoffp}	total capacity when direct cooling during off-peak	(Ton-hrs)
TC_{DCchrg}	ton-hours direct cooling while simultaneously charging	(Ton-hrs)

TC_{DConp}	0
TC_{DCoffp}	736.7
TC_{DCchrg}	297.8

Storage Capacity = 1,142 Ton-hrs

COH Full Storage Scenario				
Hour	Clg (Tons)	Cooling Mode	Summer	Winter
1	24.7	Cooling and Charging	OFF-PEAK	OFF-PEAK
2	23.6	"		
3	22.8	"		
4	22.0	"		
5	21.5	"		
6	22.0	"		
7	23.5	"		
8	138.5	Satisfy Load		
9	131.1	"	MID-PEAK	MID-PEAK
10	148.1	"		
11	156.4	"		
12	162.5	"		
13	160.3	Discharging	PEAK	
14	166.7	"		
15	173.4	"		
16	175.1	"		
17	174.0	"		
18	166.9	"		
19	125.2	"	MID-PEAK	
20	29.9	Cooling & Charging		
21	28.5	"		
22	26.9	"		OFF-PEAK
23	26.6	"		
24	25.8	"	OFF-PEAK	

On-Peak Ton-hr =	1,016.4
Off-Peak Ton-hr =	1,159.6
Total Ton-hr =	2,176.0

City of Hope
CHW Head Calc
Full Storage Primary Loop

Section	Describe Pipe	Flow (gpm)	Pipe Size (in)	Alt Pipe Size (in)	Length (ft)	Tag No.	Fittings Description	No. Fittings	Actual Pressure Drop (ft)	Velocity (fps)	Alt C	Head Loss / 100ft	Fitting Equiv. Length	Pressure Drop (ft)	Total Pressure Drop (ft)
	MECH ROOM					1	NA								
Pump to Chase	Supply	232.0	5			4	Pump		5.0	3.72		1.34		5.00	5.00
		232.0	5		48	2	Straight Pipe			3.72		1.34		0.64	5.64
		232.0	5			12	Long Radius 90 Elbow	4		3.72		1.34	6.73	0.36	6.01
		232.0	5			13	45 Standard Elbow	1		3.72		1.34	6.73	0.09	6.10
		232.0	5			14	Standard Tee-thru flow	1		3.72		1.34	8.41	0.11	6.21
Chase to Pump	Return	232.0	5			12	Long Radius 90 Elbow	9		3.72		1.34	6.73	0.81	7.02
		232.0	5		140	2	Straight Pipe			3.72		1.34		1.88	8.90
		232.0	5			14	Standard Tee-thru flow	2		3.72		1.34	8.41	0.23	9.13
		232.0	5			15	Standard Tee-branch flow	6		3.72		1.34	25.2	2.03	11.16
		232.0	5			32	Control Valve (25 ft)		15.0	3.72		1.34		15.00	26.16
	Ice Storage	232.0	5			33	Other		7.0	3.72		1.34		7.00	33.16
Chase	Supply + Return	232.0	5		70	2	Straight Pipe			3.72		1.34		0.94	34.09
3rd Flr	Supply + Return	232.0	5		290	2	Straight Pipe			3.72		1.34		3.89	37.99
		232.0	5			12	Long Radius 90 Elbow	12		3.72		1.34	6.73	1.08	39.07
		232.0	5			15	Standard Tee-branch flow	2		3.72		1.34	25.2	0.68	39.75
		232.0	5			22	Butterfly valve	2		3.72		1.34	18.9	0.51	40.25
Roof	Supply + Return	232.0	5		20	2	Straight Pipe			3.72		1.34		0.27	40.52
		232.0	5			12	Long Radius 90 Elbow	4		3.72		1.34	6.73	0.36	40.88
	Chiller	232.0	5			33	Other		4.5	3.72		1.34		4.50	45.38
			3/4			1	NA								45.38
			3/4			1	NA								45.38

Total Head = 45.38
Safety Factor = 20%

Grand Total = 54.46

* Based on Cameron Hydraulic Data Book.
Small Pipe Add 10% Safety Factor.
Medium to Large Pipe 20% Safety Factor.

Air-Cooled Series R™ Rotary Liquid Chiller

Model RTAC
140 to 500 Tons (60 Hz)
140 to 400 Tons (50 Hz)

Built For the Industrial and Commercial Markets

November 2006

RLC-PRC006-EN

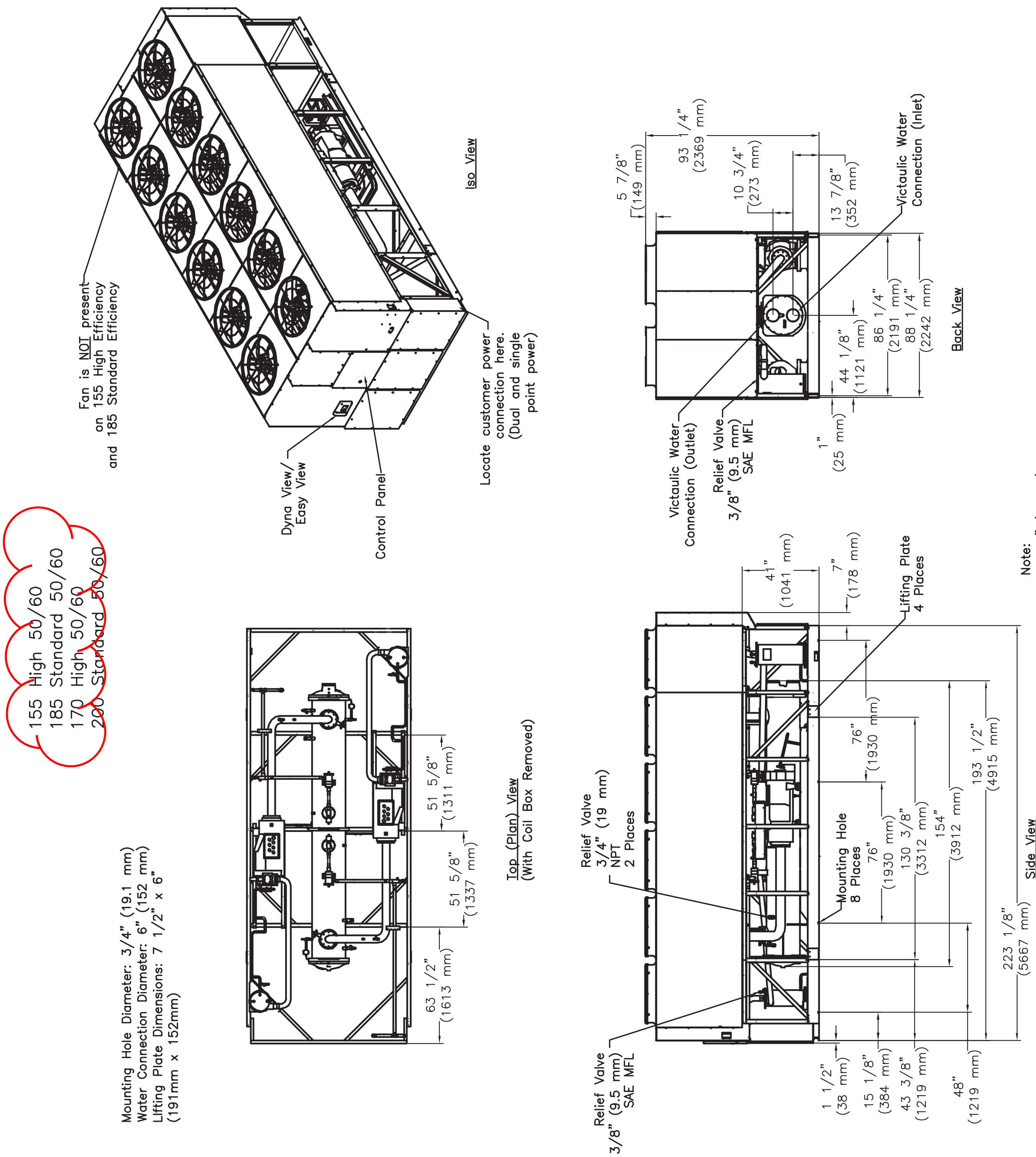
General Data

Table G-1. General data — 140-500 ton 60 Hz units - standard efficiency

Size		140	155	170	185	200	225	250	275	300	350	400	450	500
Type		STD	STD	STD	STD	STD	STD	STD	STD	STD	STD	STD	STD	STD
Compressor														
Quantity (1)		2	2	2	2	2	2	2	3	3	3	4	4	4
Nominal size (tons) @ 60 Hz		70/70	85/70	85/85	100/85	100/100	120/100	120/120	85-85/100	100-100/100	120-120/100	100-100 / 100-100	120-120 / 100-100	120-120 / 120-120
Evaporator														
Water storage	(gallons)	29	32	33	35	39	38	42	60	65	70	81	84	89
	(liters)	111	121	127	134	146	145	158	229	245	264	306	316	337
2 Pass arrangement														
Minimum flow	(gpm)	193	214	202	217	241	217	241	309	339	375	404	422	461
	(L/s)	12	14	13	14	15	14	15	20	21	24	26	27	29
Maximum flow	(gpm)	709	785	741	796	883	796	883	1134	1243	1374	1483	1548	1690
	(L/s)	45	50	47	50	56	50	56	72	78	87	94	98	107
3 Pass arrangement														
Minimum flow	(gpm)	129	143	135	145	161	145	161	206	226	250	270	282	307
	(L/s)	8	9	9	9	10	9	10	13	14	16	17	18	19
Maximum flow	(gpm)	473	523	494	531	589	531	589	756	829	916	989	1032	1127
	(L/s)	30	33	31	33	37	33	37	48	52	58	62	65	71
Condenser														
Qty of coils		4	4	4	4	4	4	4	8	8	8	8	8	8
Coil length	(inches)	156/156	180/156	180/180	216/180	216/216	252/216	252/252	180/108	216/108	252/108	216/216	252/216	252/252
	(millimeters)	3962/3962	4572/3962	4572/4572	5486/4572	5486/5486	6401/5486	6401/6401	4572/2743	5486/2743	6401/4572	5486/5486	6401/5486	6401/6401
Coil height	(inches)	42	42	42	42	42	42	42	42	42	42	42	42	42
	(millimeters)	1067	1067	1067	1067	1067	1067	1067	1067	1067	1067	1067	1067	1067
Fins/Ft		192	192	192	192	192	192	192	192	192	192	192	192	192
Number of rows		3	3	3	3	3	3	3	3	3	3	3	3	3
Condenser fans														
Quantity (1)		4/4	5/4	5/5	6/5	6/6	7/6	7/7	10/6	12/6	14/6	12/12	14/12	14/14
Diameter	(inches)	30	30	30	30	30	30	30	30	30	30	30	30	30
	(millimeters)	762	762	762	762	762	762	762	762	762	762	762	762	762
Total airflow	(cfm)	77000	84542	92087	101296	110506	119725	128946	147340	165766	184151	221016	239456	257991
	(m^3/hr)	130811	143623	156441	172086	187732	203394	219059	250307	281610	312843	375471	406797	438285
Nominal fan speed	rpm	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140
	rps	19	19	19	19	19	19	19	19	19	19	19	19	19
Tip speed	(ft/min)	8954	8954	8954	8954	8954	8954	8954	8954	8954	8954	8954	8954	8954
	M/S	45	45	45	45	45	45	45	45	45	45	45	45	45
Minimum starting/operating ambient (2)														
Standard unit	(F)	25	25	25	25	25	25	25	25	25	25	25	25	25
	(C)	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9
Low ambient	(F)	0	0	0	0	0	0	0	0	0	0	0	0	0
	(C)	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8
General unit														
Refrigerant		HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a
No. of independent refrigerant circuits		2	2	2	2	2	2	2	2	2	2	2	2	2
% Minimum load		15	15	15	15	15	15	15	15	15	15	15	15	15
Refrigerant charge (1)	(pounds)	165/165	175/165	175/175	215/210	215/215	225/215	225/225	365/200	415/200	460/200	415/415	460/415	460/460
	(kilograms)	75/75	79/75	79/79	98/95	98/98	102/98	102/102	166/91	188/91	209/91	188/188	209/188	209/209
Oil charge (1)	[gallons]	1.5/1.5	1.5/1.5	1.5/1.5	2.1/1.5	2.1/2.1	2.1/2.1	2.1/2.1	4.6/2.1	5.0/2.1	5.0/2.1	5.0/5.0	5.0/5.0	5.0/5.0
	[liters]	6/6	6/6	6/6	6/8	8/8	8/8	8/8	17/8	19/8	19/8	19/19	19/19	19/19

Notes:
1. Data containing information on two circuits shown as follows: CKT 1/CKT 2
2. Minimum start-up/operating ambient based on a 5 mph wind across the condenser

Dimensions



Mounting Hole Diameter: 3/4" (19.1 mm)
Water Connection Diameter: 6" (152 mm)
Lifting Plate Dimensions: 7 1/2" x 6" (191mm x 152mm)

Note:
Add 2" (51mm) to overall width for louvered panels and coil protection.

Minimum clearances are 4 feet to each side of the unit, 2 feet to the end opposite the control panel and National Electric Code Article 110-26 requirements for control panel clearances. Tube pull clearances are given in submittals and the Installation, Operation and Maintenance manual.

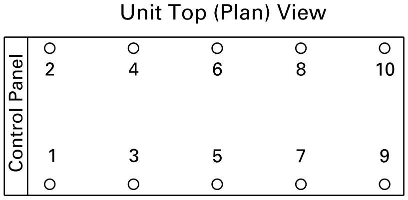
Weights

Table W-1. Aluminum fin unit weights (60 Hz units)

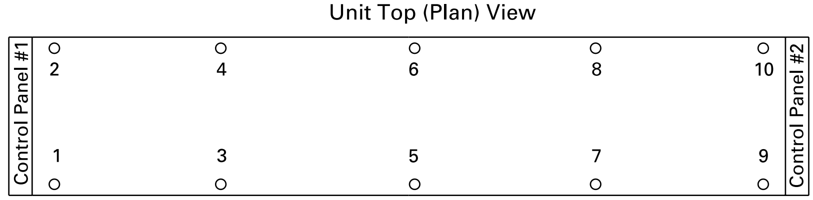
Unit Size	Units	Isolator Location 1	2	3	4	5	6	7	8	9	10	Operating Weight	Shipping Weight
RTAC 140 STD	lbs.	1384	1431	1363	1410	1340	1387	1317	1364	n/a	n/a	10995	10752
	kg	628	649	618	640	608	629	597	619	n/a	n/a	4987	4877
RTAC 140 HIGH	lbs.	1390	1437	1370	1418	1348	1395	1326	1373	n/a	n/a	11057	10780
	kg	630	652	622	643	611	633	601	623	n/a	n/a	5015	4890
RTAC 155 STD	lbs.	1389	1434	1369	1414	1346	1391	1323	1368	n/a	n/a	11034	10769
	kg	630	650	621	641	611	631	600	621	n/a	n/a	5005	4885
RTAC 155 HIGH	lbs.	1578	1630	1545	1598	1494	1547	1443	1496	n/a	n/a	12332	12038
	kg	716	740	701	725	678	702	655	679	n/a	n/a	5594	5460
RTAC 170 STD	lbs.	1391	1439	1372	1420	1350	1398	1328	1375	n/a	n/a	11073	10796
	kg	631	653	622	644	612	634	602	624	n/a	n/a	5023	4897
RTAC 170 HIGH	lbs.	1586	1641	1555	1610	1504	1559	1454	1509	n/a	n/a	12418	12098
	kg	719	744	705	730	682	707	660	685	n/a	n/a	5633	5488
RTAC 185 STD	lbs.	1642	1662	1608	1628	1553	1574	1499	1520	n/a	n/a	12685	12391
	kg	745	754	729	738	705	714	680	689	n/a	n/a	5754	5621
RTAC 185 HIGH	lbs.	1409	1513	1395	1499	1370	1475	1348	1452	1325	1429	14214	13897
	kg	639	686	633	680	622	669	611	659	601	648	6447	6304
RTAC 200 STD	lbs.	1663	1717	1636	1690	1593	1648	1551	1606	n/a	n/a	13104	12784
	kg	754	779	742	767	723	748	704	728	n/a	n/a	5944	5799
RTAC 200 HIGH	lbs.	1487	1537	1468	1519	1435	1486	1405	1456	1375	1425	14593	14247
	kg	674	697	666	689	651	674	637	660	623	646	6619	6462
RTAC 225 STD	lbs.	1483	1554	1466	1536	1435	1505	1406	1477	1378	1448	14687	14370
	kg	673	705	665	697	651	683	638	670	625	657	6662	6518
RTAC 225 HIGH	lbs.	1631	1674	1618	1661	1597	1640	1581	1624	1557	1601	16184	15838
	kg	740	759	734	753	724	744	717	737	706	726	7341	7184
RTAC 250 STD	lbs.	1510	1561	1493	1543	1461	1512	1433	1483	1404	1454	14853	14507
	kg	685	708	677	700	663	686	650	673	637	660	6737	6580
RTAC 250 HIGH	lbs.	1651	1676	1639	1664	1619	1644	1603	1629	1581	1607	16314	15968
	kg	749	760	743	755	734	746	727	739	717	729	7400	7243
RTAC 275 STD	lbs.	2168	1915	2124	1877	2072	1860	2052	1767	1976	1723	19536	18876
	kg	984	870	964	852	941	844	932	802	897	782	8869	8570
RTAC 275 HIGH	lbs.	2060	1819	2124	1877	2191	1950	2272	2083	2385	2183	20944	20266
	kg	935	826	964	852	995	885	1031	946	1083	991	9509	9201
RTAC 300 STD	lbs.	2163	1926	2188	1952	2220	1984	2256	2019	2324	2070	21103	20544
	kg	982	875	993	886	1008	901	1024	917	1055	940	9581	9327
RTAC 300 HIGH	lbs.	2382	2137	2381	2110	2347	2077	2309	2039	2274	2004	22060	22508
	kg	1081	970	1081	958	1066	943	1048	926	1032	910	10015	10219
RTAC 350 STD	lbs.	2134	1897	2203	1967	2291	2055	2389	2153	2526	2290	21904	21450
	kg	969	861	1000	893	1040	933	1085	977	1147	1040	9945	9738
RTAC 350 HIGH	lbs.	2637	2619	2525	2507	2442	2424	2389	2370	2284	2290	24487	23803
	kg	1197	1189	1146	1138	1109	1100	1085	1076	1037	1040	11117	10806
RTAC 400 STD	lbs.	2734	2748	2657	2636	2574	2554	2521	2500	2418	2412	25754	25074
	kg	1241	1248	1206	1197	1169	1160	1145	1135	1098	1095	11692	11383
RTAC 400 HIGH	lbs.	2734	2695	2763	2719	2787	2744	2812	2768	2836	2792	27650	26913
	kg	1241	1224	1254	1234	1265	1246	1277	1257	1288	1268	12553	12219
RTAC 450 STD	lbs.	2751	2751	2694	2694	2637	2637	2581	2581	2524	2524	26373	25678
	kg	1249	1249	1223	1223	1197	1197	1172	1172	1146	1146	11973	11658
RTAC 500 STD	lbs.	2753	2709	2777	2734	2802	2758	2826	2782	2850	2807	27798	27056
	kg	1250	1230	1261	1241	1272	1252	1283	1263	1294	1274	12620	12283

Notes:
1. Operating weight includes refrigerant and water.
2. Shipping weight includes refrigerant.
3. All weights +/- 3%.

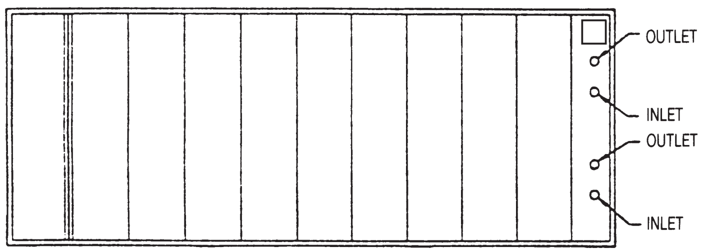
Unit Top (Plan) View



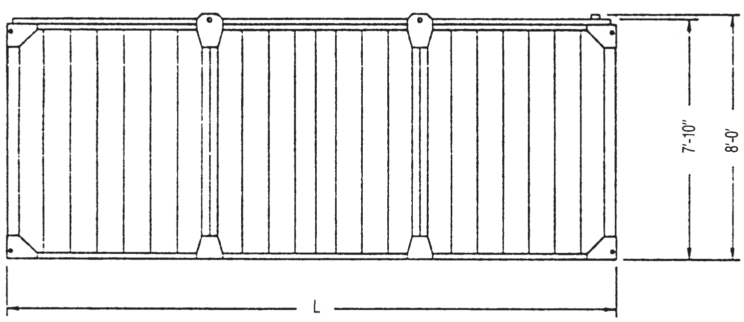
Unit Top (Plan) View

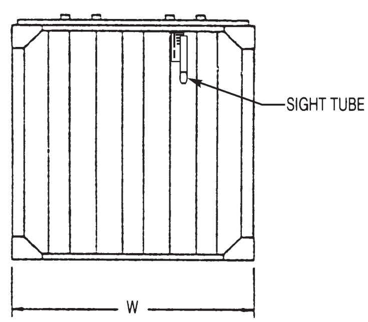


ENGINEERING DATA



PLAN VIEW



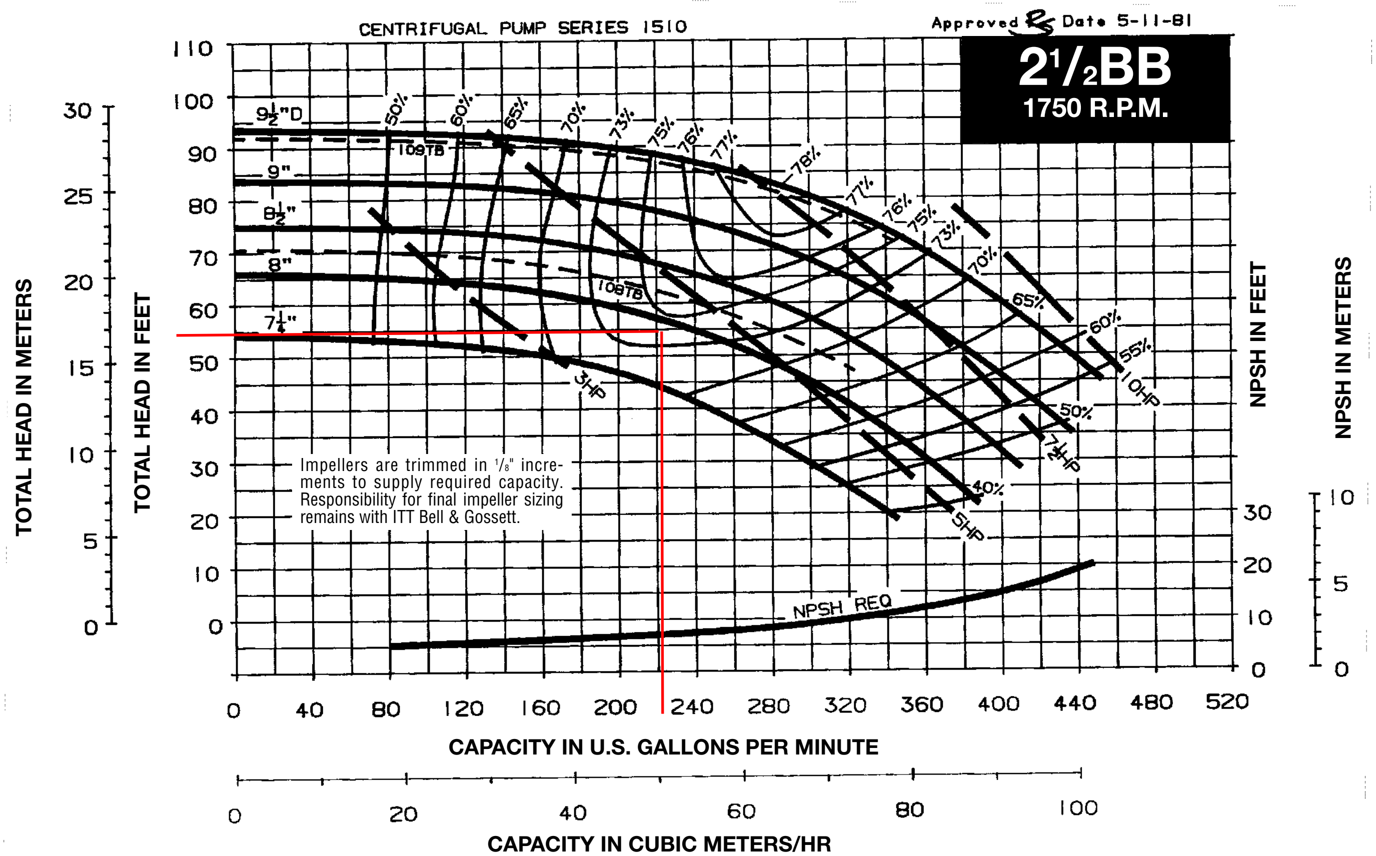


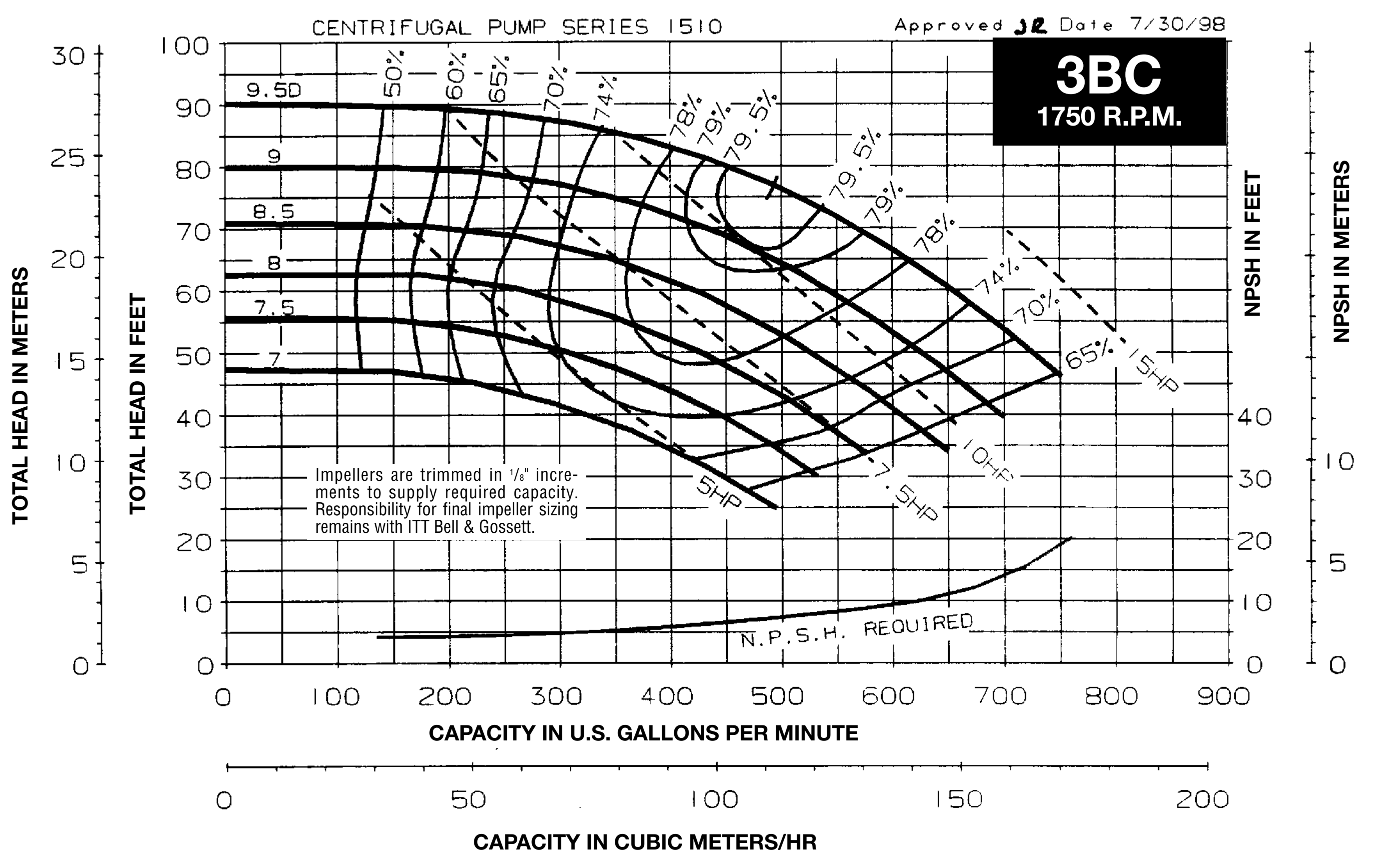
Notes:

1. All dimensions are in feet and inches. Weights are in pounds.
2. Unit should be continuously supported on a flat level surface.
3. All connections are grooved for mechanical coupling.

MODEL	TSU–237M	TSU–476M	TSU–594M	TSU–761M
Latent Capacity (Ton–Hours)	237	476	594	761
Approx. Shipping Weight (Pounds)	9,750	16,750	20,200	24,000
Approx. Operating Weight (Pounds)	39,100	73,900	93,100	113,800
Tank Water Volume (Gallons)	2,990	5,840	7,460	9,150
Coil Glycol Volume (Gallons)	260	495	610	790
Connection Size (Inches)	2"	3"	3"	3"
Unit Width	7' 10 3/8"	7' 10 3/8"	9' 9 1/4"	11' 9 3/4"
Unit Length	10' 7 5/8"	19' 10 1/4"	19' 10 1/4"	19' 10 1/4"

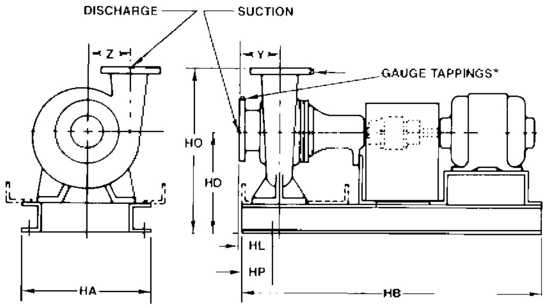
1750 RPM PUMP CURVES





Series 1510 Centrifugal Pumps

Dimensions



*Gauge Tapping Sizes: 1/8" for NPT, 1/4" for Flanged Sizes

Motor Horsepower and Frame Tabulation three phase (Dripproof Enclosure)

Horsepower	Frame @ 1750 RPM	Frame @ 3500 RPM	Horsepower	Frame @ 1750 RPM	Frame @ 3500 RPM
1/2	56		20	256T	254T
3/4	56		25	284T	256T
1	143T		30	286T	284TS
1 1/2	145T		40	324T	286TS
2	145T	145T	50	326T	324TS
3	182T	145T	60	364T	326TS
5	184T	182T	75	365T	364TS
7 1/2	213T	184T	100	404TS	365TS
10	215T	213T	125	—	404TS
15	254T	215T			

DIMENSIONS – INCHES (MM)			STANDARD MECHANICAL SEAL PUMP MODEL 1510, 1510-F								STUFFING BOX CONSTRUCTION PUMP MODEL 1510-PF, 1510-S							
PUMP SIZE DISCHARGE	SUCTION SIZE	MOTOR FRAME SIZE	HA	HB	HD	HL	HO	HP	Y	Z	HA	HB	HD	HL	HO	HP	Y	Z
1 1/4 AC (NPT)	1 1/2 (NPT)	56	12 (305)	28 3/4 (730)	9 3/4 (248)	3 1/8 (79)	14 3/4 (375)	3 (76)	3 1/4 (83)	4 1/2 (114)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	1 3/4 (44)	14 3/4 (375)	3 (76)	3 1/4 (83)	4 1/2 (114)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		1 3/4 (46)												
		213T-215T		34 5/8 (879)								39 3/8 (1000)						
1 1/4 BC (NPT)		143T-145T		31 (787)	10 3/4 (273)	1 13/16 (46)	18 3/4 (476)			5 1/2 (140)		34 5/8 (879)	10 3/4 (273)	1 13/16 (46)	18 3/4 (476)			5 1/2 (140)
		182T-184T																
		213T-215T		39 3/8 (1000)							16 (406)	46 1/2 (1181)	12 (305)	2 15/16 (75)	20 (508)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)	2 15/16 (75)	20 (508)	5 (127)				51 3/4 (1314)						
		284TS-286TS			13 (330)		21 (533)						13 (330)		21 (533)			
1 1/2 AC (NPT)	2 (NPT)	56	12 (305)	28 3/4 (730)	9 3/4 (248)	3 1/16 (78)	15 3/4 (400)	3 (76)	3 1/8 (79)	4 5/8 (117)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	1 11/16 (43)	15 3/4 (400)	3 (76)	3 1/8 (79)	4 5/8 (117)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		1 11/16 (43)												
		213T-215T		34 5/8 (879)								39 3/8 (1000)						
		254T-256T		39 3/8 (1000)	10 3/4 (273)		16 3/4 (425)				16 (406)	46 1/2 (1181)	12 (305)	2 13/16 (71)	18 (457)	5 (127)		
1 1/2 BC (NPT)		143T-145T		31 (787)			17 1/4 (438)			5 3/4 (146)	14 5/8 (371)	34 5/8 (879)	10 3/4 (273)	1 11/16 (43)	17 1/4 (438)	3 (76)		5 3/4 (146)
		182T-184T																
		213T-1750		34 5/8 (879)								39 3/8 (1000)						
		213T-215T-3500		39 3/8 (1000)							16 (406)	46 1/2 (1181)	12 (305)	2 13/16 (71)	18 1/2 (470)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)	2 13/16 (71)	18 1/2 (470)	5 (127)				51 3/4 (1314)						
		284TS-286TS			13 (330)		19 1/2 (495)						13 (330)		19 1/2 (495)			
2 AC	2 1/2	56	12 (305)	28 3/4 (730)	9 3/4 (248)	3 9/16 (90)	16 1/4 (413)	3 (76)	3 1/2 (89)	4 3/4 (121)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	2 3/16 (56)	16 1/4 (413)	3 (76)	3 1/2 (89)	4 3/4 (121)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		2 3/16 (56)												
		213T-215T		34 5/8 (879)							16 (406)	46 1/2 (1181)	11 (279)	3 5/16 (84)	17 1/2 (445)	5 (127)		
		254T-256T		39 3/8 (1000)	10 3/4 (273)		17 1/4 (438)					51 3/4 (1314)	12 (305)		18 1/2 (470)			
2 BC		143T-145T		31 (787)		2 11/16 (68)	17 3/4 (451)		4 (102)	5 7/8 (149)	14 5/8 (371)	34 5/8 (879)	10 3/4 (273)	2 11/16 (68)	17 3/4 (451)	3 (76)	4 (102)	5 7/8 (149)
		182T-184T																
		213T-215T-1750		34 5/8 (879)								39 3/8 (1000)						
		254T-3500		39 3/8 (1000)		3 13/16 (97)		5 (127)			16 (406)	46 1/2 (1181)	12 (305)	3 13/16 (97)	19 (483)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)		19 (483)					51 3/4 (1314)						
		284TS-286TS			13 (330)		20 (508)						13 (330)		20 (508)			
		324TS-326TS			12 (305)		19 (483)						12 (305)		19 (483)			
2 E†	3	182T		42 1/4 (1073)	14 (356)	6 1/2 (165)	22 (559)	5 (127)	5 1/2 (140)	6 1/2 (165)		42 1/4 (1073)	14 (356)	6 1/2 (165)	22 (559)	5 (127)	5 1/2 (140)	6 1/4 (165)
		184T																
		213T																
		215T																
		254T																
		286TS		46 1/2 (1181)		4 1/8 (105)						51 3/4 (1314)		4 1/8 (105)				
		324TS		51 3/4 (1314)														
		326TS																
		364TS	24 (610)	56 (1422)	16 1/2 (419)	4 3/4 (121)	24 1/2 (622)	6 (152)			24 (610)	56 (1422)	16 1/2 (419)	4 3/4 (121)	24 1/2 (622)	6 (152)		
		365TS																
2 G†		213T-215T	16 (406)	46 1/2 (1181)	14 (356)	3 7/8 (98)	23 (584)	5 (127)		7 1/4 (184)	16 (406)	46 1/2 (1181)	14 (356)	3 7/8 (98)	23 (584)	5 (127)		7 1/4 (184)
		254T-256T										51 3/4 (1314)						
		284T		51 3/4 (1314)														
2 1/2 AB		56	12 (305)	28 3/4 (730)	9 3/4 (248)	4 3/8 (111)	15 3/4 (400)	3 (76)	4 1/4 (108)	4 11/16 (119)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	3 (76)	15 3/4 (400)	3 (76)	4 1/4 (108)	4 11/16 (119)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		3 (76)												
		213T-215T		34 5/8 (879)							16 (406)	46 1/2 (1181)	11 (279)	4 1/8 (105)	17 (432)	5 (127)		
		254T-256T		39 3/8 (1000)	10 3/4 (273)		16 3/4 (425)					51 3/4 (1314)	12 (305)					
2 1/2 BB		182T-184T		31 (787)		2 3/4 (70)	17 1/2 (445)		4 (102)	6 (152)	14 5/8 (371)	34 5/8 (879)	10 3/4 (273)	2 3/4 (70)	17 1/2 (445)	3 (76)	4 (102)	6 (152)
		213T-215T		34 5/8 (879)								39 3/8 (1000)						
		284TS-286TS	16 (406)	46 1/2 (1181)	13 (330)	3 7/8 (98)	19 3/4 (502)	5 (127)			16 (406)	51 3/4 (1314)	13 (330)	3 7/8 (98)	19 3/4 (502)	5 (127)		
		324TS-326TS			12 (305)		18 3/4 (476)						12 (305)		18 3/4 (476)			
		346TS		51 3/4 (1314)	13 (330)		19 3/4 (502)						13 (330)		19 3/4 (502)			
3 AC	4	143T-145T	12 (305)	28 3/4 (730)	9 3/4 (248)	4 5/16 (110)	15 3/4 (400)	3 (76)	4 1/8 (105)	5 (127)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	2 15/16 (75)	15 3/4 (400)	3 (76)	4 1/8 (105)	5 (127)
		182T-184T	14 5/8 (371)	31 (787)		2 15/16 (75)												
		215T		39 3/8 (1000)							16 (406)	46 1/2 (1181)	11 (279)	4 1/16 (103)	17 (432)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)	4 1/16 (103)	18 (457)	5 (127)				51 3/4 (1314)	12 (305)		18 (457)			
		284TS-286TS			13 (330)		19 (483)						13 (330)		19 (483)			

These dimensions are not to be used for installation purposes unless certified.
†250 psi (17 bar) available

Maximum Working Pressure 175 psi (12 bar)

Energy Cost Budget / PRM Summary

By META Engineers

Project Name: City of Hope Amini Medical Center	Date: April 22, 2009
City: Duarte California	Weather Data: Pasadena, California (CTZ09)

Note: The percentage displayed for the "Proposed/ Base %" column of the base case is actually the percentage of the total energy consumption.

* Denotes the base alternative for the ECB study.

		* Alt-1 185 Ton Chiller			Alt-2 Thermal Storage - Load Le			Alt-3 Thermal Storage - Full Loa			Alt-4 Thermal Storage - Demand		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Lighting - Conditioned	Electricity	942.2	13	258	942.2	100	258	942.2	100	258	942.2	100	258
Space Heating	Electricity	1.4	0	0	1.4	100	0	1.4	100	0	1.4	100	0
	Purchased Steam	198.6	3	249	198.6	100	249	198.6	100	249	198.6	100	249
Space Cooling	Electricity	1,572.9	21	682	1,481.3	94	440	1,511.3	96	610	1,548.4	98	476
Pumps	Electricity	241.1	3	52	193.5	80	37	234.0	97	49	228.2	95	43
Heat Rejection	Electricity	170.5	2	75	170.5	100	46	177.7	104	68	173.1	102	53
Fans - Conditioned	Electricity	536.3	7	213	536.3	100	213	536.3	100	213	536.3	100	213
Receptacles - Conditioned	Electricity	3,697.2	50	663	3,697.2	100	663	3,697.2	100	663	3,697.2	100	663
Stand-alone Base Utilities	Electricity	27.4	0	6	27.4	100	6	27.4	100	6	27.4	100	6
Total Building Consumption		**7,387.7**			**7,248.6**			**7,326.2**			**7,352.9**		

		* Alt-1 185 Ton Chiller	Alt-2 Thermal Storage - Load Le	Alt-3 Thermal Storage - Full Loa	Alt-4 Thermal Storage - Demand
Total	**Number of hours heating load not met**	31	31	31	31
	Number of hours cooling load not met	5	5	5	5

	* Alt-1 185 Ton Chiller		Alt-2 Thermal Storage - Load Le		Alt-3 Thermal Storage - Full Loa		Alt-4 Thermal Storage - Demand	
	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	7,189.1	533,070	7,050.0	395,718	7,127.5	396,679	7,154.3	400,928
Purchased Steam	198.6	0	198.6	0	198.6	0	198.6	0
Total	**7,388**	**533,070**	**7,249**	**395,718**	**7,326**	**396,679**	**7,353**	**400,928**

MONTHLY ENERGY CONSUMPTION

By META Engineers

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

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 3	**Thermal Storage - Full Load Storage**												
Electric													
On-Pk Cons. (kWh)	0	0	0	0	0	41,556	38,052	43,812	37,977	0	0	0	161,397
Off-Pk Cons. (kWh)	73,771	71,433	76,371	82,445	84,919	77,958	96,122	91,057	89,782	87,607	77,657	79,663	988,788
Mid-Pk Cons. (kWh)	81,394	75,121	92,555	82,252	92,592	64,699	60,574	71,537	59,391	93,014	86,206	78,833	938,168
On-Pk Demand (kW)	0	0	0	0	0	327	329	329	329	0	0	0	329
Off-Pk Demand (kW)	406	420	418	426	443	474	513	510	499	466	428	412	513
Mid-Pk Demand (kW)	424	438	439	446	463	487	523	524	512	487	450	431	524
Purchased Steam													
On-Pk Cons. (therms)	0	0	0	0	0	47	41	47	40	0	0	0	175
Off-Pk Cons. (therms)	159	105	78	50	26	23	24	22	26	28	63	141	745
Mid-Pk Cons. (therms)	135	105	116	94	100	51	46	54	48	101	104	113	1,066
On-Pk Demand (therms/hr)	0	0	0	0	0	1	1	1	1	0	0	0	1
Off-Pk Demand (therms/hr)	2	2	1	1	1	1	1	1	1	1	1	2	2
Mid-Pk Demand (therms/hr)	1	1	1	1	1	1	1	1	1	1	1	1	1

Energy Consumption		
Building	137,967	Btu/(ft2-year)
Source	407,707	Btu/(ft2-year)
Floor Area	53,101	ft2

Environmental Impact Analysis	
CO_2	No Data Available
SO_2	No Data Available
NOX	No Data Available

MONTHLY UTILITY COSTS

By META Engineers

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Alternative 3													
Electric													
On-Pk Cons. ($)	256	256	256	256	256	8,534	7,836	8,984	7,821	256	256	256	35,224
Off-Pk Cons. ($)	10,526	10,200	10,888	11,733	12,078	10,812	13,271	12,585	12,413	12,452	11,067	11,346	139,371
Mid-Pk Cons. ($)	14,452	13,358	16,399	14,602	16,405	11,359	10,651	12,533	10,448	16,479	15,291	14,005	165,983
Off-Pk Demand ($)	4,207	4,351	4,328	4,413	4,586	4,913	5,316	5,285	5,170	4,831	4,434	4,267	56,101
Mid-Pk Demand ($)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total ($):	29,441	28,166	31,871	31,004	33,325	35,619	37,075	39,387	35,852	34,018	31,048	29,875	396,679
Monthly Total ($):	29,441	28,166	31,871	31,004	33,325	35,619	37,075	39,387	35,852	34,018	31,048	29,875	396,679

Building Area = 53,101 ft²

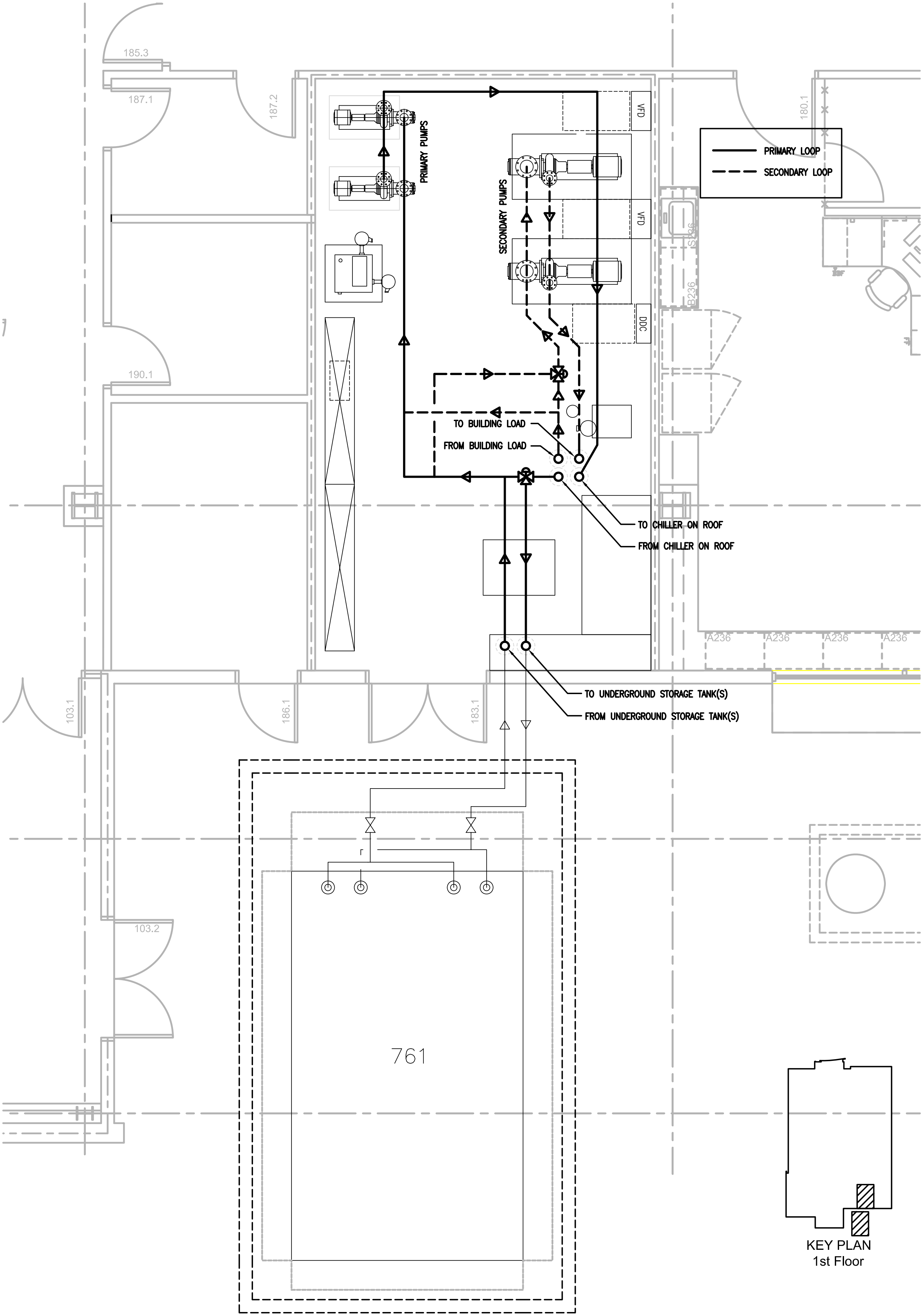
Utility Cost Per Area = 7.47 $/ft²

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative 4													
Electric													
On-Pk Cons. ($)	256	256	256	256	256	10,797	10,057	11,453	9,988	256	256	256	44,345
Off-Pk Cons. ($)	9,757	9,076	9,494	10,341	10,383	9,744	12,253	11,607	11,393	10,998	9,639	10,387	125,072
Mid-Pk Cons. ($)	15,531	14,641	17,944	16,146	18,347	11,191	10,530	12,147	10,306	18,552	16,898	15,202	177,434
Off-Pk Demand ($)	4,127	4,271	4,247	4,331	4,506	4,737	4,889	4,837	4,841	4,752	4,353	4,186	54,077
Mid-Pk Demand ($)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total ($):	29,671	28,243	31,941	31,075	33,491	36,469	37,728	40,045	36,529	34,558	31,146	30,031	400,928
Monthly Total ($):	29,671	28,243	31,941	31,075	33,491	36,469	37,728	40,045	36,529	34,558	31,146	30,031	400,928

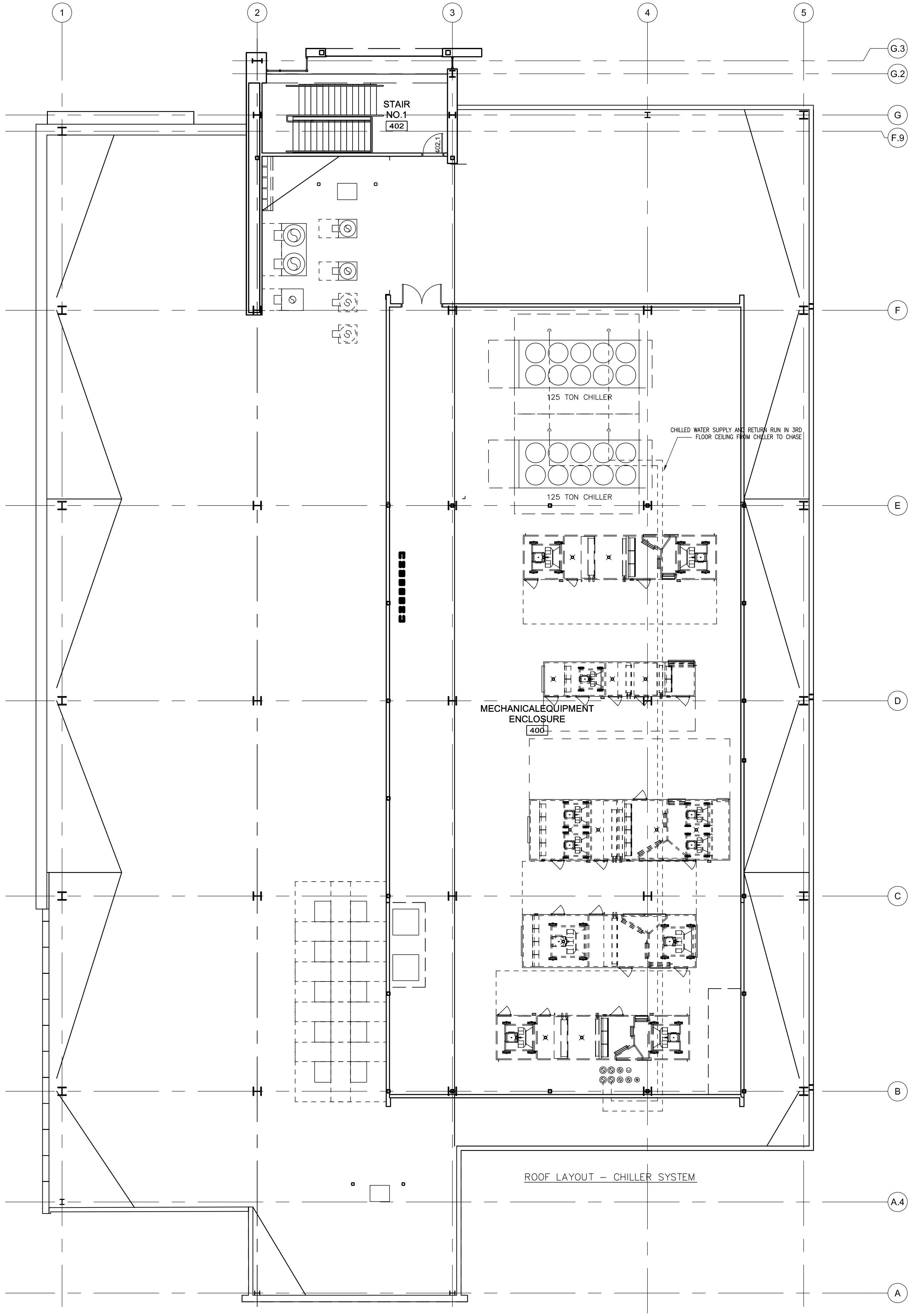
Building Area = 53,101 ft²

Utility Cost Per Area = 7.55 $/ft²

Appendix C
Load Leveling Partial Ice Storage Redesign



MECH. RM. LAYOUT — ICE STORAGE SYSTEM



ROOF LAYOUT – CHILLER SYSTEM

Load Leveling Partial Storage Equipment Sizing

Assumptions:

Total Cooling Load = Total Chiller Capacity (1) (No heat or pump losses)

Total Chiller Capacity = $H_{chrg}C_{chrg} + H_{DConp}C_{DConp} + H_{DCoffp}C_{DCoffp}$ (2)

H_{chrg}	hours charging storage
C_{chrg}	capacity when charging storage
H_{DConp}	hours direct cooling during on-peak period
C_{DConp}	capacity when cooling during on-peak period
H_{DCoffp}	hours direct cooling during off-peak period
C_{DCoffp}	capacity when cooling during off-peak period

Quick Chiller Sizing Equation (Combine (1) and (2))

Nominal Chiller Size = Total Cooling Load / ($H_{chrg}CR_{chrg} + H_{DConp}CR_{DConp} + H_{DCoffp}CR_{DCoffp}$) (3)

H_{chrg}	hours charging storage
CR_{chrg}	capacity ratio when charging storage
H_{DConp}	hours direct cooling during on-peak period
CR_{DConp}	capacity ratio when cooling during on-peak period
H_{DCoffp}	hours direct cooling during off-peak period
CR_{DCoffp}	capacity ratio when cooling during off-peak period

Full Storage System $H_{DConp}CR_{DConp} = 0$

COH Assumptions:

Supply 38 deg. solution to load

Chiller Upstream tanks provides 23 deg solution during ice making

COH Load Leveling Scenario				
Hour	Clg (Tons)	Cooling Mode	Summer	Winter
1	24.7	Satisfy Load & Charge	OFF-PEAK	OFF-PEAK
2	23.6	"		
3	22.8	"		
4	22.0	"		
5	21.5	"		
6	22.0	"		
7	23.5	"		
8	138.5	Satsify Load & Discharge		
9	131.1	"	MID-PEAK	MID-PEAK
10	148.1	"		
11	156.4	"		
12	162.5	"		
13	160.3	"	PEAK	
14	166.7	"		
15	173.4	"		
16	175.1	"		
17	174.0	"		
18	166.9	"		
19	125.2	"	MID-PEAK	
20	29.9	Satisfy Load & Charge		
21	28.5	"		
22	26.9	"		OFF-PEAK
23	26.6	"		
24	25.8	"	OFF-PEAK	

On-Peak Ton-hr =	1,016.4
Non-Peak Ton-hr =	1,159.6
Total Ton-hr =	2,176.0

COH Nominal Chiller Capacity (3) =	**117**	**Tons**
H_{chrg}	12	
CR_{chrg}	0.7	Assumed
H_{DCoffp}	6	
CR_{DCoffp}	0.85	Assumed
H_{DConp}	6	
CR_{DConp}	0.85	Assumed

Quick Storage Size

Storage Capacity = Total Cooling load - ($TC_{DConp} + TC_{DCoffp} + TH_{DCchrg}$) (4)

TC_{DConp}	total capacity when direct cooling during on-peak	(Ton-hrs)
TC_{DCoffp}	total capacity when direct cooling during off-peak	(Ton-hrs)
TC_{DCchrg}	ton-hours direct cooling while simultaneously charging	(Ton-hrs)

Storage Capacity =	**685**	**Ton-hrs**

City of Hope
CHW Head Calc
Load Leveling Part Storage

Section	Describe Pipe	Flow (gpm)	Pipe Size (in)	Alt Pipe Size (in)	Length (ft)	Tag No.	Fittings Description	No. Fittings	Actual Pressure Drop (ft)	Velocity (fps)	Alt C	Head Loss / 100ft	Fitting Equiv. Length	Pressure Drop (ft)	Total Pressure Drop (ft)
	MECH ROOM					1	NA								
Pump to Chase	Supply	157.0	4			4	Pump		5.0	3.96		1.96		5.00	5.00
		157.0	4		48	2	Straight Pipe			3.96		1.96		0.94	5.94
		157.0	4			12	Long Radius 90 Elbow	4		3.96		1.96	5.37	0.42	6.36
		157.0	4			13	45 Standard Elbow	1		3.96		1.96	5.37	0.11	6.46
		157.0	4			14	Standard Tee-thru flow	1		3.96		1.96	6.71	0.13	6.60
Chase to Pump	Return	157.0	4			12	Long Radius 90 Elbow	9		3.96		1.96	5.37	0.95	7.54
		157.0	4		140	2	Straight Pipe			3.96		1.96		2.74	10.28
		157.0	4			14	Standard Tee-thru flow	2		3.96		1.96	6.71	0.26	10.54
		157.0	4			15	Standard Tee-branch flow	6		3.96		1.96	20.1	2.36	12.90
		157.0	4			32	Control Valve (25 ft)		15.0	3.96		1.96		15.00	27.90
	Ice Storage	157.0	4			33	Other		3.0	3.96		1.96		3.00	30.90
Chase	Supply + Return	157.0	4		70	2	Straight Pipe			3.96		1.96		1.37	32.27
3rd Flr	Supply + Return	157.0	4		290	2	Straight Pipe			3.96		1.96		5.68	37.95
		157.0	4			12	Long Radius 90 Elbow	12		3.96		1.96	5.37	1.26	39.21
		157.0	4			15	Standard Tee-branch flow	2		3.96		1.96	20.1	0.79	40.00
		157.0	4			22	Butterfly valve	2		3.96		1.96	15.1	0.59	40.59
Roof	Supply + Return	157.0	4		20	2	Straight Pipe			3.96		1.96		0.39	40.98
		157.0	4			12	Long Radius 90 Elbow	4		3.96		1.96	5.37	0.42	41.40
	Chiller	157.0	4			33	Other		5.8	3.96		1.96		5.75	47.15
			3/4			1	NA								47.15
			3/4			1	NA								47.15

Total Head = 47.15
Safety Factor = 20%

Grand Total = 56.58

* Based on Cameron Hydraulic Data Book.
Small Pipe Add 10% Safety Factor.
Medium to Large Pipe 20% Safety Factor.

Air-Cooled Series R™ Rotary Liquid Chiller

Model RTAA
70 to 125 Tons

Built for Industrial and Commercial Markets

November 2006

RLC-PRC016-EN

General Data

Table G-1 — General Data RTAA — 70-125 Ton

Size		70	80	90	100	110	125
Compressor							
Quantity		2	2	2	2	2	2
Nominal Size (1)	(Tons)	35/35	40/40	50/40	50/50	60/50	60/60
Evaporator							
Water Storage	(Gallons)	39.8	37.3	34.4	32.1	53.4	45.8
	(Liters)	150.6	143.1	130.2	121.5	202.11	173.4
Min. Flow	(GPM)	84	96	108	120	132	150
	(L/Sec)	5.3	6.1	6.8	7.6	8.3	9.5
Max. Flow	(GPM)	252	288	324	360	396	450
	(L/Sec)	15.9	18.2	20.4	22.7	25.0	28.4
Condenser							
Qty of Coils		4	4	4	4	4	4
Coil Length	(In)	156/156	156/156	168/156	168/168	204/168	204/204
	(mm)	3962/3962	3962/3962	4267/3962	4267/4267	5182/4267	5182/5182
Coil Height	(In)	42	42	42	42	42	42
	(mm)	1067	1067	1067	1067	1067	1067
Fins/Ft.		192	192	192	192	192	192
Number of Rows		2	2	2	2	2	2
Condenser Fans (60 Hz)							
Quantity (1)		4/4	4/4	5/4	5/5	5/5	5/5
Diameter	(In)	30	30	30	30	30	30
	(mm)	762	762	762	762	762	762
Total Airflow	(CFM)	71750	71750	77640	83530	87505	91480
Nominal RPM	60 Hz	1140	1140	1140	1140	1140	1140
Tip Speed	(Ft/Min)	8954	8954	8954	8954	8954	8954
Motor HP (Ea)		1.25	1.25	1.25	1.25	1.25	1.25
Condenser Fans (50 Hz)							
Quantity (1)		4/4	4/4	5/4	5/5	5/5	5/5
Diameter	(In)	30	30	30	30	30	30
	(mm)	762	762	762	762	762	762
Total Airflow	(CFM)	59172	59200	63963	68724	72104	75492
Nominal RPM	50 Hz	970	970	970	970	970	970
Tip Speed	(Ft/Min)	7618	7618	7618	7618	7618	7618
Motor HP (Ea)		1.25	1.25	1.25	1.25	1.25	1.25
Min Starting/Oper Ambient (2)							
Std Unit	(Deg F)	25	25	25	25	25	25
	(Deg C)	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9
Low Ambient	(Deg F)	-10	-10	-10	-10	-10	-10
	(Deg C)	-23.3	-23.3	-23.3	-23.3	-23.3	-23.3
General Unit							
Refrigerant		HCFC-22	HCFC-22	HCFC-22	HCFC-22	HCFC-22	HCFC-22
No. of Independent Refrigerant Circuits		2	2	2	2	2	2
Refrigerant Charge (1)	(Lb)	58/58	61/61	73/61	73/73	98/73	98/98
	(Kg)	26/26	28/28	34/28	34/34	44/34	44/44
Oil Charge (1)	(Gallons)	2.5/2.5	2.5/2.5	3/2.5	3/3	3/3	3/3
	(Liters)	10.6/10.6	10.6/10.6	12.7/10.6	12.7/12.7	12.7/12.7	12.7/12.7

1. Data containing information on two circuits shown as follows: ckt 1/ckt2.
2. Minimum start-up/operating ambient based on a 5 mph wind across the condenser.

Table G-2 — General Data Pump Package

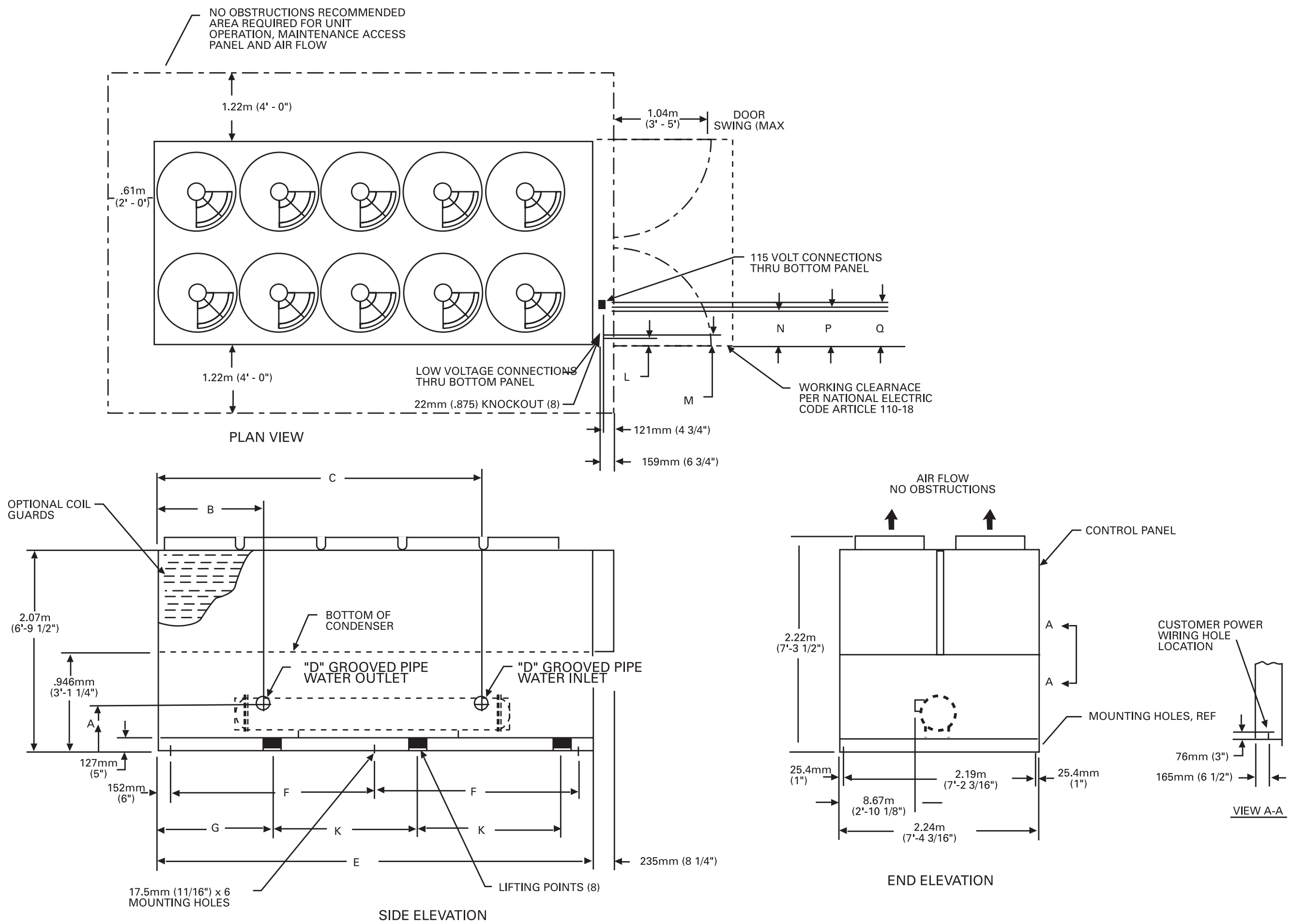
Pump Package Size		C2	D3	D5	E2	E3	F5	F7	G3	G5
Pump										
Quantity		2	2	2	2	2	2	2	2	2
Motor HP	(each)	2	3	5	2	3	5	7.5	3	5
Water Storage										
4" connection	(Gallons)	13.64	13.54	16.18	16.25	16.25	23.54	23.54	23.62	23.62
	(Liters)	51.63	51.25	61.25	61.51	61.51	89.11	89.11	89.41	89.41
6" connection	(Gallons)	--	16.8	19.41	--	19.59	26.09	26.09	26.56	26.56
	(Liters)	--	64.28	73.47	--	74.16	98.76	98.76	100.54	100.54

1. Information given for 460/60/3 units only.

Dimensional Data

Packaged Unit

Figure D-1 — RTAA 70-125 Unit Dimensions



UNIT SIZE	A	B	C	D	E	F	G	K
70-100	.492m (1'-7 3/8")	1.213m (3'-11 3/4")	2.851m (9'-4 1/4")	102mm (4")	4.940m (16'-2 1/2")	2.317m (7'-7 1/4")	1.549m (5'-1")	1.626m (5'-4")
110-125	.479m (1'-6 7/8")	1.032m (3'-4 5/8")	3.499m (11'-5 3/4")	152mm (6")	5.626m (18'-5 1/2")	2.661m (8'-8 3/4")	1.511m (4'-11 1/2")	1.930m (6'-4")

	NO. OF FANS PER UNIT					
UNIT SIZE	70	80	90	100	110	125
NO. FANS STD UNIT	8	8	9	10	10	10

	115 VOLT & LOW VOLTAGE CONNECTIONS				
PANEL TYPE	L	M	N	P	Q
X-LINE CONTROL PANEL	.889m (2'-11")	.927m (3'-0 1/2")	1.206m (3'-11 1/2")	1.245m (4'-1")	1.283m (4'-2 1/2")
WYE DELTA CONTROL PANEL	76mm (3")	114mm (4 1/2")	.39m (1'-3 1/2")	.43m (1'-5")	.47m (1'-8 1/2")

Weights

Packaged Unit

Table W-1 — Packaged Unit Weights (Aluminum)

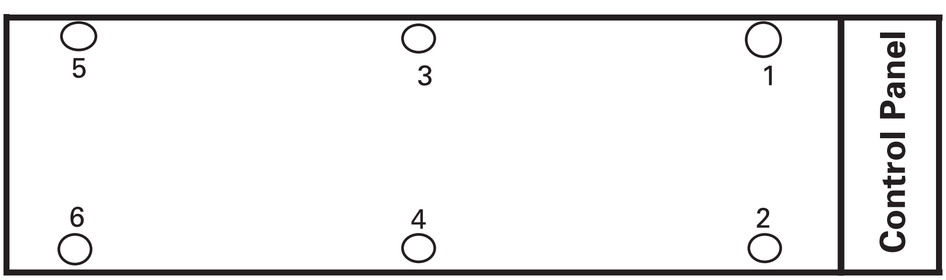
		Isolator Location						Operating	Shipping
Unit Size	Units	1	2	3	4	5	6	Weight	Weight
RTAA 70	lbs.	1622	1636	1215	1229	808	822	7332	6507
	kg	737	744	552	559	367	374	3333	2952
RTAA 80	lbs.	1624	1638	1220	1235	817	831	7364	6556
	kg	738	745	555	561	371	378	3347	2974
RTAA 90	lbs.	1667	1623	1275	1232	884	840	7521	6741
	kg	758	738	580	560	402	382	3419	3058
RTAA 100	lbs.	1672	1687	1284	1299	897	912	7751	6990
	kg	760	767	584	591	408	414	3523	3171
RTAA 110	lbs.	2033	1755	1622	1344	1211	933	8772	7706
	kg	924	798	737	611	550	424	3987	3495
RTAA 125	lbs.	2043	1759	1635	1351	1227	943	8742	7740
	kg	929	800	743	614	558	429	3974	3511

Notes:
1. Operating weight includes the weight of accessory panels and water.
2. Shipping weight does not include the weight of accessory panels or water.

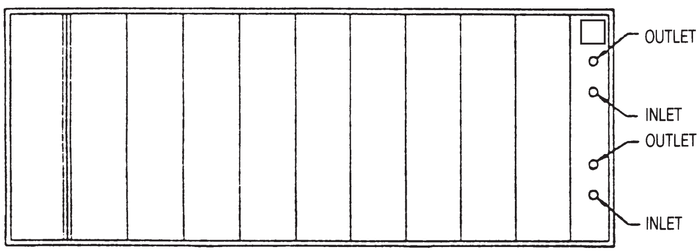
Table W-2 — Packaged Unit Weights (Copper)

		Isolator Location						Operating	Shipping
Unit Size	Units	1	2	3	4	5	6	Weight	Weight
RTAA 70	lbs.	1769	1784	1325	1341	881	897	7997	7172
	kg	804	811	602	609	401	408	3335	3253
RTAA 80	lbs.	1770	1786	1331	1346	891	906	8029	7221
	kg	805	832	605	612	405	412	3650	3275
RTAA 90	lbs.	1819	1772	1392	1345	965	917	8210	7430
	kg	827	805	633	611	438	417	3732	3370
RTAA 100	lbs.	1826	1842	1403	1419	979	996	8465	7704
	kg	830	837	638	645	445	453	3848	3495
RTAA 110	lbs.	2161	2106	1622	1566	1082	1027	9564	8498
	kg	982	957	737	712	492	467	4347	3855
RTAA 125	lbs.	2109	2127	1593	1611	1077	1095	9612	8610
	kg	959	967	724	732	489	498	4369	3905

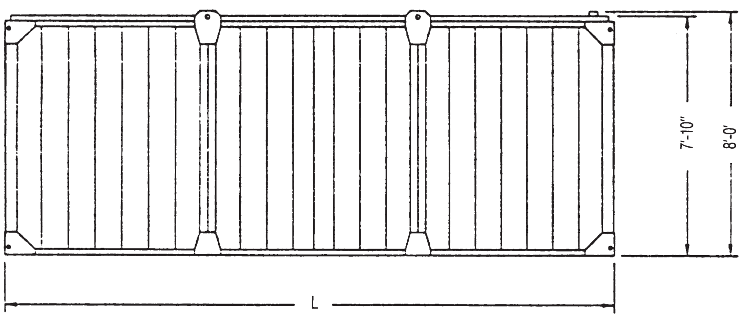
Notes:
1. Operating weight includes the weight of accessory panels and water.
2. Shipping weight does not include the weight of accessory panels or water.

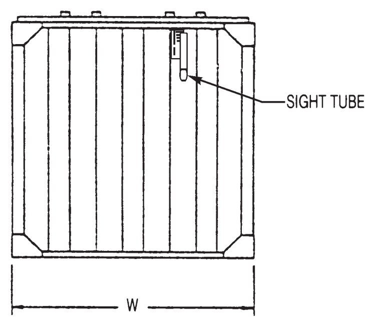


ENGINEERING DATA



PLAN VIEW

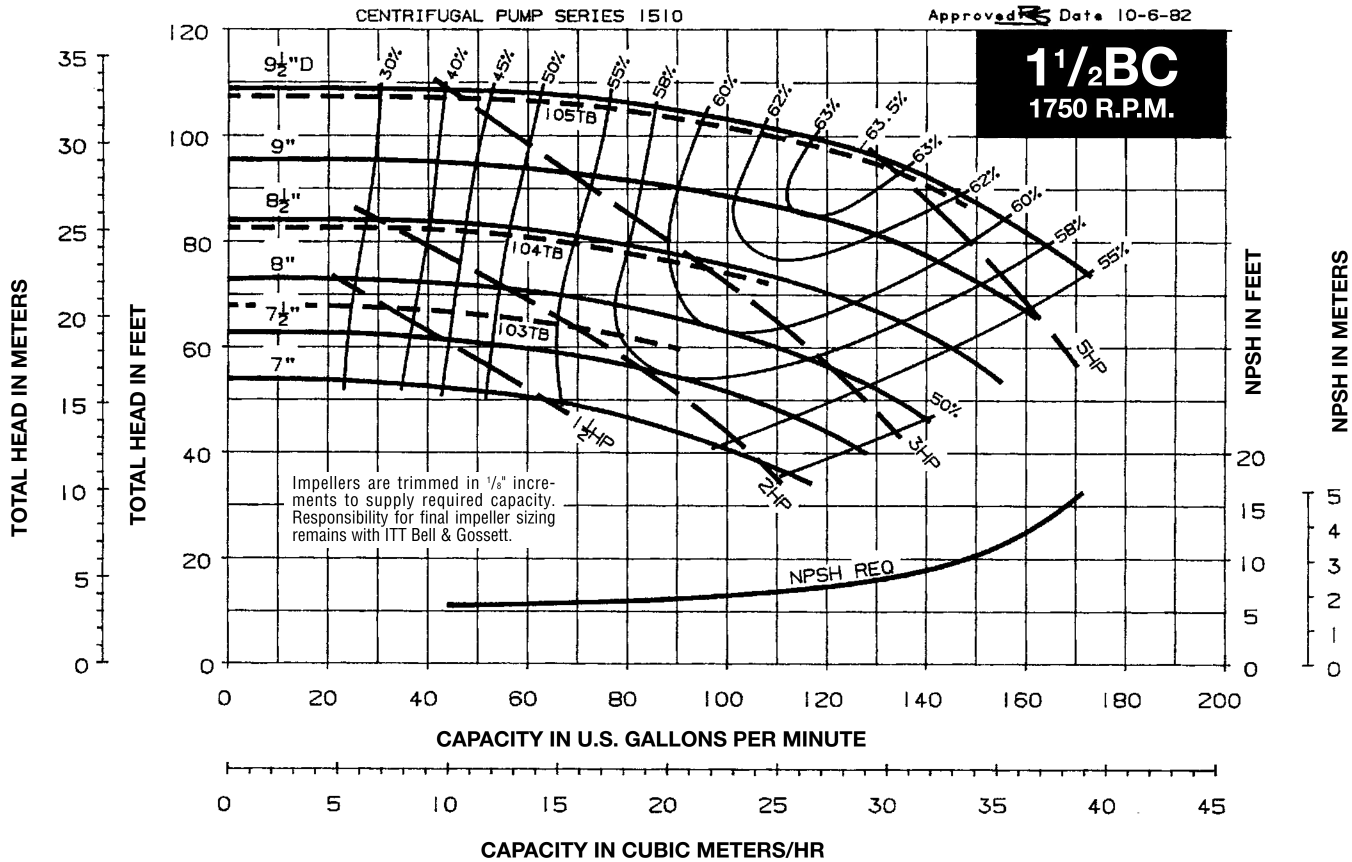


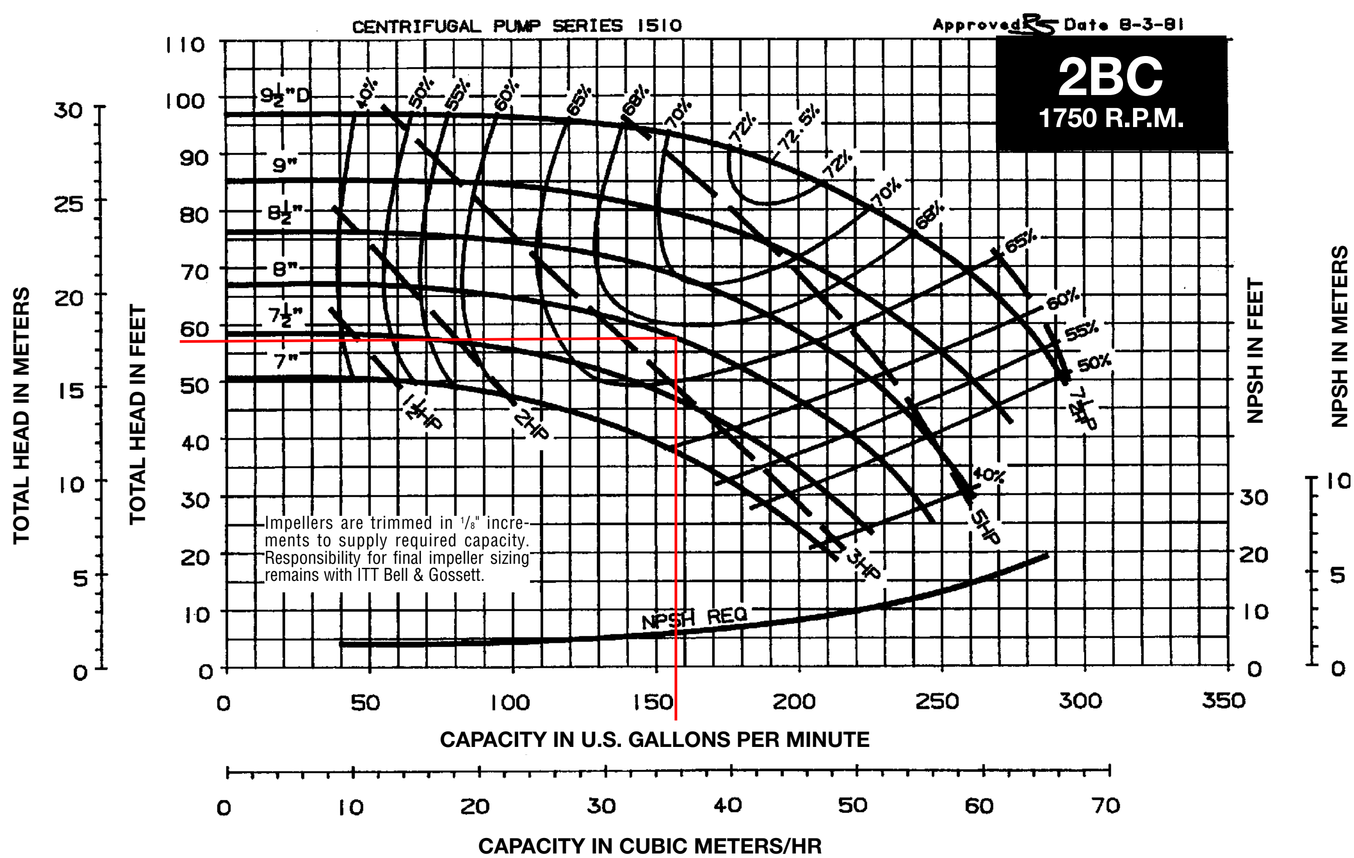


Notes:
1. All dimensions are in feet and inches. Weights are in pounds.
2. Unit should be continuously supported on a flat level surface.
3. All connections are grooved for mechanical coupling.

MODEL	TSU–237M	TSU–476M	TSU–594M	TSU–761M
Latent Capacity (Ton–Hours)	237	476	594	761
Approx. Shipping Weight (Pounds)	9,750	16,750	20,200	24,000
Approx. Operating Weight (Pounds)	39,100	73,900	93,100	113,800
Tank Water Volume (Gallons)	2,990	5,840	7,460	9,150
Coil Glycol Volume (Gallons)	260	495	610	790
Connection Size (Inches)	2"	3"	3”	3"
Unit Width	7' 10 3/8"	7' 10 3/8"	9' 9 1/4"	11' 9 3/4"
Unit Length	10' 7 5/8"	19' 10 1/4"	19' 10 1/4"	19' 10 1/4"

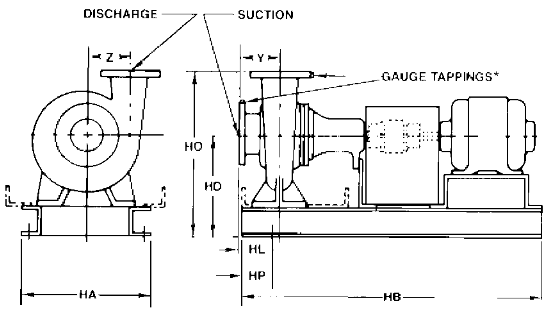
1750 RPM PUMP CURVES





Series 1510 Centrifugal Pumps

Dimensions



*Gauge Tapping Sizes: 1/8" for NPT, 1/4" for Flanged Sizes

Motor Horsepower and Frame Tabulation three phase (Dripproof Enclosure)

Horsepower	Frame @ 1750 RPM	Frame @ 3500 RPM	Horsepower	Frame @ 1750 RPM	Frame @ 3500 RPM
1/2	56		20	256T	254T
3/4	56		25	284T	256T
1	143T		30	286T	284TS
1 1/2	145T		40	324T	286TS
2	145T	145T	50	326T	324TS
3	182T	145T	60	364T	326TS
5	184T	182T	75	365T	364TS
7 1/2	213T	184T	100	404TS	365TS
10	215T	213T	125	—	404TS
15	254T	215T			

DIMENSIONS – INCHES (MM)			STANDARD MECHANICAL SEAL PUMP MODEL 1510, 1510-F								STUFFING BOX CONSTRUCTION PUMP MODEL 1510-PF, 1510-S							
PUMP SIZE DISCHARGE	SUCTION SIZE	MOTOR FRAME SIZE	HA	HB	HD	HL	HO	HP	Y	Z	HA	HB	HD	HL	HO	HP	Y	Z
1 1/4 AC (NPT)	1 1/2 (NPT)	56	12 (305)	28 3/4 (730)	9 3/4 (248)	3 1/8 (79)	14 3/4 (375)	3 (76)	3 1/4 (83)	4 1/2 (114)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	1 3/4 (44)	14 3/4 (375)	3 (76)	3 1/4 (83)	4 1/2 (114)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		1 3/4 (46)												
		213T-215T		34 5/8 (879)								39 3/8 (1000)						
1 1/4 BC (NPT)		143T-145T		31 (787)	10 3/4 (273)	1 13/16 (46)	18 3/4 (476)			5 1/2 (140)		34 5/8 (879)	10 3/4 (273)	1 13/16 (46)	18 3/4 (476)			5 1/2 (140)
		182T-184T																
		213T-215T		39 3/8 (1000)							16 (406)	46 1/2 (1181)	12 (305)	2 15/16 (75)	20 (508)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)	2 15/16 (75)	20 (508)	5 (127)				51 3/4 (1314)						
		284TS-286TS			13 (330)		21 (533)						13 (330)		21 (533)			
1 1/2 AC (NPT)	2 (NPT)	56	12 (305)	28 3/4 (730)	9 3/4 (248)	3 1/16 (78)	15 3/4 (400)	3 (76)	3 1/8 (79)	4 5/8 (117)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	1 11/16 (43)	15 3/4 (400)	3 (76)	3 1/8 (79)	4 5/8 (117)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		1 11/16 (43)												
		213T-215T		34 5/8 (879)								39 3/8 (1000)						
		254T-256T		39 3/8 (1000)	10 3/4 (273)		16 3/4 (425)				16 (406)	46 1/2 (1181)	12 (305)	2 13/16 (71)	18 (457)	5 (127)		
1 1/2 BC (NPT)		143T-145T		31 (787)			17 1/4 (438)			5 3/4 (146)	14 5/8 (371)	34 5/8 (879)	10 3/4 (273)	1 11/16 (43)	17 1/4 (438)	3 (76)		5 3/4 (146)
		182T-184T																
		213T-1750		34 5/8 (879)								39 3/8 (1000)						
		213T-215T-3500		39 3/8 (1000)							16 (406)	46 1/2 (1181)	12 (305)	2 13/16 (71)	18 1/2 (470)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)	2 13/16 (71)	18 1/2 (470)	5 (127)				51 3/4 (1314)						
		284TS-286TS			13 (330)		19 1/2 (495)						13 (330)		19 1/2 (495)			
2 AC	2 1/2	56	12 (305)	28 3/4 (730)	9 3/4 (248)	3 9/16 (90)	16 1/4 (413)	3 (76)	3 1/2 (89)	4 3/4 (121)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	2 3/16 (56)	16 1/4 (413)	3 (76)	3 1/2 (89)	4 3/4 (121)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		2 3/16 (56)												
		213T-215T		34 5/8 (879)							16 (406)	46 1/2 (1181)	11 (279)	3 5/16 (84)	17 1/2 (445)	5 (127)		
		254T-256T		39 3/8 (1000)	10 3/4 (273)		17 1/4 (438)					51 3/4 (1314)	12 (305)		18 1/2 (470)			
2 BC		143T-145T		31 (787)		2 11/16 (68)	17 3/4 (451)		4 (102)	5 7/8 (149)	14 5/8 (371)	34 5/8 (879)	10 3/4 (273)	2 11/16 (68)	17 3/4 (451)	3 (76)	4 (102)	5 7/8 (149)
		182T-184T																
		213T-215T-1750		34 5/8 (879)								39 3/8 (1000)						
		254T-3500		39 3/8 (1000)		3 13/16 (97)		5 (127)			16 (406)	46 1/2 (1181)	12 (305)	3 13/16 (97)	19 (483)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)		19 (483)					51 3/4 (1314)						
		284TS-286TS			13 (330)		20 (508)						13 (330)		20 (508)			
		324TS-326TS			12 (305)		19 (483)						12 (305)		19 (483)			
2 E†	3	182T		42 1/4 (1073)	14 (356)	6 1/2 (165)	22 (559)	5 (127)	5 1/2 (140)	6 1/2 (165)		42 1/4 (1073)	14 (356)	6 1/2 (165)	22 (559)	5 (127)	5 1/2 (140)	6 1/4 (165)
		184T																
		213T																
		215T																
		254T																
		286TS		46 1/2 (1181)		4 1/8 (105)						51 3/4 (1314)		4 1/8 (105)				
		324TS		51 3/4 (1314)														
		326TS																
		364TS	24 (610)	56 (1422)	16 1/2 (419)	4 3/4 (121)	24 1/2 (622)	6 (152)			24 (610)	56 (1422)	16 1/2 (419)	4 3/4 (121)	24 1/2 (622)	6 (152)		
		365TS																
2 G†		213T-215T	16 (406)	46 1/2 (1181)	14 (356)	3 7/8 (98)	23 (584)	5 (127)		7 1/4 (184)	16 (406)	46 1/2 (1181)	14 (356)	3 7/8 (98)	23 (584)	5 (127)		7 1/4 (184)
		254T-256T										51 3/4 (1314)						
		284T		51 3/4 (1314)														
2 1/2 AB		56	12 (305)	28 3/4 (730)	9 3/4 (248)	4 3/8 (111)	15 3/4 (400)	3 (76)	4 1/4 (108)	4 11/16 (119)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	3 (76)	15 3/4 (400)	3 (76)	4 1/4 (108)	4 11/16 (119)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		3 (76)												
		213T-215T		34 5/8 (879)							16 (406)	46 1/2 (1181)	11 (279)	4 1/8 (105)	17 (432)	5 (127)		
		254T-256T		39 3/8 (1000)	10 3/4 (273)		16 3/4 (425)					51 3/4 (1314)	12 (305)					
2 1/2 BB		182T-184T		31 (787)		2 3/4 (70)	17 1/2 (445)		4 (102)	6 (152)	14 5/8 (371)	34 5/8 (879)	10 3/4 (273)	2 3/4 (70)	17 1/2 (445)	3 (76)	4 (102)	6 (152)
		213T-215T		34 5/8 (879)								39 3/8 (1000)						
		284TS-286TS	16 (406)	46 1/2 (1181)	13 (330)	3 7/8 (98)	19 3/4 (502)	5 (127)			16 (406)	51 3/4 (1314)	13 (330)	3 7/8 (98)	19 3/4 (502)	5 (127)		
		324TS-326TS			12 (305)		18 3/4 (476)						12 (305)		18 3/4 (476)			
		346TS		51 3/4 (1314)	13 (330)		19 3/4 (502)						13 (330)		19 3/4 (502)			
3 AC	4	143T-145T	12 (305)	28 3/4 (730)	9 3/4 (248)	4 5/16 (110)	15 3/4 (400)	3 (76)	4 1/8 (105)	5 (127)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	2 15/16 (75)	15 3/4 (400)	3 (76)	4 1/8 (105)	5 (127)
		182T-184T	14 5/8 (371)	31 (787)		2 15/16 (75)												
		215T		39 3/8 (1000)							16 (406)	46 1/2 (1181)	11 (279)	4 1/16 (103)	17 (432)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)	4 1/16 (103)	18 (457)	5 (127)				51 3/4 (1314)	12 (305)		18 (457)			
		284TS-286TS			13 (330)		19 (483)						13 (330)		19 (483)			

These dimensions are not to be used for installation purposes unless certified.
†250 psi (17 bar) available

Maximum Working Pressure 175 psi (12 bar)

Energy Cost Budget / PRM Summary

By META Engineers

Project Name: City of Hope Amini Medical Center	Date: April 22, 2009
City: Duarte California	Weather Data: Pasadena, California (CTZ09)

Note: The percentage displayed for the "Proposed/ Base %" column of the base case is actually the percentage of the total energy consumption.

* Denotes the base alternative for the ECB study.

		* Alt-1 185 Ton Chiller			Alt-2 Thermal Storage - Load Le			Alt-3 Thermal Storage - Full Loa			Alt-4 Thermal Storage - Demand		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Lighting - Conditioned	Electricity	942.2	13	258	942.2	100	258	942.2	100	258	942.2	100	258
Space Heating	Electricity	1.4	0	0	1.4	100	0	1.4	100	0	1.4	100	0
	Purchased Steam	198.6	3	249	198.6	100	249	198.6	100	249	198.6	100	249
Space Cooling	Electricity	1,572.9	21	682	1,481.3	94	440	1,511.3	96	610	1,548.4	98	476
Pumps	Electricity	241.1	3	52	193.5	80	37	234.0	97	49	228.2	95	43
Heat Rejection	Electricity	170.5	2	75	170.5	100	46	177.7	104	68	173.1	102	53
Fans - Conditioned	Electricity	536.3	7	213	536.3	100	213	536.3	100	213	536.3	100	213
Receptacles - Conditioned	Electricity	3,697.2	50	663	3,697.2	100	663	3,697.2	100	663	3,697.2	100	663
Stand-alone Base Utilities	Electricity	27.4	0	6	27.4	100	6	27.4	100	6	27.4	100	6
Total Building Consumption		**7,387.7**			**7,248.6**			**7,326.2**			**7,352.9**		

		* Alt-1 185 Ton Chiller	Alt-2 Thermal Storage - Load Le	Alt-3 Thermal Storage - Full Loa	Alt-4 Thermal Storage - Demand
Total	**Number of hours heating load not met** **Number of hours cooling load not met**	31 5	31 5	31 5	31 5

	* Alt-1 185 Ton Chiller		Alt-2 Thermal Storage - Load Le		Alt-3 Thermal Storage - Full Loa		Alt-4 Thermal Storage - Demand	
	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	7,189.1	533,070	7,050.0	395,718	7,127.5	396,679	7,154.3	400,928
Purchased Steam	198.6	0	198.6	0	198.6	0	198.6	0
Total	**7,388**	**533,070**	**7,249**	**395,718**	**7,326**	**396,679**	**7,353**	**400,928**

MONTHLY ENERGY CONSUMPTION

By META Engineers

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

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 2	**Thermal Storage - Load Leveling**												
Electric													
On-Pk Cons. (kWh)	0	0	0	0	0	57,105	53,386	60,897	52,914	0	0	0	224,302
Off-Pk Cons. (kWh)	67,568	62,716	65,679	71,627	71,024	65,947	84,817	79,895	77,487	72,358	66,699	72,037	857,853
Mid-Pk Cons. (kWh)	86,694	81,385	100,023	89,668	102,907	59,146	57,014	65,648	56,024	106,470	93,921	84,571	983,472
On-Pk Demand (kW)	0	0	0	0	0	453	464	461	460	0	0	0	464
Off-Pk Demand (kW)	394	408	405	413	430	438	451	447	447	440	415	399	451
Mid-Pk Demand (kW)	433	439	440	442	446	446	456	454	453	454	443	437	456
Purchased Steam													
On-Pk Cons. (therms)	0	0	0	0	0	47	41	47	40	0	0	0	175
Off-Pk Cons. (therms)	159	105	78	50	26	23	24	22	26	28	63	141	745
Mid-Pk Cons. (therms)	135	105	116	94	100	51	46	54	48	101	104	113	1,066
On-Pk Demand (therms/hr)	0	0	0	0	0	1	1	1	1	0	0	0	1
Off-Pk Demand (therms/hr)	2	2	1	1	1	1	1	1	1	1	1	2	2
Mid-Pk Demand (therms/hr)	1	1	1	1	1	1	1	1	1	1	1	1	1

Energy Consumption

Building	136,506	Btu/(ft2-year)
Source	403,324	Btu/(ft2-year)
Floor Area	53,101	ft2

Environmental Impact Analysis

CO2	No Data Available
SO2	No Data Available
NOX	No Data Available

MONTHLY UTILITY COSTS

By META Engineers

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
					------- Monthly Utility Costs -------								
Alternative 1													
Electric													
On-Pk Cons. ($)	276	276	276	276	276	12,424	12,206	14,033	11,894	276	276	276	52,762
Off-Pk Cons. ($)	9,800	9,120	9,542	10,396	10,321	9,347	11,450	10,359	10,640	10,500	9,688	10,440	121,605
Mid-Pk Cons. ($)	15,785	14,856	18,232	16,393	18,730	10,219	9,807	11,566	9,567	19,338	17,158	15,435	177,086
On-Pk Demand ($)	0	0	0	0	0	13,098	14,121	14,089	13,846	0	0	0	55,154
Off-Pk Demand ($)	4,207	4,348	4,325	4,407	4,574	4,890	5,280	5,249	5,138	4,813	4,428	4,266	55,924
Mid-Pk Demand ($)	4,602	4,765	4,762	4,848	5,021	7,553	8,097	8,162	7,928	5,216	4,891	4,693	70,538
Total ($):	34,670	33,365	37,137	36,320	38,922	57,531	60,961	63,458	59,014	40,142	36,440	35,111	533,070
Monthly Total ($):	34,670	33,365	37,137	36,320	38,922	57,531	60,961	63,458	59,014	40,142	36,440	35,111	533,070

Building Area = 53,101 ft²

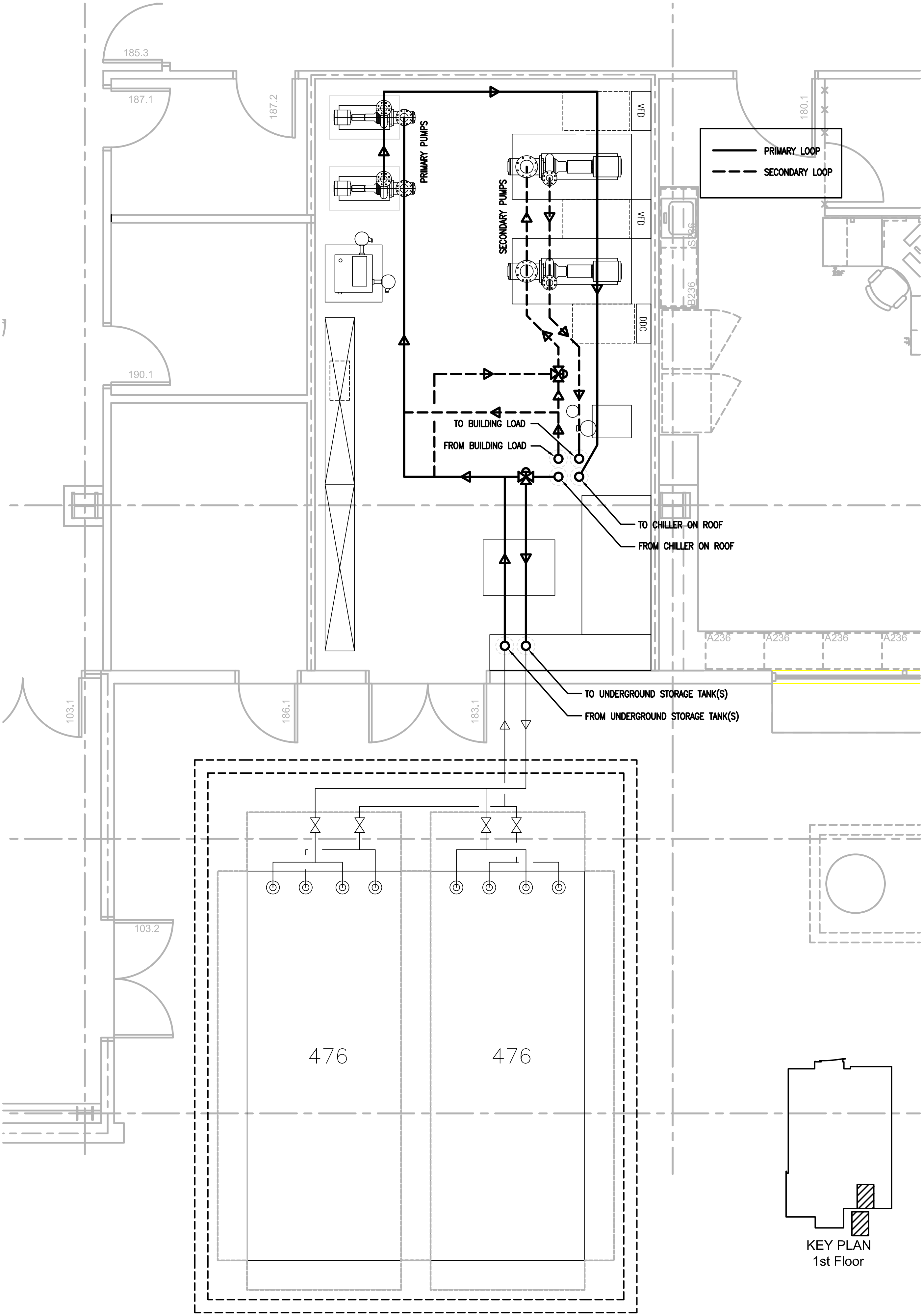
Utility Cost Per Area = 10.04 $/ft²

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative 2													
Electric													
On-Pk Cons. ($)	256	256	256	256	256	11,632	10,891	12,387	10,797	256	256	256	47,755
Off-Pk Cons. ($)	9,662	8,987	9,399	10,227	10,144	9,185	11,740	11,074	10,748	10,329	9,541	10,284	121,322
Mid-Pk Cons. ($)	15,377	14,451	17,701	15,895	18,204	10,406	10,040	11,522	9,870	18,826	16,637	15,006	173,936
Off-Pk Demand ($)	4,079	4,222	4,199	4,283	4,456	4,538	4,673	4,627	4,631	4,556	4,304	4,138	52,705
Mid-Pk Demand ($)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total ($):	29,374	27,916	31,556	30,661	33,060	35,761	37,344	39,610	36,046	33,966	30,738	29,685	395,718
Monthly Total ($):	29,374	27,916	31,556	30,661	33,060	35,761	37,344	39,610	36,046	33,966	30,738	29,685	395,718

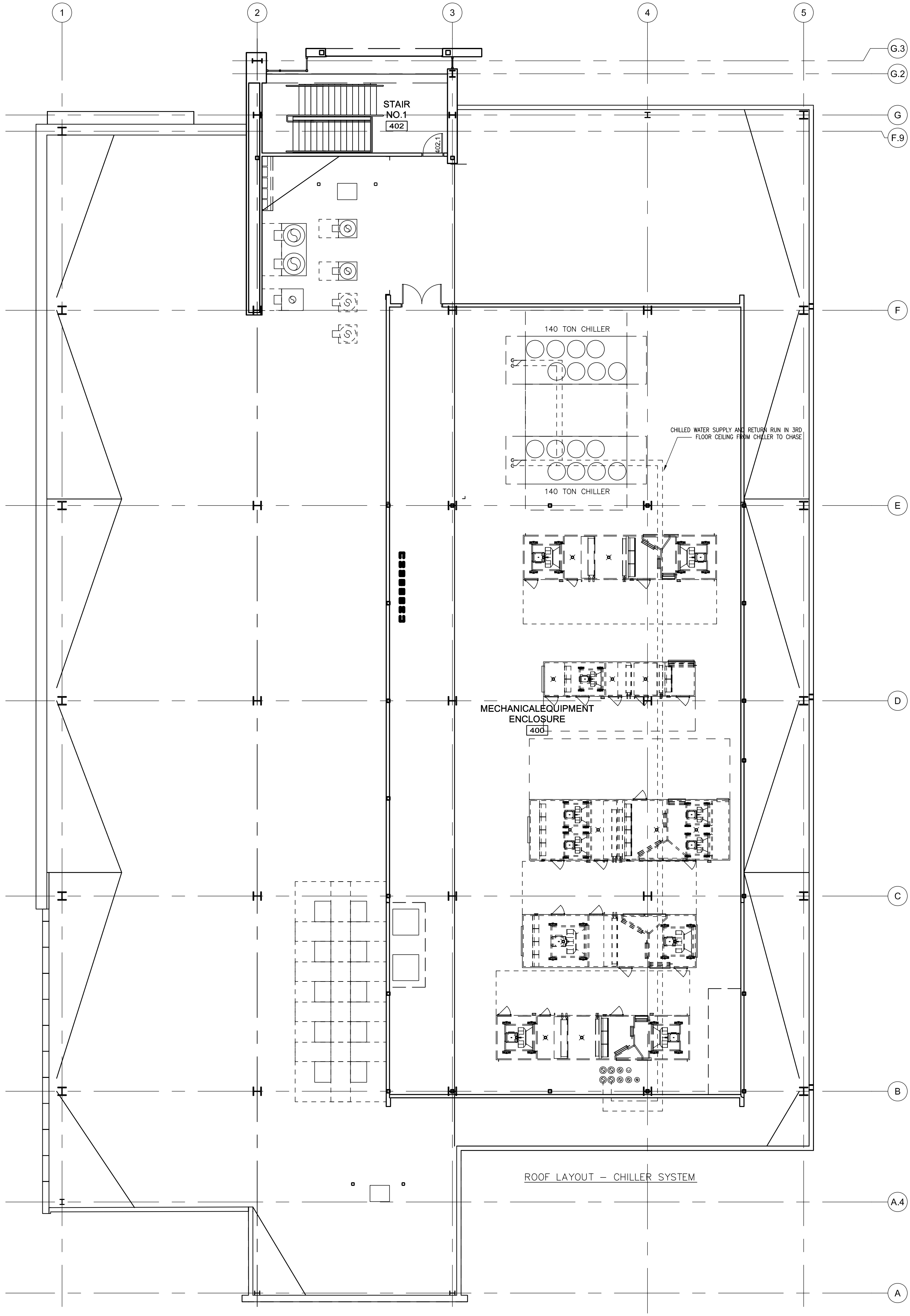
Building Area = 53,101 ft²

Utility Cost Per Area = 7.45 $/ft²

Appendix D
Demand Limiting Partial Ice Storage Redesign



MECH. RM. LAYOUT – ICE STORAGE SYSTEM



ROOF LAYOUT – CHILLER SYSTEM

Demand Limiting Partial Storage Equipment Sizing

Assumptions:
Total Cooling Load = Total Chiller Capacity (1) (No heat or pump losses)

Total Chiller Capacity = $H_{chrg}C_{chrg} + H_{DConp}C_{DConp} + H_{DCoffp}C_{DCoffp}$ (2)

H_{chrg}	hours charging storage
C_{chrg}	capacity when charging storage
H_{DConp}	hours direct cooling during on-peak period
C_{DConp}	capacity when cooling during on-peak period
H_{DCoffp}	hours direct cooling during off-peak period
C_{DCoffp}	capacity when cooling during off-peak period

Quick Chiller Sizing Equation (Combine (1) and (2))

Nominal Chiller Size = Total Cooling Load / ($H_{chrg}CR_{chrg} + H_{DConp}CR_{DConp} + H_{DCoffp}CR_{DCoffp}$) (3)

H_{chrg}	hours charging storage
CR_{chrg}	capacity ratio when charging storage
H_{DConp}	hours direct cooling during on-peak period
CR_{DConp}	capacity ratio when cooling during on-peak period
H_{DCoffp}	hours direct cooling during off-peak period
CR_{DCoffp}	capacity ratio when cooling during off-peak period

Full Storage System $H_{DConp}CR_{DConp} = 0$

COH Assumptions:
Supply 38 deg. solution to load
Chiller Upstream tanks provides 23 deg solution during ice making

COH Demand Limiting Scenario				
Hour	Clg (Tons)	Cooling Mode	Summer	Winter
1	24.7	Satisfy Load & Charge	OFF-PEAK	OFF-PEAK
2	23.6	"		
3	22.8	"		
4	22.0	"		
5	21.5	"		
6	22.0	"		
7	23.5	"		
8	138.5	Satisfy Load & Discharge		
9	131.1	"	MID-PEAK	MID-PEAK
10	148.1	"		
11	156.4	"		
12	162.5	"		
13	160.3	45% Chiller Cap. & Discharge	PEAK	
14	166.7	"		
15	173.4	"		
16	175.1	"		
17	174.0	"		
18	166.9	"		
19	125.2	"	MID-PEAK	
20	29.9	Satisfy Load & Charge		
21	28.5	"		
22	26.9	"		OFF-PEAK
23	26.6	"		
24	25.8	"	OFF-PEAK	

On-Peak Ton-hr =	1,016.4
Non-Peak Ton-hr =	1,159.6
Total Ton-hr =	2,176.0

COH Nominal Chiller Capacity (3) =	**138**	**Tons**
H_{chrg}	12	
CR_{chrg}	0.7	Assumed
H_{DCoffp}	5	
CR_{DCoffp}	0.85	Assumed
H_{DConp}	7	
CR_{DConp}	0.45	Assumed

Quick Storage Size

Storage Capacity = Total Cooling load - ($TC_{DConp} + TC_{DCoffp} + TH_{DCchrg}$) (4)

TC_{DConp}	total capacity when direct cooling during on-peak	(Ton-hrs)
TC_{DCoffp}	total capacity when direct cooling during off-peak	(Ton-hrs)
TC_{DCchrg}	ton-hours direct cooling while simultaneously charging	(Ton-hrs)

Storage Capacity = 859 Ton-hrs

City of Hope
CHW Head Calc
Demand Limiting Partial Storage

Section	Describe Pipe	Flow (gpm)	Pipe Size (in)	Alt Pipe Size (in)	Length (ft)	Tag No.	Fittings Description	No. Fittings	Actual Pressure Drop (ft)	Velocity (fps)	Alt C	Head Loss / 100ft	Fitting Equiv. Length	Pressure Drop (ft)	Total Pressure Drop (ft)
	MECH ROOM					1	NA								
Pump to Chase	Supply	176.0	4			4	Pump		5.0	4.44		2.42		5.00	5.00
		176.0	4		48	2	Straight Pipe			4.44		2.42		1.16	6.16
		176.0	4			12	Long Radius 90 Elbow	4		4.44		2.42	5.37	0.52	6.68
		176.0	4			13	45 Standard Elbow	1		4.44		2.42	5.37	0.13	6.81
		176.0	4			14	Standard Tee-thru flow	1		4.44		2.42	6.71	0.16	6.97
Chase to Pump	Return	176.0	4			12	Long Radius 90 Elbow	9		4.44		2.42	5.37	1.17	8.14
		176.0	4		140	2	Straight Pipe			4.44		2.42		3.38	11.52
		176.0	4			14	Standard Tee-thru flow	2		4.44		2.42	6.71	0.32	11.85
		176.0	4			15	Standard Tee-branch flow	6		4.44		2.42	20.1	2.92	14.77
		176.0	4			32	Control Valve (25 ft)		15.0	4.44		2.42		15.00	29.77
	Ice Storage	176.0	4			33	Other		6.0	4.44		2.42		6.00	35.77
Chase	Supply + Return	176.0	4		70	2	Straight Pipe			4.44		2.42		1.69	37.46
3rd Flr	Supply + Return	176.0	4		290	2	Straight Pipe			4.44		2.42		7.01	44.47
		176.0	4			12	Long Radius 90 Elbow	12		4.44		2.42	5.37	1.56	46.03
		176.0	4			15	Standard Tee-branch flow	2		4.44		2.42	20.1	0.97	47.00
		176.0	4			22	Butterfly valve	2		4.44		2.42	15.1	0.73	47.73
Roof	Supply + Return	176.0	4		20	2	Straight Pipe			4.44		2.42		0.48	48.21
		176.0	4			12	Long Radius 90 Elbow	4		4.44		2.42	5.37	0.52	48.73
	Chiller	176.0	4			33	Other		7.0	4.44		2.42		7.00	55.73
			3/4			1	NA								55.73
			3/4			1	NA								55.73

Total Head = 55.73
Safety Factor = 20%

Grand Total = 66.88

* Based on Cameron Hydraulic Data Book.
Small Pipe Add 10% Safety Factor.
Medium to Large Pipe 20% Safety Factor.

Air-Cooled Series R™ Rotary Liquid Chiller

Model RTAC
140 to 500 Tons (60 Hz)
140 to 400 Tons (50 Hz)
Built For the Industrial and Commercial Markets

November 2006

RLC-PRC006-EN

General Data

Table G-1. General data — 140-500 ton 60 Hz units - standard efficiency

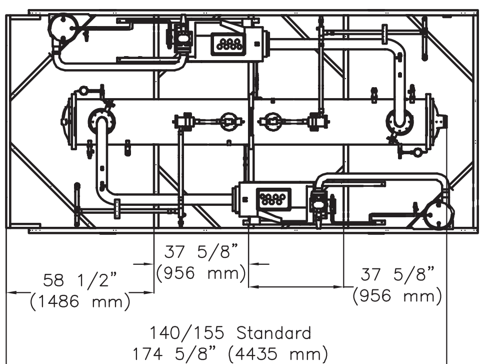
Size		140	155	170	185	200	225	250	275	300	350	400	450	500
Type		STD	STD	STD	STD	STD	STD	STD	STD	STD	STD	STD	STD	STD
Compressor														
Quantity (1)		2	2	2	2	2	2	2	3	3	3	4	4	4
Nominal size (tons) @ 60 Hz		70/70	85/70	85/85	100/85	100/100	120/100	120/120	85-85/100	100-100/100	120-120/100	100-100 / 100-100	120-120 / 100-100	120-120 / 120-120
Evaporator														
Water storage	(gallons)	29	32	33	35	39	38	42	60	65	70	81	84	89
	(liters)	111	121	127	134	146	145	158	229	245	264	306	316	337
2 Pass arrangement														
Minimum flow	(gpm)	193	214	202	217	241	217	241	309	339	375	404	422	461
	(L/s)	12	14	13	14	15	14	15	20	21	24	26	27	29
Maximum flow	(gpm)	709	785	741	796	883	796	883	1134	1243	1374	1483	1548	1690
	(L/s)	45	50	47	50	56	50	56	72	78	87	94	98	107
3 Pass arrangement														
Minimum flow	(gpm)	129	143	135	145	161	145	161	206	226	250	270	282	307
	(L/s)	8	9	9	9	10	9	10	13	14	16	17	18	19
Maximum flow	(gpm)	473	523	494	531	589	531	589	756	829	916	989	1032	1127
	(L/s)	30	33	31	33	37	33	37	48	52	58	62	65	71
Condenser														
Qty of coils		4	4	4	4	4	4	4	8	8	8	8	8	8
Coil length	(inches)	156/156	180/156	180/180	216/180	216/216	252/216	252/252	180/108	216/108	252/108	216/216	252/216	252/252
	(millimeters)	3962/3962	4572/3962	4572/4572	5486/4572	5486/5486	6401/5486	6401/6401	4572/2743	5486/2743	6401/4572	5486/5486	6401/5486	6401/6401
Coil height	(inches)	42	42	42	42	42	42	42	42	42	42	42	42	42
	(millimeters)	1067	1067	1067	1067	1067	1067	1067	1067	1067	1067	1067	1067	1067
Fins/Ft		192	192	192	192	192	192	192	192	192	192	192	192	192
Number of rows		3	3	3	3	3	3	3	3	3	3	3	3	3
Condenser fans														
Quantity (1)		4/4	5/4	5/5	6/5	6/6	7/6	7/7	10/6	12/6	14/6	12/12	14/12	14/14
Diameter	(inches)	30	30	30	30	30	30	30	30	30	30	30	30	30
	(millimeters)	762	762	762	762	762	762	762	762	762	762	762	762	762
Total airflow	(cfm)	77000	84542	92087	101296	110506	119725	128946	147340	165766	184151	221016	239456	257991
	(m^3/hr)	130811	143623	156441	172086	187732	203394	219059	250307	281610	312843	375471	406797	438285
Nominal fan speed	rpm	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140
	rps	19	19	19	19	19	19	19	19	19	19	19	19	19
Tip speed	(ft/min)	8954	8954	8954	8954	8954	8954	8954	8954	8954	8954	8954	8954	8954
	M/S	45	45	45	45	45	45	45	45	45	45	45	45	45
Minimum starting/operating ambient (2)														
Standard unit	(F)	25	25	25	25	25	25	25	25	25	25	25	25	25
	(C)	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9	-3.9
Low ambient	(F)	0	0	0	0	0	0	0	0	0	0	0	0	0
	(C)	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8	-17.8
General unit														
Refrigerant		HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a	HFC-134a
No. of independent refrigerant circuits		2	2	2	2	2	2	2	2	2	2	2	2	2
% Minimum load		15	15	15	15	15	15	15	15	15	15	15	15	15
Refrigerant charge (1)	(pounds)	165/165	175/165	175/175	215/210	215/215	225/215	225/225	365/200	415/200	460/200	415/415	460/415	460/460
	(kilograms)	75/75	79/75	79/79	98/95	98/98	102/98	102/102	166/91	188/91	209/91	188/188	209/188	209/209
Oil charge (1)	[gallons]	1.5/1.5	1.5/1.5	1.5/1.5	2.1/1.5	2.1/2.1	2.1/2.1	2.1/2.1	4.6/2.1	5.0/2.1	5.0/2.1	5.0/5.0	5.0/5.0	5.0/5.0
	[liters]	6/6	6/6	6/6	6/8	8/8	8/8	8/8	17/8	19/8	19/8	19/19	19/19	19/19

Notes:
1. Data containing information on two circuits shown as follows: CKT 1/CKT 2
2. Minimum start-up/operating ambient based on a 5 mph wind across the condenser

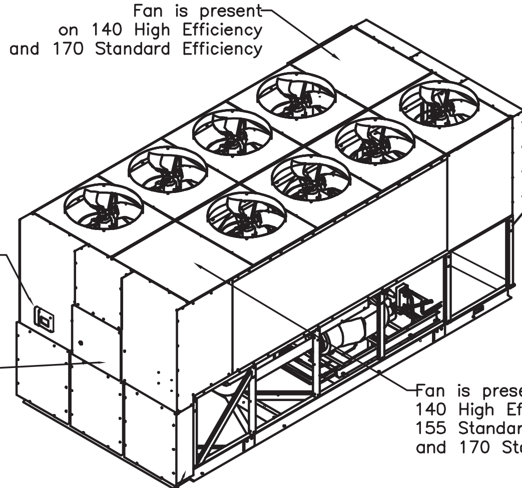
Dimensions

140 Standard 50/60
155 Standard 50/60
170 Standard 50/60
140 High 50/60

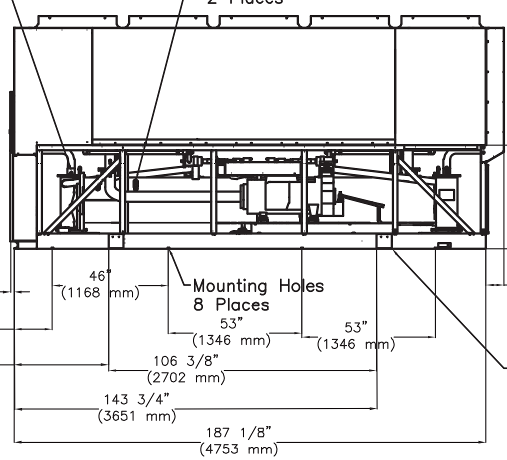
Mounting Hole Diameter: 3/4” (19.1 mm)
Water Connection Diameter:
140 Standard 50/60Hz and 155 Standard 50/60Hz – 4” (102 mm)
140 High 50/60Hz and 170 Standard 50/60 Hz – 6” (152 mm)
Lifting Plate Dimensions: 7 1/2” x 6” (191mm x 152mm)



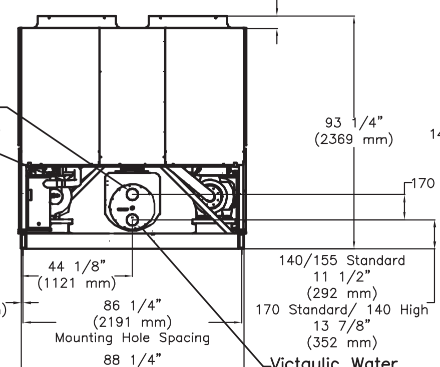
Top (Plan) View
(With Coil Box Removed)



Iso View



Side View



Back View

Note:
Add 2” (51mm) to overall width for louvered panels and coil protection.

Minimum clearances are 4 feet to each side of the unit, 2 feet to the end opposite the control panel and National Electric Code Article 110-26 requirements for control panel clearances. Tube pull clearances are given in submittals and the Installation, Operation and Maintenance manual.

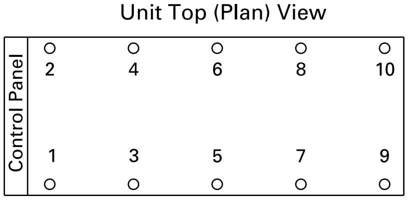
Weights

Table W-1. Aluminum fin unit weights (60 Hz units)

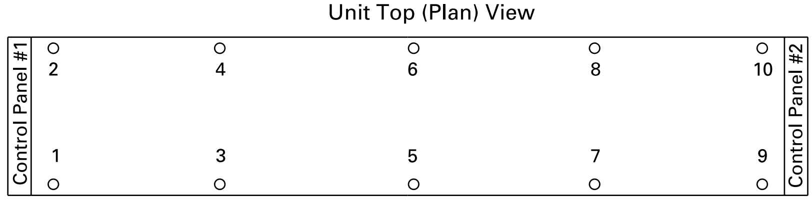
Unit Size	Units	Isolator Location 1	2	3	4	5	6	7	8	9	10	Operating Weight	Shipping Weight
RTAC 140 STD	lbs.	1384	1431	1363	1410	1340	1387	1317	1364	n/a	n/a	10995	10752
	kg	628	649	618	640	608	629	597	619	n/a	n/a	4987	4877
RTAC 140 HIGH	lbs.	1390	1437	1370	1418	1348	1395	1326	1373	n/a	n/a	11057	10780
	kg	630	652	622	643	611	633	601	623	n/a	n/a	5015	4890
RTAC 155 STD	lbs.	1389	1434	1369	1414	1346	1391	1323	1368	n/a	n/a	11034	10769
	kg	630	650	621	641	611	631	600	621	n/a	n/a	5005	4885
RTAC 155 HIGH	lbs.	1578	1630	1545	1598	1494	1547	1443	1496	n/a	n/a	12332	12038
	kg	716	740	701	725	678	702	655	679	n/a	n/a	5594	5460
RTAC 170 STD	lbs.	1391	1439	1372	1420	1350	1398	1328	1375	n/a	n/a	11073	10796
	kg	631	653	622	644	612	634	602	624	n/a	n/a	5023	4897
RTAC 170 HIGH	lbs.	1586	1641	1555	1610	1504	1559	1454	1509	n/a	n/a	12418	12098
	kg	719	744	705	730	682	707	660	685	n/a	n/a	5633	5488
RTAC 185 STD	lbs.	1642	1662	1608	1628	1553	1574	1499	1520	n/a	n/a	12685	12391
	kg	745	754	729	738	705	714	680	689	n/a	n/a	5754	5621
RTAC 185 HIGH	lbs.	1409	1513	1395	1499	1370	1475	1348	1452	1325	1429	14214	13897
	kg	639	686	633	680	622	669	611	659	601	648	6447	6304
RTAC 200 STD	lbs.	1663	1717	1636	1690	1593	1648	1551	1606	n/a	n/a	13104	12784
	kg	754	779	742	767	723	748	704	728	n/a	n/a	5944	5799
RTAC 200 HIGH	lbs.	1487	1537	1468	1519	1435	1486	1405	1456	1375	1425	14593	14247
	kg	674	697	666	689	651	674	637	660	623	646	6619	6462
RTAC 225 STD	lbs.	1483	1554	1466	1536	1435	1505	1406	1477	1378	1448	14687	14370
	kg	673	705	665	697	651	683	638	670	625	657	6662	6518
RTAC 225 HIGH	lbs.	1631	1674	1618	1661	1597	1640	1581	1624	1557	1601	16184	15838
	kg	740	759	734	753	724	744	717	737	706	726	7341	7184
RTAC 250 STD	lbs.	1510	1561	1493	1543	1461	1512	1433	1483	1404	1454	14853	14507
	kg	685	708	677	700	663	686	650	673	637	660	6737	6580
RTAC 250 HIGH	lbs.	1651	1676	1639	1664	1619	1644	1603	1629	1581	1607	16314	15968
	kg	749	760	743	755	734	746	727	739	717	729	7400	7243
RTAC 275 STD	lbs.	2168	1915	2124	1877	2072	1860	2052	1767	1976	1723	19536	18876
	kg	984	870	964	852	941	844	932	802	897	782	8869	8570
RTAC 275 HIGH	lbs.	2060	1819	2124	1877	2191	1950	2272	2083	2385	2183	20944	20266
	kg	935	826	964	852	995	885	1031	946	1083	991	9509	9201
RTAC 300 STD	lbs.	2163	1926	2188	1952	2220	1984	2256	2019	2324	2070	21103	20544
	kg	982	875	993	886	1008	901	1024	917	1055	940	9581	9327
RTAC 300 HIGH	lbs.	2382	2137	2381	2110	2347	2077	2309	2039	2274	2004	22060	22508
	kg	1081	970	1081	958	1066	943	1048	926	1032	910	10015	10219
RTAC 350 STD	lbs.	2134	1897	2203	1967	2291	2055	2389	2153	2526	2290	21904	21450
	kg	969	861	1000	893	1040	933	1085	977	1147	1040	9945	9738
RTAC 350 HIGH	lbs.	2637	2619	2525	2507	2442	2424	2389	2370	2284	2290	24487	23803
	kg	1197	1189	1146	1138	1109	1100	1085	1076	1037	1040	11117	10806
RTAC 400 STD	lbs.	2734	2748	2657	2636	2574	2554	2521	2500	2418	2412	25754	25074
	kg	1241	1248	1206	1197	1169	1160	1145	1135	1098	1095	11692	11383
RTAC 400 HIGH	lbs.	2734	2695	2763	2719	2787	2744	2812	2768	2836	2792	27650	26913
	kg	1241	1224	1254	1234	1265	1246	1277	1257	1288	1268	12553	12219
RTAC 450 STD	lbs.	2751	2751	2694	2694	2637	2637	2581	2581	2524	2524	26373	25678
	kg	1249	1249	1223	1223	1197	1197	1172	1172	1146	1146	11973	11658
RTAC 500 STD	lbs.	2753	2709	2777	2734	2802	2758	2826	2782	2850	2807	27798	27056
	kg	1250	1230	1261	1241	1272	1252	1283	1263	1294	1274	12620	12283

Notes:
1. Operating weight includes refrigerant and water.
2. Shipping weight includes refrigerant.
3. All weights +/- 3%.

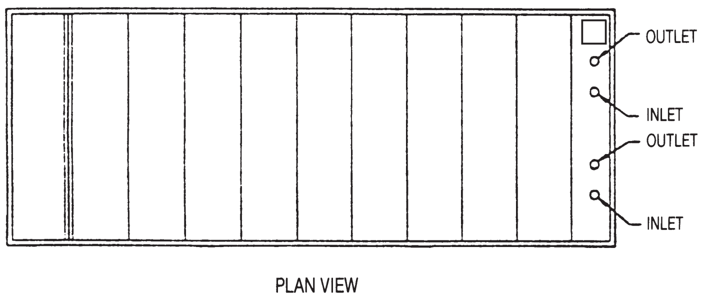
Unit Top (Plan) View



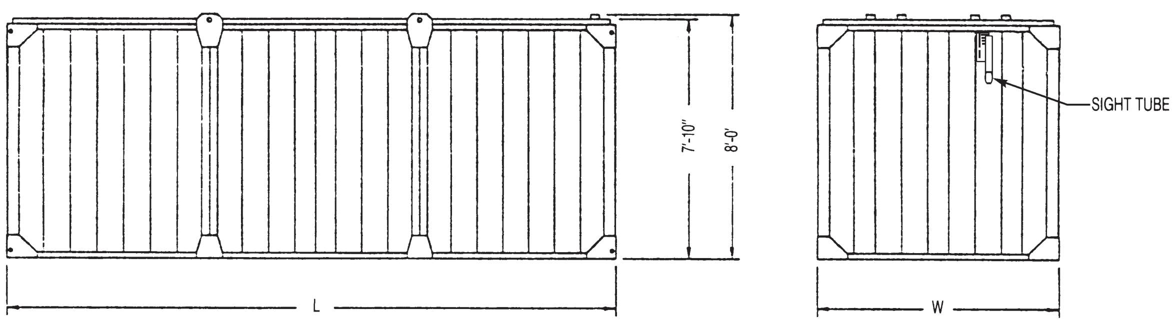
Unit Top (Plan) View



ENGINEERING DATA

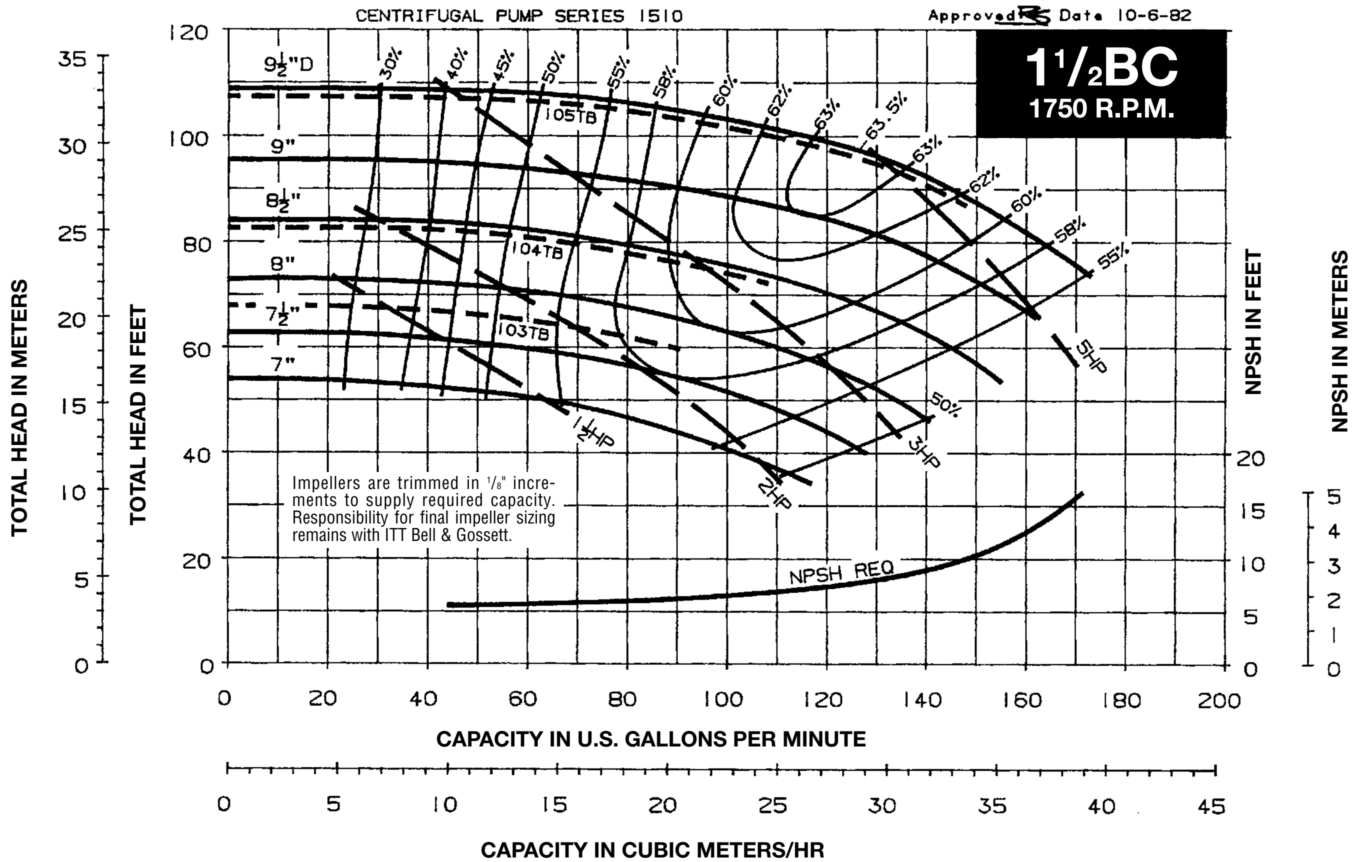


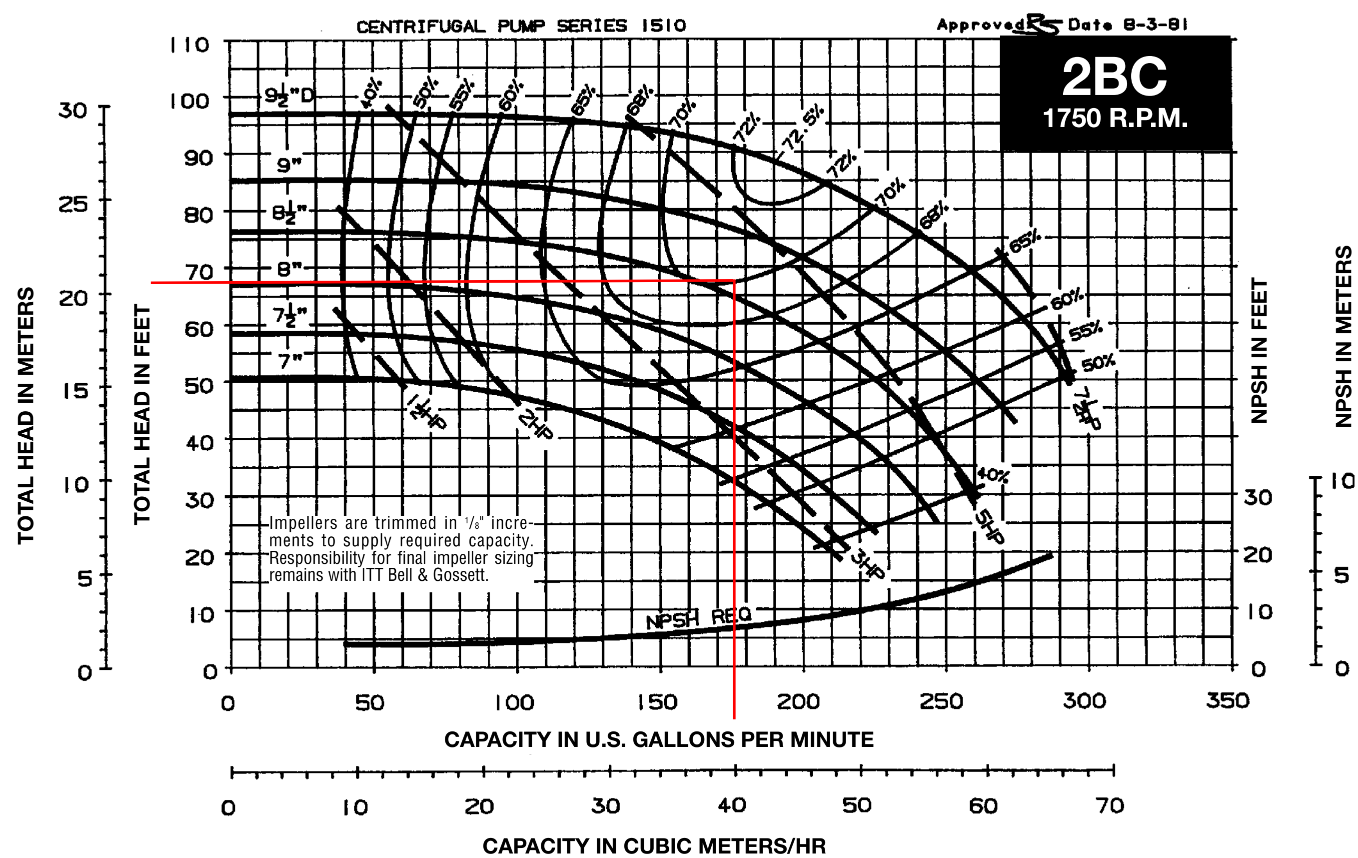
Notes:
1. All dimensions are in feet and inches. Weights are in pounds.
2. Unit should be continuously supported on a flat level surface.
3. All connections are grooved for mechanical coupling.



MODEL	TSU–237M	TSU–476M	TSU–594M	TSU–761M
Latent Capacity (Ton–Hours)	237	476	594	761
Approx. Shipping Weight (Pounds)	9,750	16,750	20,200	24,000
Approx. Operating Weight (Pounds)	39,100	73,900	93,100	113,800
Tank Water Volume (Gallons)	2,990	5,840	7,460	9,150
Coil Glycol Volume (Gallons)	260	495	610	790
Connection Size (Inches)	2"	3"	3”	3"
Unit Width	7' 10$\frac{3}{8}$"	7' 10$\frac{3}{8}$"	9' 9$\frac{1}{4}$"	11' 9$\frac{3}{4}$"
Unit Length	10' 7$\frac{5}{8}$"	19' 10$\frac{1}{4}$"	19' 10$\frac{1}{4}$"	19' 10$\frac{1}{4}$"

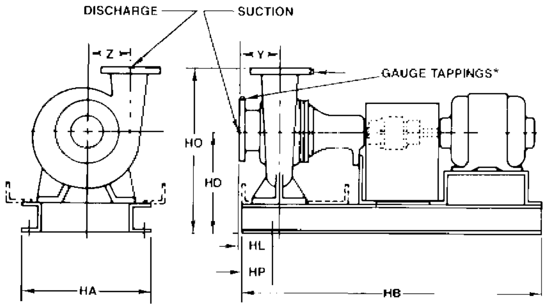
1750 RPM PUMP CURVES





Series 1510 Centrifugal Pumps

Dimensions



*Gauge Tapping Sizes: 1/8" for NPT, 1/4" for Flanged Sizes

Motor Horsepower and Frame Tabulation three phase (Dripproof Enclosure)

Horsepower	Frame @ 1750 RPM	Frame @ 3500 RPM	Horsepower	Frame @ 1750 RPM	Frame @ 3500 RPM
1/2	56		20	256T	254T
3/4	56		25	284T	256T
1	143T		30	286T	284TS
1 1/2	145T		40	324T	286TS
2	145T	145T	50	326T	324TS
3	182T	145T	60	364T	326TS
5	184T	182T	75	365T	364TS
7 1/2	213T	184T	100	404TS	365TS
10	215T	213T	125	—	404TS
15	254T	215T			

DIMENSIONS – INCHES (MM)			STANDARD MECHANICAL SEAL PUMP MODEL 1510, 1510-F								STUFFING BOX CONSTRUCTION PUMP MODEL 1510-PF, 1510-S							
PUMP SIZE DISCHARGE	SUCTION SIZE	MOTOR FRAME SIZE	HA	HB	HD	HL	HO	HP	Y	Z	HA	HB	HD	HL	HO	HP	Y	Z
1 1/4 AC (NPT)	1 1/2 (NPT)	56	12 (305)	28 3/4 (730)	9 3/4 (248)	3 1/8 (79)	14 3/4 (375)	3 (76)	3 1/4 (83)	4 1/2 (114)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	1 3/4 (44)	14 3/4 (375)	3 (76)	3 1/4 (83)	4 1/2 (114)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		1 3/4 (46)												
		213T-215T		34 5/8 (879)								39 3/8 (1000)						
1 1/4 BC (NPT)		143T-145T		31 (787)	10 3/4 (273)	1 13/16 (46)	18 3/4 (476)			5 1/2 (140)		34 5/8 (879)	10 3/4 (273)	1 13/16 (46)	18 3/4 (476)			5 1/2 (140)
		182T-184T																
		213T-215T		39 3/8 (1000)							16 (406)	46 1/2 (1181)	12 (305)	2 15/16 (75)	20 (508)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)	2 15/16 (75)	20 (508)	5 (127)				51 3/4 (1314)						
		284TS-286TS			13 (330)		21 (533)						13 (330)		21 (533)			
1 1/2 AC (NPT)	2 (NPT)	56	12 (305)	28 3/4 (730)	9 3/4 (248)	3 1/16 (78)	15 3/4 (400)	3 (76)	3 1/8 (79)	4 5/8 (117)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	1 11/16 (43)	15 3/4 (400)	3 (76)	3 1/8 (79)	4 5/8 (117)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		1 11/16 (43)												
		213T-215T		34 5/8 (879)								39 3/8 (1000)						
		254T-256T		39 3/8 (1000)	10 3/4 (273)		16 3/4 (425)				16 (406)	46 1/2 (1181)	12 (305)	2 13/16 (71)	18 (457)	5 (127)		
1 1/2 BC (NPT)		143T-145T		31 (787)			17 1/4 (438)			5 3/4 (146)	14 5/8 (371)	34 5/8 (879)	10 3/4 (273)	1 11/16 (43)	17 1/4 (438)	3 (76)		5 3/4 (146)
		182T-184T																
		213T-1750		34 5/8 (879)								39 3/8 (1000)						
		213T-215T-3500		39 3/8 (1000)							16 (406)	46 1/2 (1181)	12 (305)	2 13/16 (71)	18 1/2 (470)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)	2 13/16 (71)	18 1/2 (470)	5 (127)				51 3/4 (1314)						
		284TS-286TS			13 (330)		19 1/2 (495)						13 (330)		19 1/2 (495)			
2 AC	2 1/2	56	12 (305)	28 3/4 (730)	9 3/4 (248)	3 9/16 (90)	16 1/4 (413)	3 (76)	3 1/2 (89)	4 3/4 (121)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	2 3/16 (56)	16 1/4 (413)	3 (76)	3 1/2 (89)	4 3/4 (121)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		2 3/16 (56)												
		213T-215T		34 5/8 (879)							16 (406)	46 1/2 (1181)	11 (279)	3 5/16 (84)	17 1/2 (445)	5 (127)		
		254T-256T		39 3/8 (1000)	10 3/4 (273)		17 1/4 (438)					51 3/4 (1314)	12 (305)		18 1/2 (470)			
2 BC		143T-145T		31 (787)		2 11/16 (68)	17 3/4 (451)		4 (102)	5 7/8 (149)	14 5/8 (371)	34 5/8 (879)	10 3/4 (273)	2 11/16 (68)	17 3/4 (451)	3 (76)	4 (102)	5 7/8 (149)
		182T-184T																
		213T-215T-1750		34 5/8 (879)								39 3/8 (1000)						
		254T-3500		39 3/8 (1000)		3 13/16 (97)		5 (127)				46 1/2 (1181)	12 (305)	3 13/16 (97)	19 (483)	5 (127)		
		254T-256T		46 1/2 (1181)	12 (305)		19 (483)					51 3/4 (1314)						
		284TS-286TS			13 (330)		20 (508)						13 (330)		20 (508)			
		324TS-326TS			12 (305)		19 (483)						12 (305)		19 (483)			
2 E†	3	182T	16 (406)	42 1/4 (1073)	14 (356)	6 1/2 (165)	22 (559)	5 (127)	5 1/2 (140)	6 1/2 (165)	16 (406)	42 1/4 (1073)	14 (356)	6 1/2 (165)	22 (559)	5 (127)	5 1/2 (140)	6 1/4 (165)
		184T																
		213T																
		215T																
		254T																
		286TS		46 1/2 (1181)		4 1/8 (105)						51 3/4 (1314)		4 1/8 (105)				
		324TS		51 3/4 (1314)														
		326TS																
		364TS	24 (610)	56 (1422)	16 1/2 (419)	4 3/4 (121)	24 1/2 (622)	6 (152)			24 (610)	56 (1422)	16 1/2 (419)	4 3/4 (121)	24 1/2 (622)	6 (152)		
		365TS																
2 G†		213T-215T	16 (406)	46 1/2 (1181)	14 (356)	3 7/8 (98)	23 (584)	5 (127)		7 1/4 (184)	16 (406)	46 1/2 (1181)	14 (356)	3 7/8 (98)	23 (584)	5 (127)		7 1/4 (184)
		254T-256T										51 3/4 (1314)						
		284T		51 3/4 (1314)														
2 1/2 AB		56	12 (305)	28 3/4 (730)	9 3/4 (248)	4 3/8 (111)	15 3/4 (400)	3 (76)	4 1/4 (108)	4 11/16 (119)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	3 (76)	15 3/4 (400)	3 (76)	4 1/4 (108)	4 11/16 (119)
		143T-145T																
		182T-184T	14 5/8 (371)	31 (787)		3 (76)												
		213T-215T		34 5/8 (879)							16 (406)	46 1/2 (1181)	11 (279)	4 1/8 (105)	17 (432)	5 (127)		
		254T-256T		39 3/8 (1000)	10 3/4 (273)		16 3/4 (425)					51 3/4 (1314)	12 (305)					
2 1/2 BB		182T-184T		31 (787)		2 3/4 (70)	17 1/2 (445)		4 (102)	6 (152)	14 5/8 (371)	34 5/8 (879)	10 3/4 (273)	2 3/4 (70)	17 1/2 (445)	3 (76)	4 (102)	6 (152)
		213T-215T		34 5/8 (879)								39 3/8 (1000)						
		284TS-286TS	16 (406)	46 1/2 (1181)	13 (330)	3 7/8 (98)	19 3/4 (502)	5 (127)			16 (406)	51 3/4 (1314)	13 (330)	3 7/8 (98)	19 3/4 (502)	5 (127)		
		324TS-326TS			12 (305)		18 3/4 (476)						12 (305)		18 3/4 (476)			
		346TS		51 3/4 (1314)	13 (330)		19 3/4 (502)						13 (330)		19 3/4 (502)			
3 AC	4	143T-145T	12 (305)	28 3/4 (730)	9 3/4 (248)	4 5/16 (110)	15 3/4 (400)	3 (76)	4 1/8 (105)	5 (127)	14 5/8 (371)	34 5/8 (879)	9 3/4 (248)	2 15/16 (75)	15 3/4 (400)	3 (76)	4 1/8 (105)	5 (127)
		182T-184T	14 5/8 (371)	31 (787)		2 15/16 (75)												
		215T		39 3/8 (1000)							16 (406)	46 1/2 (1181)	11 (279)	4 1/16 (103)	17 (432)	5 (127)		
		254T-256T	16 (406)	46 1/2 (1181)	12 (305)	4 1/16 (103)	18 (457)	5 (127)				51 3/4 (1314)	12 (305)		18 (457)			
		284TS-286TS			13 (330)		19 (483)						13 (330)		19 (483)			

These dimensions are not to be used for installation purposes unless certified.
†250 psi (17 bar) available

Maximum Working Pressure 175 psi (12 bar)

Energy Cost Budget / PRM Summary

By META Engineers

Project Name: City of Hope Amini Medical Center	Date: April 22, 2009
City: Duarte California	Weather Data: Pasadena, California (CTZ09)

Note: The percentage displayed for the "Proposed/ Base %" column of the base case is actually the percentage of the total energy consumption.

* Denotes the base alternative for the ECB study.

		* Alt-1 185 Ton Chiller			Alt-2 Thermal Storage - Load Le			Alt-3 Thermal Storage - Full Loa			Alt-4 Thermal Storage - Demand		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Lighting - Conditioned	Electricity	942.2	13	258	942.2	100	258	942.2	100	258	942.2	100	258
Space Heating	Electricity	1.4	0	0	1.4	100	0	1.4	100	0	1.4	100	0
	Purchased Steam	198.6	3	249	198.6	100	249	198.6	100	249	198.6	100	249
Space Cooling	Electricity	1,572.9	21	682	1,481.3	94	440	1,511.3	96	610	1,548.4	98	476
Pumps	Electricity	241.1	3	52	193.5	80	37	234.0	97	49	228.2	95	43
Heat Rejection	Electricity	170.5	2	75	170.5	100	46	177.7	104	68	173.1	102	53
Fans - Conditioned	Electricity	536.3	7	213	536.3	100	213	536.3	100	213	536.3	100	213
Receptacles - Conditioned	Electricity	3,697.2	50	663	3,697.2	100	663	3,697.2	100	663	3,697.2	100	663
Stand-alone Base Utilities	Electricity	27.4	0	6	27.4	100	6	27.4	100	6	27.4	100	6
Total Building Consumption		**7,387.7**			**7,248.6**			**7,326.2**			**7,352.9**		

		* Alt-1 185 Ton Chiller	Alt-2 Thermal Storage - Load Le	Alt-3 Thermal Storage - Full Loa	Alt-4 Thermal Storage - Demand
Total	**Number of hours heating load not met** **Number of hours cooling load not met**	31 5	31 5	31 5	31 5

	* Alt-1 185 Ton Chiller		Alt-2 Thermal Storage - Load Le		Alt-3 Thermal Storage - Full Loa		Alt-4 Thermal Storage - Demand	
	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	7,189.1	533,070	7,050.0	395,718	7,127.5	396,679	7,154.3	400,928
Purchased Steam	198.6	0	198.6	0	198.6	0	198.6	0
Total	**7,388**	**533,070**	**7,249**	**395,718**	**7,326**	**396,679**	**7,353**	**400,928**

MONTHLY ENERGY CONSUMPTION

By META Engineers

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

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative: 4	**Thermal Storage - Demand Limiting**												
Electric													
On-Pk Cons. (kWh)	0	0	0	0	0	52,916	49,200	56,211	48,856	0	0	0	207,183
Off-Pk Cons. (kWh)	68,247	63,355	66,358	72,446	72,742	70,074	88,604	83,831	82,252	77,166	67,399	72,773	885,248
Mid-Pk Cons. (kWh)	87,579	82,476	101,412	91,109	103,725	63,717	59,864	69,291	58,562	104,902	95,419	85,692	1,003,749
On-Pk Demand (kW)	0	0	0	0	0	418	432	424	424	0	0	0	432
Off-Pk Demand (kW)	398	412	410	418	435	457	472	467	467	459	420	404	472
Mid-Pk Demand (kW)	416	430	431	438	455	466	478	475	474	466	442	423	478
Purchased Steam													
On-Pk Cons. (therms)	0	0	0	0	0	47	41	47	40	0	0	0	175
Off-Pk Cons. (therms)	159	105	78	50	26	23	24	22	26	28	63	141	745
Mid-Pk Cons. (therms)	135	105	116	94	100	51	46	54	48	101	104	113	1,066
On-Pk Demand (therms/hr)	0	0	0	0	0	1	1	1	1	0	0	0	1
Off-Pk Demand (therms/hr)	2	2	1	1	1	1	1	1	1	1	1	2	2
Mid-Pk Demand (therms/hr)	1	1	1	1	1	1	1	1	1	1	1	1	1

Energy Consumption

Building	138,470	Btu/(ft2-year)
Source	409,216	Btu/(ft2-year)
Floor Area	53,101	ft2

Environmental Impact Analysis

CO_2	No Data Available
SO_2	No Data Available
NOX	No Data Available

MONTHLY UTILITY COSTS

By META Engineers

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative 3													
Electric													
On-Pk Cons. ($)	256	256	256	256	256	8,534	7,836	8,984	7,821	256	256	256	35,224
Off-Pk Cons. ($)	10,526	10,200	10,888	11,733	12,078	10,812	13,271	12,585	12,413	12,452	11,067	11,346	139,371
Mid-Pk Cons. ($)	14,452	13,358	16,399	14,602	16,405	11,359	10,651	12,533	10,448	16,479	15,291	14,005	165,983
Off-Pk Demand ($)	4,207	4,351	4,328	4,413	4,586	4,913	5,316	5,285	5,170	4,831	4,434	4,267	56,101
Mid-Pk Demand ($)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total ($):	29,441	28,166	31,871	31,004	33,325	35,619	37,075	39,387	35,852	34,018	31,048	29,875	396,679
Monthly Total ($):	29,441	28,166	31,871	31,004	33,325	35,619	37,075	39,387	35,852	34,018	31,048	29,875	396,679

Building Area = 53,101 ft²

Utility Cost Per Area = 7.47 $/ft²

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Alternative 4													
Electric													
On-Pk Cons. ($)	256	256	256	256	256	10,797	10,057	11,453	9,988	256	256	256	44,345
Off-Pk Cons. ($)	9,757	9,076	9,494	10,341	10,383	9,744	12,253	11,607	11,393	10,998	9,639	10,387	125,072
Mid-Pk Cons. ($)	15,531	14,641	17,944	16,146	18,347	11,191	10,530	12,147	10,306	18,552	16,898	15,202	177,434
Off-Pk Demand ($)	4,127	4,271	4,247	4,331	4,506	4,737	4,889	4,837	4,841	4,752	4,353	4,186	54,077
Mid-Pk Demand ($)	0	0	0	0	0	0	0	0	0	0	0	0	0
Total ($):	29,671	28,243	31,941	31,075	33,491	36,469	37,728	40,045	36,529	34,558	31,146	30,031	400,928
Monthly Total ($):	29,671	28,243	31,941	31,075	33,491	36,469	37,728	40,045	36,529	34,558	31,146	30,031	400,928

Building Area = 53,101 ft²

Utility Cost Per Area = 7.55 $/ft²

Appendix E
Electrical Breadth Existing Design

LITHONIA LIGHTING®

Catalog Number	
Notes	Type

FEATURES & SPECIFICATIONS

INTENDED USE

Specification premium air-handling luminaires offer general illumination for recessed applications.

CONSTRUCTION

Black reveal provides floating door appearance, conceals optional air-supply slots. Optional air flow controls available.

Standard steel doorframe has superior structural integrity with premium extruded appearance and precision flush mitered corners. Steel door allows lens replacement without frame disassembly (for lenses up to .156" thick). Superior mechanical light seal requires no foam gasketing. Latches spring loaded, concealed in reveal.

Overlapping flange and modular ceiling trims factory-installed with standard swing-gate hangers.

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

Housing formed from cold-rolled steel. Acrylic shielding material 100% UV stabilized. 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). Optional: Canada CSA or C-UL. Mexico NOM.

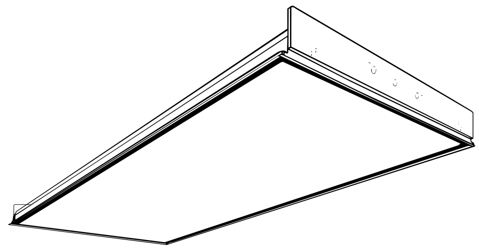
WARRANTY

Guaranteed for one year against mechanical defects in manufacture.

NOTE: Specifications subject to change without notice.

Specification Premium Air-Handling Troffer

SP AIR 2'X4'



2, 3, 4 or 6 Lamps

Specifications

Length: 48 (1219)

Width: 24 (610)

Depth: 4-1/2 (114)

All dimensions are inches (millimeters).

ORDERING INFORMATION

For shortest lead times, configure product using **standard options (shown in bold).**

Example: 2SP G B 3 32 FW A12125 MVOLT 1/3 GEB10IS

2SP

Series

- **2SP 2' wide**

Trim type

- **G Grid**
- **F Overlapping flanged**
- MT Modular fit-in

Air function

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

Number of lamps

- **2**
- **3**
- **4**
- 6

Not included.

Lamp type

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

Door frame

- (blank) **Flush steel, white**
- FN Flush aluminum, natural
- FM Flush aluminum, matte black
- **FW Flush aluminum, white**
- RN Regressed aluminum, natural
- RM Regressed aluminum, matte black
- **RW Regressed aluminum, white**

Diffuser type

- **A12 #12 pattern acrylic**
- **A12125 #12 pattern acrylic, 0.125" thick**
- **A19 #19 pattern acrylic, 0.156" thick**
- A15 #15 pattern acrylic, 0.2" thick
- PC1S 1/2" x 1/2" x 1/2" plastic cube louver, silver
- PC2S 1-1/2" x 1-1/2" x 1" plastic cube louver, silver w/ flange
- PC3S 3/4" x 3/4" x 1/2" plastic cube louver, silver

Voltage

- 120
- 277
- 347
- **MVOLT**

Others available.

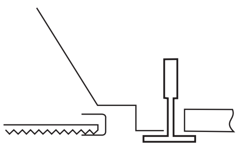
Options

- **1/4 One 4-lamp ballast**
- **1/3 One 3-lamp ballast**
- **GEB10IS Electronic ballast, ≤10% THD, Instant Start**
- **GEB10RS Electronic ballast, ≤ 10% THD, Rapid Start**
- **EL Emergency battery pack (nominal 300 lumens)**
- **EL14 Emergency battery pack (nominal 1400 lumes)**
- GLR Internal fast-blow fuse
- GMF Internal slow-blow fuse
- **PWS1836 6' prewire, 3/8" dia., 18-gauge, 1 circuit**
- **LP735 Lamped; 700-series, 3500K**
- **LP741 Lamped; 700-series, 4100K**
- LP__ Lamped, specify lamp type and color
- HRD Heat-removal dampers (H and D models only)
- APB Air-pattern control blades (A and D models only)
- ACS Air closure strips (A and D models only)
- PAF Painted after fabrication (white enamel)
- SSR Specular silver interior finish (95% reflective)
- **CSA CSA Certified**
- NOM NOM Certified
- **JP Palletized and stretch-wrapped (G trim only)**

MOUNTING DATA

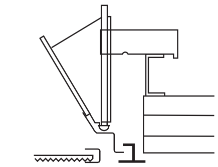
Continuous row mounting of flanged units requires CRE and CRM trim options (see Options).

G



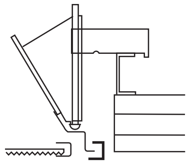
Lay-in Grid
(exposed or concealed grid)

F[1]



Overlapping Flanged Trim
with swing-gate hangers

MT



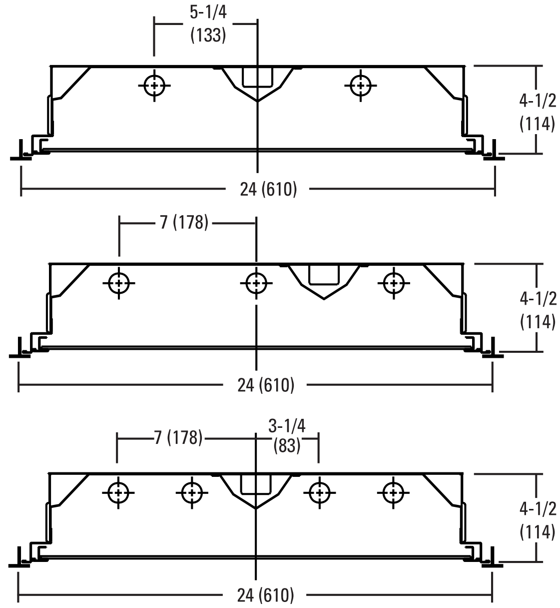
Modular Fit-In Trim with
swing-gate hangers

NOTES:

1 Recommended rough-in dimensions for F trim fixtures 24"x48" (Tolerance is +1/4", -0"). Swing-gate range 1-1/4" to 3-7/16", span 23-7/16" to 26-15/16".

DIMENSIONS

All dimensions are inches (millimeters). Specifications subject to change without notice.



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.

2SP G B 2 32 A12 GEB

Report: **LTL12404**
LUMENS PER LAMP:**2850**
Luminaire Efficiency: 75.4%

Coefficients of Utilization

pf	20%								
pc	80%			50%			30%		
pw	70%	50%	30%	50%	30%	10%	50%	30%	10%
RCR 0	90	90	90	84	84	84	80	80	80
1	83	79	76	74	72	70	72	70	68
2	76	70	65	66	62	59	64	61	58
3	70	62	57	59	54	51	57	53	50
4	64	56	50	53	48	44	51	47	43
5	59	50	44	48	43	38	46	42	38
6	55	45	39	43	38	34	42	37	34
7	51	41	35	40	34	30	39	34	30
8	48	38	32	36	31	27	35	31	27
9	45	35	29	34	28	25	33	28	25
10	42	32	26	31	26	23	30	26	22

Zonal Lumen Summary

Zone	Lumens	% Lamp	% Fixture
0˚ - 30˚	1390	24.4	32.4
0˚ - 40˚	2263	39.7	52.7
0˚ - 60˚	3671	64.4	85.5
0˚ - 90˚	4296	75.4	100.0
90˚ - 180˚	0	0.0	0.0
0˚ - 180˚	4296	75.4	100.0

2SP G B 3 32 A12 1/3 GEB

Report: **LTL12405**
LUMENS PER LAMP:**2850**
Luminaire Efficiency: 71.6%

Coefficients of Utilization

pf	20%								
pc	80%			50%			30%		
pw	70%	50%	30%	50%	30%	10%	50%	30%	10%
RCR 0	85	85	85	80	80	80	76	76	76
1	79	75	73	71	69	67	68	66	65
2	72	67	62	63	59	56	61	58	55
3	66	59	54	56	52	48	54	50	47
4	61	53	47	50	46	42	49	45	41
5	56	48	42	45	40	37	44	40	36
6	52	43	37	41	36	32	40	36	32
7	49	39	33	38	33	29	37	32	29
8	45	36	30	35	30	26	34	29	26
9	42	33	28	32	27	24	31	27	23
10	40	31	25	30	25	22	29	25	21

Zonal Lumen Summary

Zone	Lumens	% Lamp	% Fixture
0˚ - 30˚	2005	23.5	32.8
0˚ - 40˚	3230	37.8	52.8
0˚ - 60˚	5226	61.1	85.4
0˚ - 90˚	6120	71.6	100.0
90˚ - 180˚	0	0.0	0.0
0˚ - 180˚	6120	71.6	100.0

2SP G B 4 32 A12 GEB

Report: **LTL12406**
LUMENS PER LAMP:**2850**
Luminaire Efficiency: 70.9%

Coefficients of Utilization

pf	20%								
pc	80%			50%			30%		
pw	70%	50%	30%	50%	30%	10%	50%	30%	10%
RCR 0	84	84	84	79	79	79	75	75	75
1	78	75	72	70	68	66	67	66	64
2	71	66	62	62	59	56	60	57	55
3	66	59	53	56	51	48	54	50	47
4	61	53	47	50	45	42	48	44	41
5	56	47	41	45	40	36	44	39	36
6	52	43	37	41	36	32	40	35	32
7	48	39	33	37	32	29	36	32	29
8	45	36	30	34	29	26	34	29	26
9	42	33	27	32	27	23	31	27	23
10	40	31	25	29	25	21	29	24	21

Zonal Lumen Summary

Zone	Lumens	% Lamp	% Fixture
0˚ - 30˚	2659	23.3	32.9
0˚ - 40˚	4293	37.7	53.1
0˚ - 60˚	6920	60.7	85.6
0˚ - 90˚	8088	70.9	100.0
90˚ - 180˚	0	0.0	0.0
0˚ - 180˚	8088	70.9	100.0

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

LER	ANNUAL ENERGY COST*	LAMP DESCRIPTION	LAMP LUMENS	BALLAST FACTOR	WATTS
66	$3.66	(2) 32W T8	2850	.86	56
68	$3.55	(3) 32W T8	2850	.89	81
66	$3.64	(4) 32W T8	2850	.88	108

* Comparative yearly lighting energy cost per 1000 lumens

Lithonia Lighting
Fluorescent
One Lithonia Way, Conyers, GA 30012
Phone: 800-858-7763
www.lithonia.com

Voice™

LEDALITE

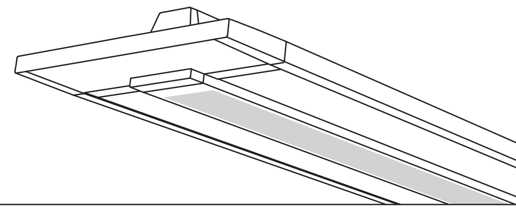
Suspended

Direct/Indirect

2 T5HO

mesoOptics®

RESPONSE READY



Project Name

Spec Type

Notes

Order Guide

Some combinations of product options may not be available. Consult factory for assistance with your specification.

7306	H02			–	–	–	–	–
Product Series & Type	**Lamping**	**Lower Optics**	**Upper Optics**	**Run Length**	**Wiring**	**Voltage**	**Ballast**	**Color & Finish**
Voice Suspended Direct/ Indirect	2 T5HO	**I** Slot Perf	**N** 60% Up / 40% Down **G** 20% Up / 80% Down **J** 100% Down	*Enter the total run length in feet (4ft increments)* See details on reverse	**1** 1 cct **2** 2 cct **3** 1 cct w/ Emergency cct **4** 2 cct w/ Emergency cct **5** 1 cct w/ Battery Pack **6** 2 cct w/ Battery Pack **7** 1 cct Dimming Consult website for complete list of standard wiring options	**1** 120V **2** 277V **3** 347V	**E** Standard Ballast Consult website for ballast manufacturer information	**W** Standard White

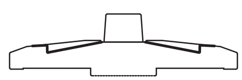
Mounting Hardware

Mount Type	Suspension Length
Consult separate mounting spec sheet for mount type options	*Enter distance from ceiling to top of fixture in inches*

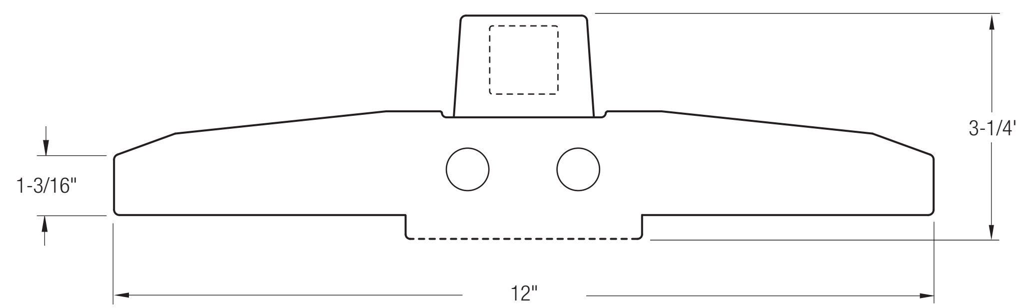
Upgrades & Accessories

Please indicate with check mark.

- ☐ Lamps Included
- ☐ Lamps Included and Installed
- ☐ Flat Endcap
  See details on reverse
- ☐ Dust Cover
  Available with upper optics option N (options G & J include integral dust cover)

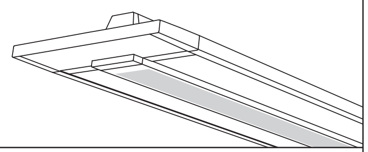


- ☐ Response Daylight (Integrated Controls)
  For details visit www.ledalite.com/response



Voice™

Suspended
Direct/Indirect
2 T5HO



Photometry Optics IN 60% Up / 40% Down

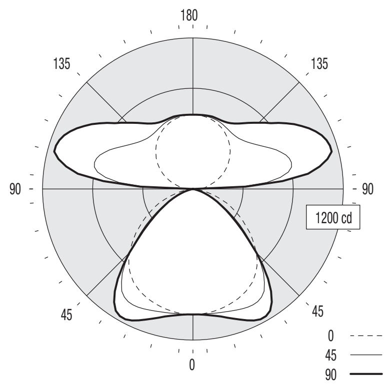
Report Summary

Efficiency 69.5%
Peak Candela Value* 1146 @ 105°
Peak to Zenith Ratio* 1.9 : 1

Report # 9900790
Filename 7306H02IN.ies
* Between 90-180° vertical angle

Candela Distribution

Vertical Angle	Horizontal Angle 0	22.5	45	67.5	90	Zonal Lumens
0	997	997	997	997	997	
5	994	995	997	1000	1003	97
15	971	980	1010	1042	1059	288
25	929	957	1036	1118	1153	479
35	854	895	991	1078	1097	609
45	716	715	715	733	718	554
55	519	470	405	389	371	385
65	334	261	186	182	173	219
75	145	86	40	41	38	73
85	16	0	0	0	0	5
90	0	0	0	1	0	
95	87	335	593	651	718	475
105	152	437	814	1063	1146	768
115	252	392	734	999	1081	691
125	342	398	615	837	909	557
135	421	448	552	692	744	441
145	487	503	541	605	635	347
155	538	546	565	580	591	261
165	571	575	584	591	596	165
175	588	588	590	591	591	57
180	590	590	590	590	590	



Coefficients of Utilization (%)

Ceiling:	80				70			50			0
Wall:	70	50	30	10	70	50	30	50	30	10	0
0 RCR	74	74	74	74	67	67	67	55	55	55	29
1	68	65	62	60	62	59	57	49	47	46	25
2	62	57	53	49	56	52	49	43	41	38	22
3	56	50	45	41	51	46	42	38	35	33	18
4	52	44	39	35	47	41	36	34	31	28	16
5	47	40	34	30	43	36	32	30	27	24	14
6	44	35	30	26	40	33	28	27	24	21	12
7	40	32	27	23	37	29	25	25	21	18	11
8	37	29	24	20	34	27	22	22	19	16	10
9	35	26	21	18	32	24	20	20	17	14	9
10	32	24	19	16	29	22	18	19	15	13	8

Based on a floor reflectance of 0.2

Avg. Luminance (cd/m²)

Vertical Angle	Horizontal Angle 0	45	90
55	2735	2134	1955
65	2389	1330	1237
75	1693	467	444
85	555	0	0

IES files for this and other photometric options can be downloaded online at www.ledalite.com

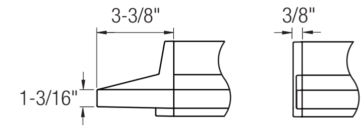
Additional Information

Modules

Module length excludes endcaps. Nominal mount spacing for individually mounted modules.

Module	Mount Spacing
4ft	4' 0"
8ft	8' 0"

Endcap



Sculptured (Standard) Flat

Specifications

Due to continuing product improvements, Ledalite reserves the right to change specifications without notice.

Housing
18 gauge die-formed cold-rolled steel, precision formed and welded.

Weight
Maximum 5.5 lb/ft.

Optical System
Optical frame is constructed from 20 gauge die-formed cold-rolled steel. The optical lens assembly consists of flat acrylic panels with a layer of MesoOptics® film that provides high-angle glare control and high efficiency. The panels are secured to a perforated center basket using an acrylic lens. Optical door frame is secured to housing with safety straps. Frame can be removed from housing using a lift-and-shift mechanism. No hardware is visible. Standard distribution is 60% up/ 40% down. Also available in 20% up / 80% down and 100% down distributions.

Endcaps
Available with sculptured die-cast endcaps (standard) or flat die-cast endcaps (optional).

Joints
Self-aligning joining system with hands-free pre-joining wire access.

Mounting
Aircraft cable gripper is tamper-resistant and provides infinite vertical adjustment capability. Aircraft cable, crimp and cable gripper independently tested to meet stringent safety requirements. Continuous run mounting on T-bar grid is limited to 32ft runs, but is unlimited in other ceiling types.

Electrical
Factory pre-wired to section ends with quick-wire connectors.

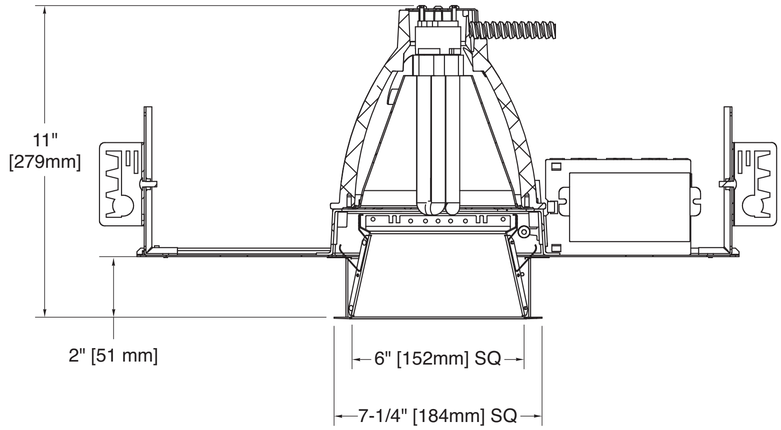
Ballast
Electronic.

Approvals
Certified to UL and CSA standards.

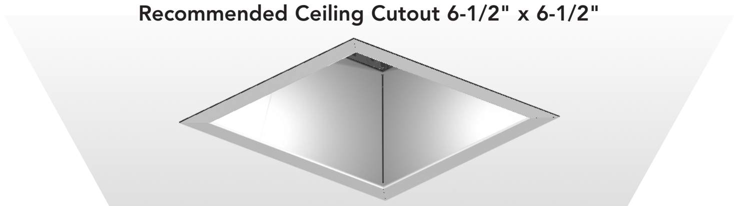
Finish
High-quality powder coat. Available in Ledalite Standard White only (textured matte finish).

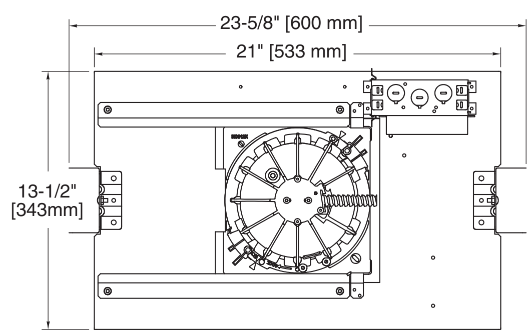
SQUARE VERTICAL LAMP DOWNLIGHT

6" Aperture
KL6SQ42PLT2SGCFF



Recommended Ceiling Cutout 6-1/2" x 6-1/2"





DESCRIPTION
Downlight luminaire with 6" square aperture, designed for a single 26, 32 or 42 Watt PLT Triple Twin Tube lamp or 26 Watt QPL Quad lamp. Two-piece optical assembly provides a broad, even light distribution, combining low brightness with maximum efficiency.

FEATURES
- Luminaire uses one 26, 32 or 42 Watt Triple Twin Tube lamp or 26 Watt QPL Quad lamp.
- Upper reflector is spun, specular 0.060" thick, pre-finished aluminum.
- Lower cone is die formed, satin glow clear, low-iridescent, 0.032" thick, pre-finished aluminum.
- Precision stainless steel cone retainers guaranteed to hold cone in proper position.
- Die-cast aluminum housing with Slideways™ feature for ease of maintenance from below the ceiling. All surfaces painted optical matte black to reduce stray light.
- Integral Twist Lock allows relamping above ceiling.
- Program start electronic ballast with Lamp EOL (end of life) protection and auto-restart.
  – Universal voltage, 120V through 277V, 50 or 60 Hz standard, 347V ballast also available
  – Minimum .98 power factor
  – THD less than 10%
  – Minimum starting temperature 0°F (-18°C)
- 2" aperture throat to accommodate all standard and extra-thick ceilings and provide flexibility in mounting.
- Provided with quick mounting brackets for optional carrying channels. Adjustable from above or below ceiling.
- UL/CUL listed for damp location and thru-wiring 8#12-75°C.
- Patents Pending.

OPTIONS
DA	Dimming Analog (0-10V DC)
DH	Dimming 3 Wire (Lutron Hi-Lume)*
DL	Dimming 3 Wire (Lutron Compact SE)
DM	Dimming Ballast (Power Line)
FS	Fusing (For Canada consult factory)
MC	Mounting C Channels 30"
WF	White Flange (Replace FF with WF) (Not Available with textured trim finishes)
XF	Flange Color as Specified (Replace FF with XF) (Not Available with textured trim finishes)
EM	Integral battery not available (Consult Factory for remote EM battery option)

* Option available with 26PLT or 32PLT only

COMPANION LUMINAIRES
Horizontal Lamp Downlight
KL6SQ1X42PLT2SGCFF	FS.4
KL6SQ2X26QPL2SGCFF	FS.5

Horizontal Lamp Cross Baffle
KL6SQ1X42PLTXBSGCFF	FS.6
KL6SQ2X26QPLXBSGCFF	FS.7

Lensed Wall Washer
KL6SQ1X42PLTLWWSGCFF	FS.8

HOW TO SPECIFY

Select: **KL** ___ **SQ** ___ **2** ___ ___ ___ ___ ___

Aperture Size
- **6** 6"

Lamp
- **42PLT** 42W PLT
- **32PLT** 32W PLT
- **26PLT** 26W PLT
- **26QPL** 26W QPL

Lens Media
- **Blank** No Lens
- **CL** Clear Glass Lens
- **PL** Prismatic (C73) Glass Lens
- **SL** Microprism ...ns

Reflector/Cone Finish
- **S** Soft Satin Glow *(Add as prefix)*
- **SGC** Satin Glow Clear
- **C** Premium Grade Specular Clear (2)
- **SGCG** Satin Glow Champagne Gold
- **SGBR** Satin Glow Bronze
- **SGWH** Satin Glow Wheat
- **SGPE** Satin Glow Pewter
- **SGGR** Satin Glow Graphite
- **SGB** Satin Glow Black
- **W** Painted High Gloss White

Textures (add as suffix)
- **CC** Corrugated (1)
- **BP** Ball Peen (1)
- **SC** Stucco Satin (1)

Notes (1) – Not available with painted flange (**WF** or **XF**)
(2) – Not available in texture finish (**CC**, **BP**, or **SC**)

Flange Finish
- **FF** Full Flange Same finish as reflector/cone
- **WF** Painted White
- **XF** Flange Painted Custom Color (Consult Factory)

Voltage
- **120** 120V
- **277** 277V
- **347** 347V
- **U** Universal 120-277V

Options
Select from Options above left.

Notes:

Example: **KL 6 SQ 42PLT 2 ___ SGC FF U ___**

kramer® LIGHTING
1200 92nd STREET, STURTEVANT, WISCONSIN 53177
TOLL FREE: 800.236.6800 FAX 262.504.5415 www.kramerlighting.com

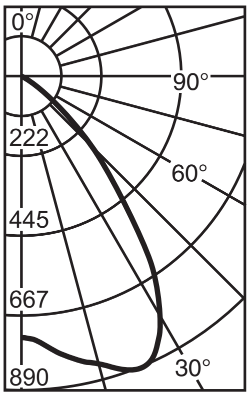
SQUARE VERTICAL LAMP

DOWNLIGHT

KL6SQ42PLT2SGCFF

KL6SQ42PLT2SGCFF
Lamp: **One Sylvania 42 Watt**
Total Luminaire Efficiency: **36.3%**
Spacing Criterion: **Along 1.16**
Across 1.20
Test No.: **LSI 21695**

CANDELA DISTRIBUTION



degrees	Along	Across
0°	739	739
5°	764	768
10°	807	811
15°	819	835
20°	792	826
25°	708	748
30°	568	618
35°	399	455
40°	263	306
45°	152	180
50°	64	74
55°	7	10
60°	2	2
65°	0	0
70°	0	0
75°	0	0
80°	0	0
85°	0	0
90°	0	0

LUMINANCE DATA

candela/meter²

ANGLE IN DEGREE	ALONG	ACROSS
45°	9259	10962
55°	555	757
65°	0	0
75°	0	0
85°	0	0

CONE OF LIGHT

DISTANCE TO ILLUMINATED PLANE	INITIAL NADIR FOOTCANDLES	BEAM DIAMETER
6'	21.5	6.8'
8'	12.1	9.2'
10'	7.7	11.5'
12'	5.4	13.7'
14'	4	15.9'

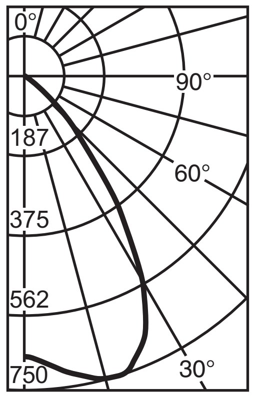
Beam diameter is to 50% of maximum footcandles. Footcandle values are initial and are rounded to the nearest footcandle.

CO-EFFICIENT OF UTILIZATION

FLOOR	20												
RC	80				70				50		30		0
RW	70	50	30	10	70	50	30	10	50	10	50	10	0
RCR													
0	.43	.43	.43	.43	.42	.42	.42	.42	.40	.40	.39	.39	.36
1	.41	.40	.39	.38	.40	.39	.38	.37	.38	.36	.36	.35	.34
2	.39	.37	.35	.34	.38	.36	.35	.33	.35	.33	.34	.32	.31
3	.36	.34	.32	.30	.36	.33	.32	.30	.32	.30	.32	.29	.28
4	.34	.31	.29	.27	.34	.31	.29	.27	.30	.27	.29	.27	.26
5	.32	.29	.27	.25	.32	.29	.26	.25	.28	.24	.27	.24	.23
6	.30	.27	.24	.23	.30	.27	.24	.23	.26	.22	.25	.22	.22
7	.29	.25	.22	.21	.28	.25	.22	.21	.24	.21	.24	.20	.20
8	.27	.23	.21	.19	.27	.23	.21	.19	.23	.19	.22	.19	.18
9	.25	.22	.19	.18	.25	.21	.19	.18	.21	.18	.21	.17	.17
10	.24	.20	.18	.16	.24	.20	.18	.16	.20	.16	.19	.16	.16

KL6SQ32PLT2SGCFF
Lamp: **One Sylvania 32 Watt**
Total Luminaire Efficiency: **39.9%**
Spacing Criterion: **Along 1.12**
Across 1.20
Test No.: **LSI 21694**

CANDELA DISTRIBUTION



degrees	Along	Across
0°	661	661
5°	683	685
10°	707	717
15°	703	746
20°	678	739
25°	596	669
30°	468	549
35°	310	385
40°	190	236
45°	101	122
50°	44	50
55°	6	5
60°	2	3
65°	1	1
70°	1	1
75°	0	0
80°	0	0
85°	0	0
90°	0	0

LUMINANCE DATA

candela/meter²

ANGLE IN DEGREE	ALONG	ACROSS
45°	6150	7428
55°	412	397
65°	61	122
75°	17	17
85°	0	0

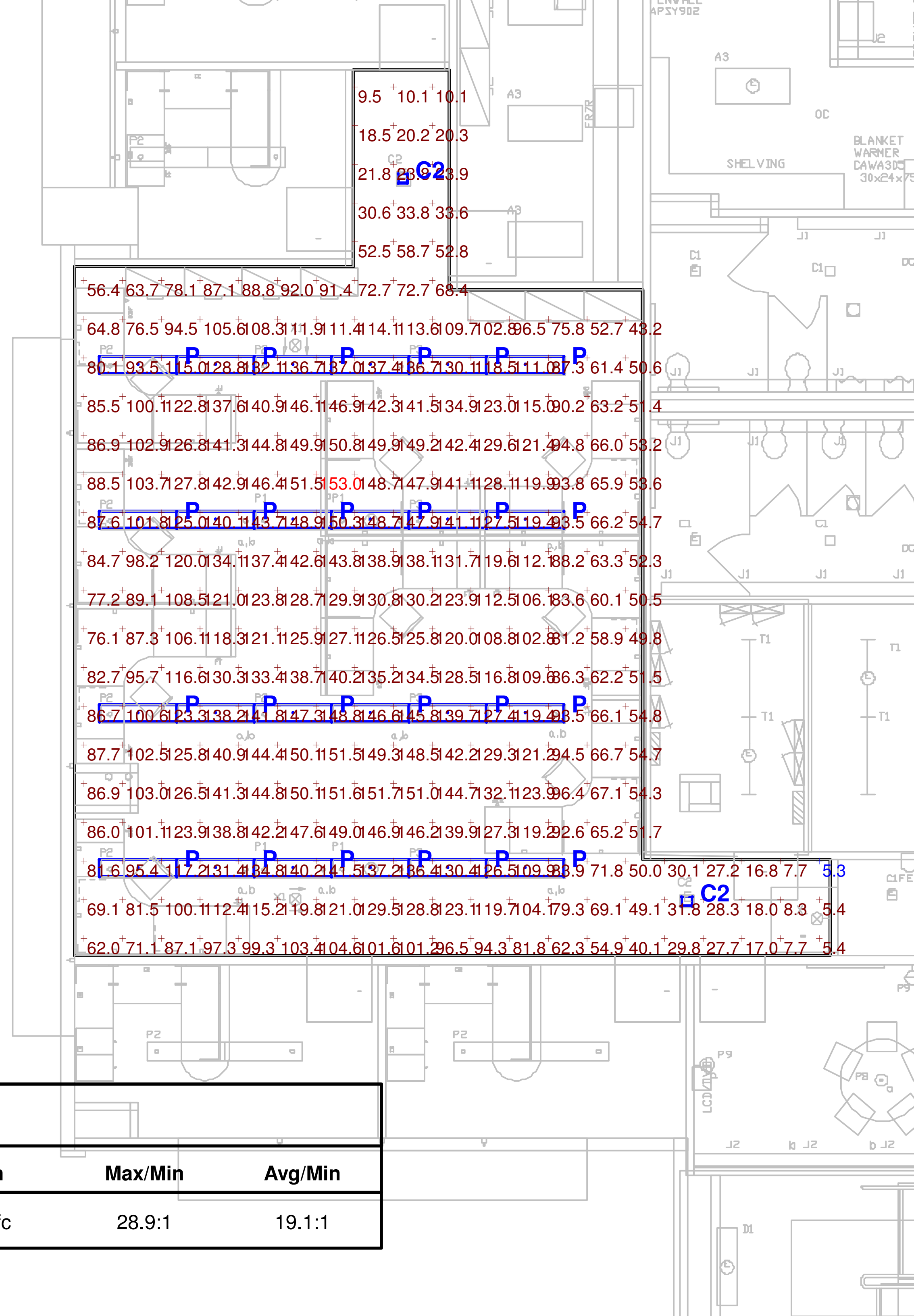
CONE OF LIGHT

DISTANCE TO ILLUMINATED PLANE	INITIAL NADIR FOOTCANDLES	BEAM DIAMETER
6'	19	6.7'
8'	11	9.0'
10'	7	11.3'
12'	4.8	13.4'
14'	3.5	15.8'

Beam diameter is to 50% of maximum footcandles. Footcandle values are initial and are rounded to the nearest footcandle.

CO-EFFICIENT OF UTILIZATION

FLOOR	20												
RC	80				70				50		30		0
RW	70	50	30	10	70	50	30	10	50	10	50	10	0
RCR													
0	.48	.48	.48	.48	.46	.46	.46	.46	.44	.44	.42	.42	.40
1	.45	.44	.43	.42	.44	.43	.42	.41	.42	.40	.40	.39	.37
2	.43	.41	.39	.37	.42	.40	.38	.37	.39	.36	.37	.35	.34
3	.40	.38	.35	.34	.39	.37	.35	.33	.36	.33	.35	.32	.31
4	.38	.35	.32	.31	.37	.34	.32	.30	.33	.30	.33	.30	.29
5	.36	.32	.30	.28	.35	.32	.29	.28	.31	.27	.30	.27	.26
6	.34	.30	.27	.25	.33	.30	.27	.25	.29	.25	.28	.25	.24
7	.32	.28	.25	.23	.31	.28	.25	.23	.27	.23	.27	.23	.22
8	.30	.26	.23	.22	.30	.26	.23	.22	.25	.21	.25	.21	.21
9	.28	.24	.22	.20	.28	.24	.22	.20	.24	.20	.23	.20	.19
10	.27	.23	.20	.19	.27	.23	.20	.19	.22	.18	.22	.18	.18



LUMINAIRE SCHEDULE

Symbol	Label	Lumens	LLF	Watts
	P	4650	0.91	108
	C2	2400	0.91	32

STATISTICS

Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
Work Area 260	+	101.0 fc	153.0 fc	5.3 fc	28.9:1	19.1:1

Calculated values include direct and interreflected components.

LUMINAIRE SCHEDULE

Symbol	Label	Lumens	LLF	Watts
	P	4650	0.91	108
	A3	2850	0.91	96

STATISTICS

Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
Break Room 280	+	64.3 fc	104.1 fc	17.6 fc	5.9:1	3.7:1
Conference Room 283	+	116.8 fc	180.8 fc	33.5 fc	5.4:1	3.5:1
Office 286	+	59.6 fc	91.1 fc	28.5 fc	3.2:1	2.1:1

Calculated values include direct and interreflected components.

Appendix F
Electrical Breadth Redesign

LITHONIA LIGHTING®

Catalog Number	
Notes	Type

Avante®
Recessed Direct/Indirect Lighting

2AV 2'x4'

FEATURES & SPECIFICATIONS

INTENDED USE

The Avante 2x4 is a general lighting luminaire for large spaces including open offices, circulation areas, classrooms, libraries, cafeterias, airport ticketing and waiting areas, and numerous other commercial applications. Static or air functions available.

CONSTRUCTION

Housing is gloss white enamel on cold rolled steel. All edges hemmed or rounded.

All shieldings pivot on light traps and swing down for easy lamp access.

Molded light traps prevent light leaks between shielding and endplates.

All air and screw slot units supplied with screw-on tee bar clips. Ballast access is from below.

OPTICAL SYSTEM

Twin matte white polyester powder paint finished reflectors provide uniform light distribution. Optional low brightness diffuse aluminum stepped reflectors available.

All diffusers control direct light distribution and glare by shielding lamps from direct view.

Metal diffuser staggered round holes (MDR) 52% open perforated metal with .075" diameter holes backed with white acrylic diffuser.

Straight blade louver (SBL) sides of perforated metal with staggered round holes and solid blade louvered center. Sides and louver backed with white acrylic diffuser.

Metal diffuser aligned mini slots (MDM) 46% open perforated metal backed with white acrylic diffuser.

Acrylic diffuser prismatic lens (ADP) extruded acrylic lens backed with white acrylic diffuser.

Metal diffuser with center slots (MDC). 52% open metal, .075" diameter holes with 1" wide solid center. With 1/2"x2" open slots. Diffuser is backed with white acrylic overlay.

ELECTRICAL SYSTEM

All ballasts supplied are class P, thermally protected, resetting, HPF, non-PCB, UL Listed, CSA Certified. Ballasts are sound rated A. Standard combinations conform to UL 935. All T5 and T5HO ballasts are program start.

Step-level dimming option allows system to be switched to 50% power for compliance with common energy codes while maintaining fixture appearance.

The F28T5 two-lamp configuration is available with SIMPLY5™ lighting intelligence. S5 option available for use with Simply5 lighting intelligence system. See 2AV-2x4-T5_S5 or Lithonia Controls specification sheets for more information.

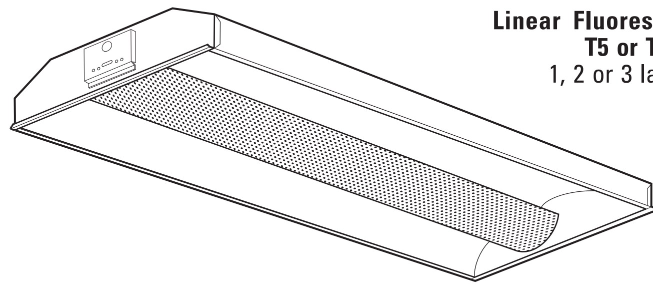
INSTALLATION

Trims available for standard 1" and 9/16" tee bar or screw slot grids.

Fixtures can be row mounted end-to-end.

Drywall ceiling adapters available.

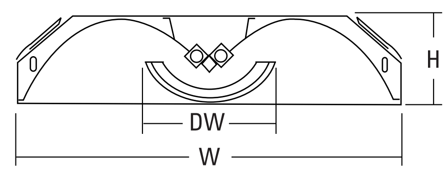
Linear Fluorescent
T5 or T5HO
1, 2 or 3 lamps



Specifications

Length: 48" (1214)
Width: 24" (602)
Diffuser Width: 8" (203)
Depth: 5-1/2" (140)

All dimensions are inches (millimeters).



SIMPLY5™ LIGHTING INTELLIGENCE

LISTING

UL Listed to US and Canadian safety standards. Chicago Plenum approved and NYC approved (see Options).

Specifications are subject to change without notice.

Avante is covered by one or more of the following patents: 5,988,829; 399,586; 411,641; 413,402; 2,212,513; 87,513.

ORDERING INFORMATION

For shortest lead times, configure product using **standard options (shown in bold).**

Example: 2AV G 2 28T5 MDR MVOLT GEB115

2AV ___ ___ ___ ___ ___ ___ ___

Series
- **2AV 2' wide**

Trim type
- **G Grid trim**
- ST Screw slot

Air function
- (blank) **Static (no air function)**
- A Air return/supply

Number of lamps
- 1
- **2**
- 3

Not included.

Lamp type
- **28T5 28W T5 (46")**
- 54T5HO 24W T5HO (46")

Diffuser
- **MDR Metal diffuser, round holes**
- SBL Straight blade louver, round holes
- MDM Metal diffuser, mini slots
- ADP Acrylic diffuser, linear prismatic lens
- MDC Metal diffuser, round holes with large center slots[1]

Others available.

Voltage
- **MVOLT**[2]
- 347

Others available.

Options

GEB10PS	Electronic ballast, ≤ 10% THD, program start[3]
GEB115	**1.15 ballast factor, two-lamp only**
GEB115S	1.15 ballast factor, step-dim
S5	0.95 ballast factor, SIMPLY5 system[4]
ALG	Acrylic litter guard[1]
EL14	**Emergency battery pack (nominal 300 lumens, see Life Safety section)**[5]
HW	Hardwire for SIMPLY5™ system; replaces RELOC®
GLR	Internal fast-blow fuse[6]
LP_	Lamped. Specify lamp type and color
PWS1836	**6' prewire, 3/8" dia., 18-gauge, 3 wires**
QFC	Quick-Flex® cable[6]
NYC	New York City approved
CP	Chicago Plenum approved
APB	Air pattern control blades[1]
Reflector option	
ASR	Aluminum stepped reflector

Accessories

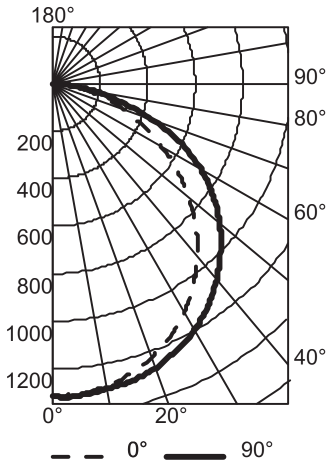
Order as separate catalog number.

DGA24 Drywall ceiling adapter, unit installation. Use G trim plus DGA accessory for fixture trim flange and fixture support in plaster or plasterboard ceilings.

NOTES:
1 Refer to options and accessories section for more detailed information.
2 MVOLT (120 - 277 volt).
3 For two-lamp 28T5 only.
4 SIMPLY5 system includes 13' S5SSC RELOC® wiring system. Specify voltage unless HW (hardwire) or PWS1836 is ordered. For two-lamp 28T5 only.
5 Not available in Canada.
6 Must specify voltage, 120 or 277.

2AV 2x4 Direct/Indirect Lighting

2AV G 2 28T5 MDR, (2) 28W T5 lamps, 2600 lumens per lamp, test no. LTL 8780



CP Summary

	0°	90
0°	1313	1313
5°	1310	1317
15°	1264	1294
25°	1174	1239
35°	1034	1141
45°	853	1000
55°	641	826
65°	417	598
75°	217	303
85°	46	63
90	0	0

Coefficients of Utilization

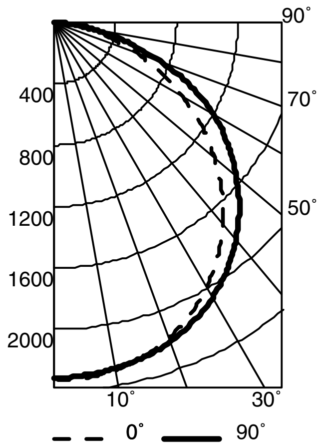
pf	20%								
pc	80%			70%			50%		
pw	70%	50%	30%	50%	30%	10%	50%	30%	10%
RCR 0	91	91	91	89	89	89	85	85	85
1	83	79	76	78	75	72	74	72	70
2	75	69	64	67	63	58	65	61	57
3	69	60	54	59	53	48	57	52	48
4	63	53	46	52	46	41	50	45	40
5	57	47	40	47	40	35	45	39	35
6	53	43	36	42	35	31	41	35	30
7	49	39	32	38	32	27	37	31	27
8	46	35	29	35	28	24	34	28	24
9	43	32	26	32	26	22	31	25	21
10	40	30	24	29	23	19	29	23	19

Zonal Lumen Summary

Zone	Lumens	% Lamp	% Fixture
0° - 30°	1039	20.0	26.1
0° - 40°	1719	33.1	43.2
0° - 60°	3099	59.6	77.9
0° - 90°	3977	76.5	100.0
90° - 180°	0	0.0	0.0
0° - 180°	3977	76.5	100.0

Efficiency: 76.5%

2AV G 2 54T5HO MDR, (2) 54W T5HO lamps, 4450 lumens per lamp, s/m 1.3 (along) 1.3 (across), test no. LTL 10196



CP Summary

	0°	90
0°	2321	2321
5°	2324	2304
15°	2250	2258
25°	2101	2149
35°	1863	1972
45°	1549	1711
55°	1175	1385
65°	760	990
75°	369	499
85°	74	103
90	0	0

Coefficients of Utilization

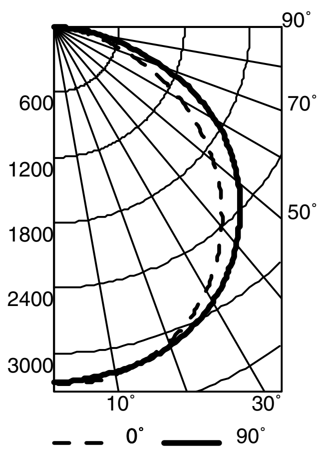
pf	20%								
pc	80%			70%			50%		
pw	70%	50%	30%	50%	30%	10%	50%	30%	10%
RCR 0	93	93	93	91	91	91	87	87	87
1	85	81	78	80	77	74	76	74	71
2	77	71	65	69	64	60	67	62	59
3	70	62	56	61	55	50	58	53	49
4	64	55	48	54	47	42	52	46	42
5	59	49	42	48	41	36	46	40	36
6	55	44	37	43	36	32	42	36	31
7	50	40	33	39	32	28	38	32	28
8	47	36	29	36	29	25	35	29	25
9	44	33	27	33	26	22	32	26	22
10	41	31	24	30	24	20	29	24	20

Zonal Lumen Summary

Zone	Lumens	% Lamp	% Fixture
0° - 30°	1837	20.6	26.3
0° - 40°	3039	34.1	43.5
0° - 60°	5471	61.5	78.3
0° - 90°	6985	78.5	100.0
90° - 180°	0	0.0	0.0
0° - 180°	6985	78.5	100.0

Efficiency: 78.5%

2AV G 3 54T5HO MDR, (3) 54W T5HO lamps, 4450 lumens per lamp, s/m 1.3 (along) 1.3 (across), test no. LTL 10197



CP Summary

	0°	90
0°	3273	3273
5°	3284	3251
15°	3178	3182
25°	2959	3032
35°	2615	2780
45°	2168	2423
55°	1632	1975
65°	1046	1413
75°	496	729
85°	96	151
90	0	0

Coefficients of Utilization

pf	20%								
pc	80%			70%			50%		
pw	70%	50%	30%	50%	30%	10%	50%	30%	10%
RCR 0	88	88	88	86	86	86	82	82	82
1	80	77	73	75	72	69	72	69	67
2	73	67	61	65	60	56	62	59	55
3	66	58	52	57	51	47	55	50	46
4	60	51	45	50	44	40	49	43	39
5	56	46	39	45	39	34	43	38	34
6	51	41	35	41	34	30	39	34	29
7	47	37	31	37	30	26	36	30	26
8	44	34	28	33	27	23	33	27	23
9	41	31	25	31	25	21	30	25	21
10	39	29	23	28	23	19	28	22	19

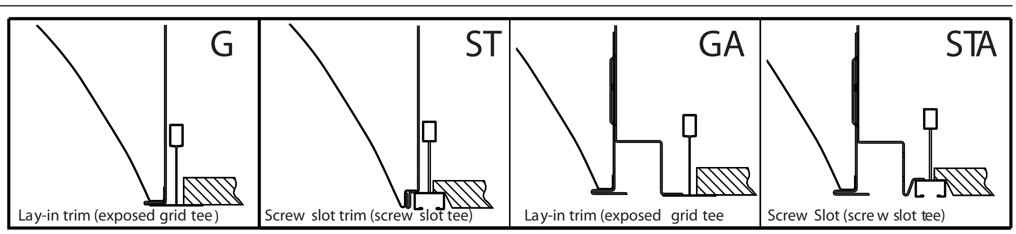
Zonal Lumen Summary

Zone	Lumens	% Lamp	% Fixture
0° - 30°	2588	19.4	26.3
0° - 40°	4279	32.1	43.5
0° - 60°	7704	57.7	78.3
0° - 90°	9844	73.7	100.0
90° - 180°	0	0.0	0.0
0° - 180°	9844	73.7	100.0

Efficiency: 73.7%

MOUNTING DATA

Ceiling Type	Appropriate Trim Type
Exposed grid tee (1' and 9/16")	G
Concealed grid tee	G
Screw slot	ST
Plaster or plasterboard	G*



*DGA accessory available to provide ceiling trim flange and fixture support for plaster or plasterboard ceiling. Recommended rough-in dimensions for DGA installation is 24-3/4" x 48-3/4" (Tolerance is +1/8", -0").

LITHONIA LIGHTING®

An Acuity Brands Company

Sheet #: 2AV 2X4 T5

Lithonia Lighting
Fluorescent
One Lithonia Way, Conyers, GA 30012
Phone: 800-858-7763 Fax: 770-929-8789
www.lithonia.com

LITHONIA LIGHTING®

Catalog Number	
Notes	Type

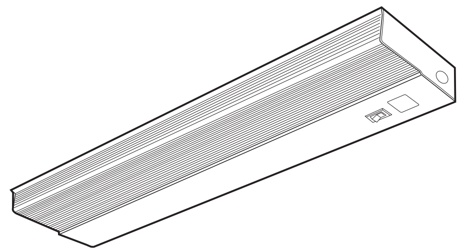
FEATURES

- Trim, low-profile design, only 1-3/16" deep.
- Flattened knockouts for cleaner appearance.
- Snap-fit channel cover attachment. No tools required for wireway access.
- Hinged, removable channel cover allows hands-free wiring and quick installation.
- Factory-installed starters on all preheat models.
- Romex/BXR conduit connector provided with each fixture.
- Optional instant-on electronic start magnetic ballast for flicker-free lamp start.
- Low-brightness, linear prismatic diffuser provides improved visual comfort.
- 15% DR acrylic and snap-fit diffuser design for improved shatter-resistant and positive attachment.
- Optional task diffuser with clear linear prismatic bottom and opaque front for maximum illumination without direct edge glare.
- Five fixture lengths available.
- Available with factory-installed lamp, switch, cordset and convenience outlet options.

Undercabinet Light

UC

1" Wrap-Front Lens



SPECIFICATIONS

BALLAST — Normal power factor reactor type ballast standard. Others available (See ordering information).

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 — Metal parts precision roll-formed from 20 gauge cold rolled steel.

FINISH — Five-stage iron-phosphate pre-treatment ensures superior paint adhesion and rust resistance. Painted parts finished with polyester powder paint.

LISTING — UL listed and labeled. Listed and labeled to comply with Canadian and Mexican Standards.

NOTE: Specifications subject to change without notice.

ORDERING INFORMATION

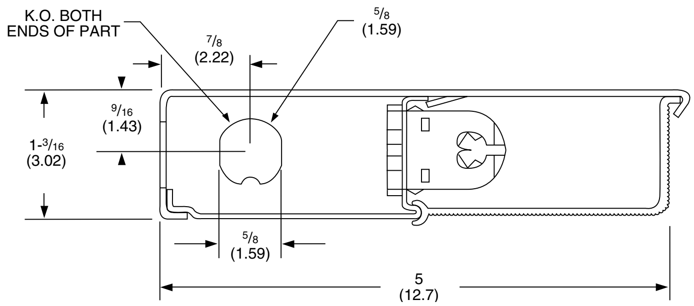
Example: **UC 33K OP 120**

UC

Series	Fixture length/ballast type	Diffuser	Voltage	Options
UC Undercabinet light	12 (1) 8W T5, preheat 12E (1) 8W T5, instant start electronic 21 (1) 13W T5, preheat 21E (1) 13W T5, instant start electronic 24 (2) 8W T5, preheat 24E (2) 8W T5, instant start electronic 33 (1) 8W and (1) 13W T5, preheat 33E (1) 8W and 13W T5, instant start electronic 42 (2) 13W T5, preheat 42E (2) 13W T5, instant start electronic	(blank) Standard, milk-white, DR acrylic OP Opaque-front, clear bottom DR acrylic	120	GLR Internal fast-blow fuse GMF Internal slow-blow fuse CSW 6-foot, 3-wire, grounded cordset, right end LPWW Warm white 3000K T5 lamp(s); factory supplied PAF White powder paint finish after fabrication CO Grounded convenience outlet. Installed, bottom right, 120V only SWR Rocker switch, installed bottom right, 120V only CSA Listed and labeled to comply with Canadian Standards NOM Listed and labeled to comply with Mexican Standards

MOUNTING DATA

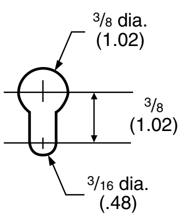
For unit or row mount installation, surface mounting only.

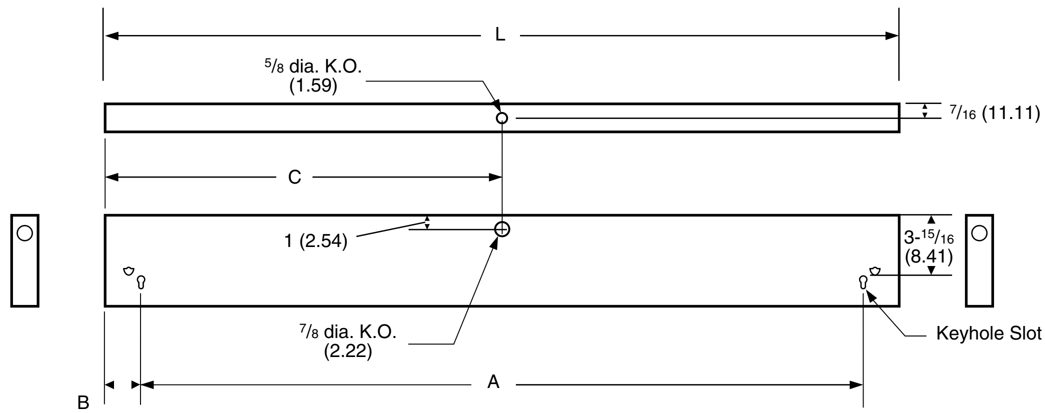


DIMENSIONS

Inches (centimeters). Subject to change without notice.

Length	A	B	C	# Keyholes
12-3/8 (31.43)	7-1/16 (17.94)	2-5/8 (6.67)	6-1/8 (15.56)	2
21-3/8 (52.23)	16-1/16 (40.80)	2-5/8 (6.67)	10-11/16 (27.15)	2
24-1/2 (62.25)	19-1/4 (48.90)	2-5/8 (6.67)	12-1/4 (31.12)	2
33-1/2 (85.10)	28-1/4 (71.76)	2-5/8 (6.67)	17 (43.18)	2
42-1/2 (107.96)	37-1/4 (94.62)	2-5/8 (6.67)	21-1/4 (53.98)	2





PHOTOMETRICS

Photometry derived in accordance with IESNA LM41 procedure. Vertical and horizontal illuminance is calculated with fixture mounted 15" from work surface. Full photometric data available upon request.

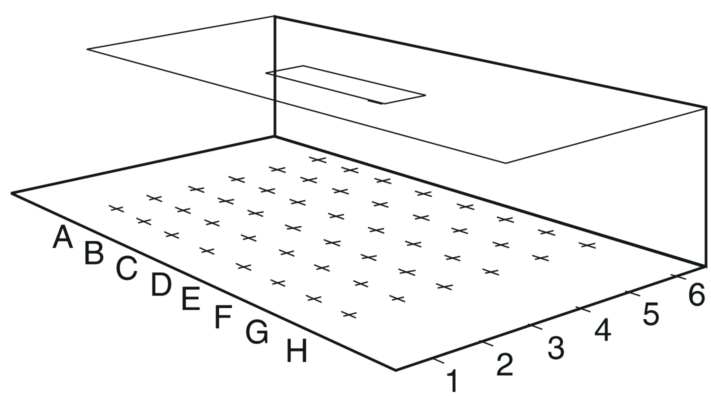
Coordinates are on 6" centers.

UC 24
Report LTL 6349

	1	2	3	4	5	6
A	7	9	9	7	5	3
	13	19	18	13	8	4
	21	30	29	19	10	6
	26	38	36	23	12	7
	26	38	36	23	12	7
	21	30	29	19	10	6
	13	18	18	13	8	4
	7	9	9	7	5	3

UC 42
Report LTL 6447

22	31	31	21	13	7
32	46	44	30	17	9
37	54	52	35	19	11
40	58	56	37	21	12
40	58	56	37	21	12
37	54	52	35	19	11
32	46	44	30	17	9
22	31	31	21	13	7



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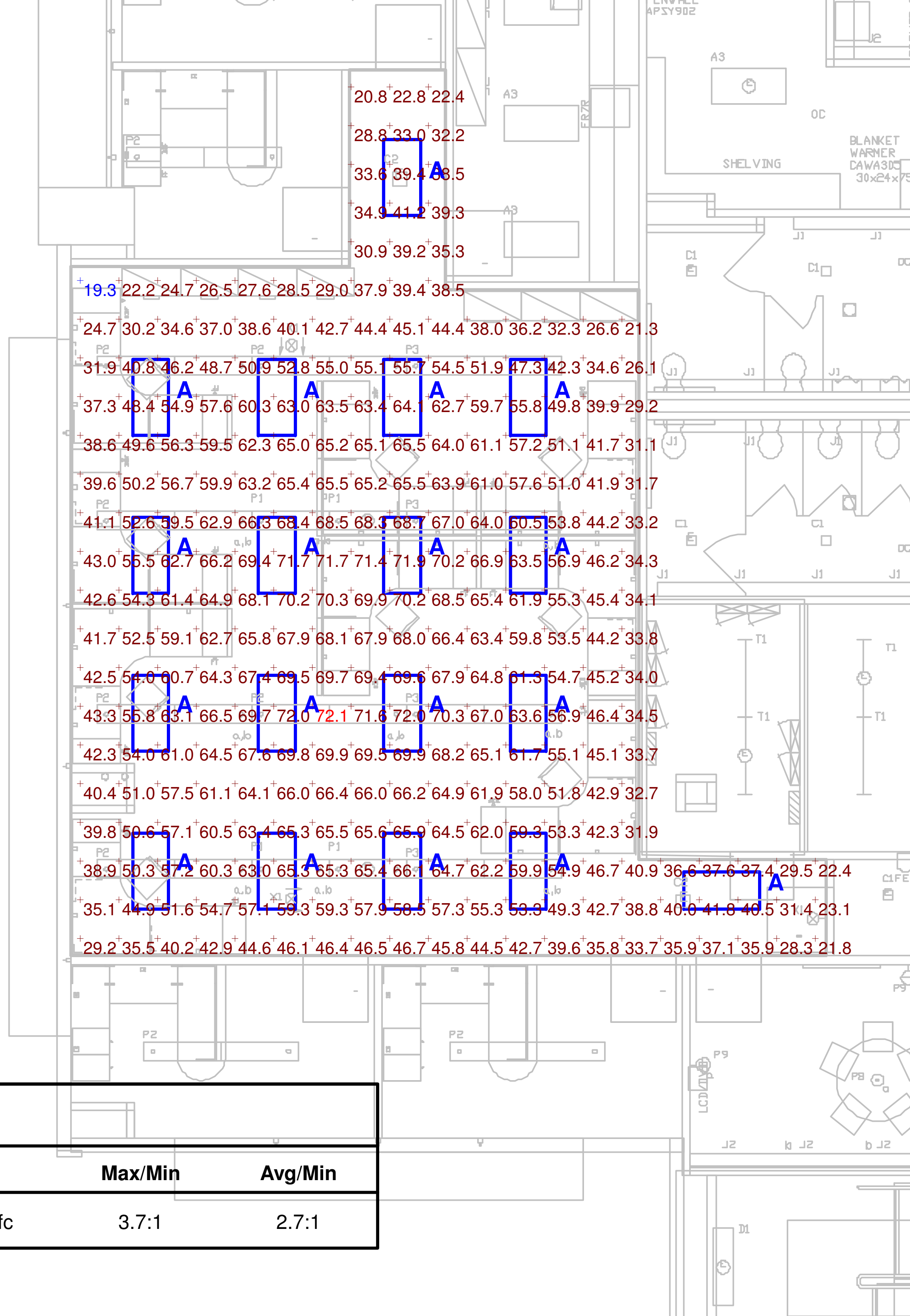
Phone: 800-858-7763
www.lithonia.com



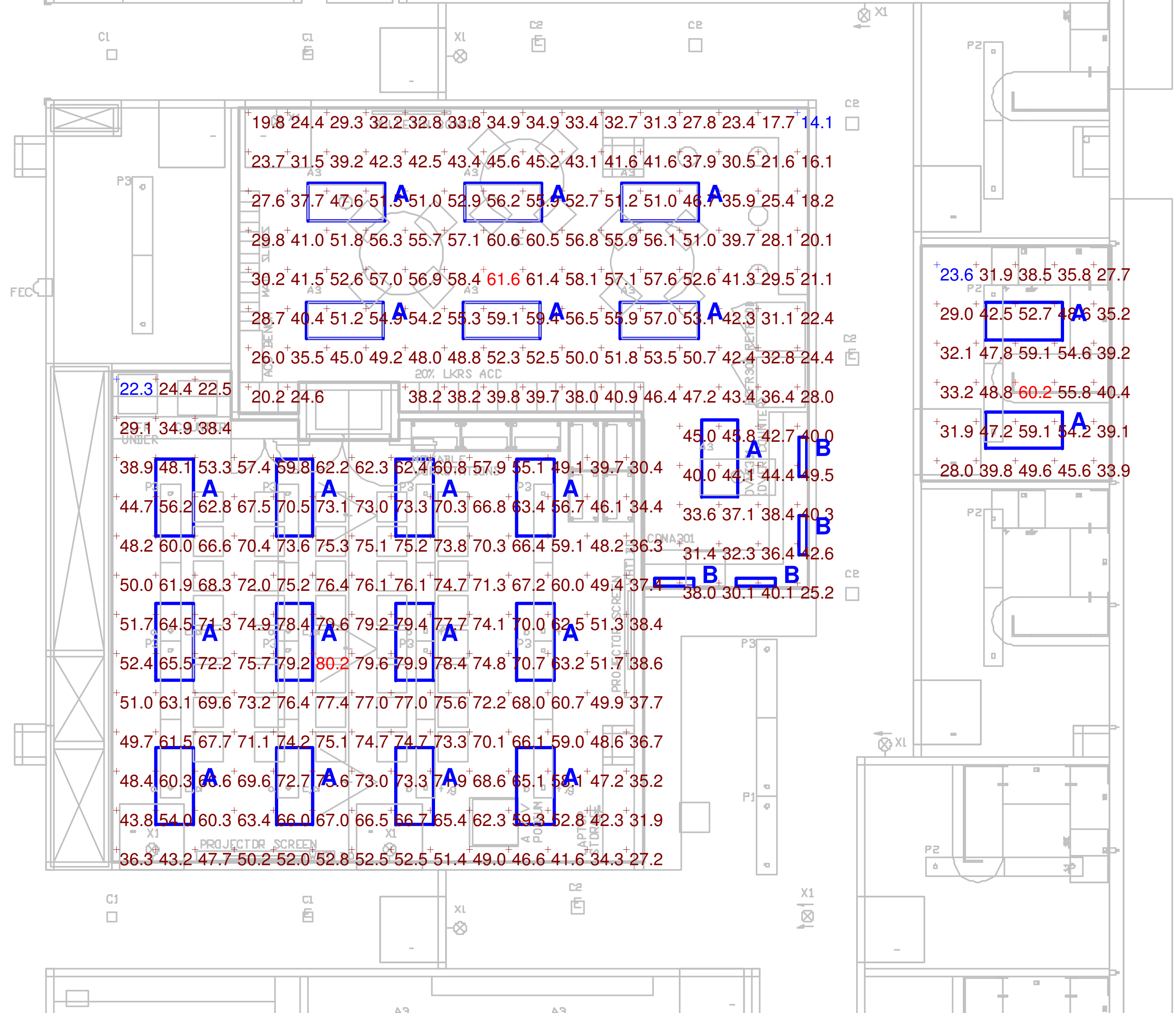
LUMINAIRE SCHEDULE

Symbol	Label	Lumens	LLF	Watts
▯	A	2600	0.91	56

STATISTICS

Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
Work Area 260	+	51.7 fc	72.1 fc	19.3 fc	3.7:1	2.7:1

Calculated values include direct and interreflected components.



LUMINAIRE SCHEDULE

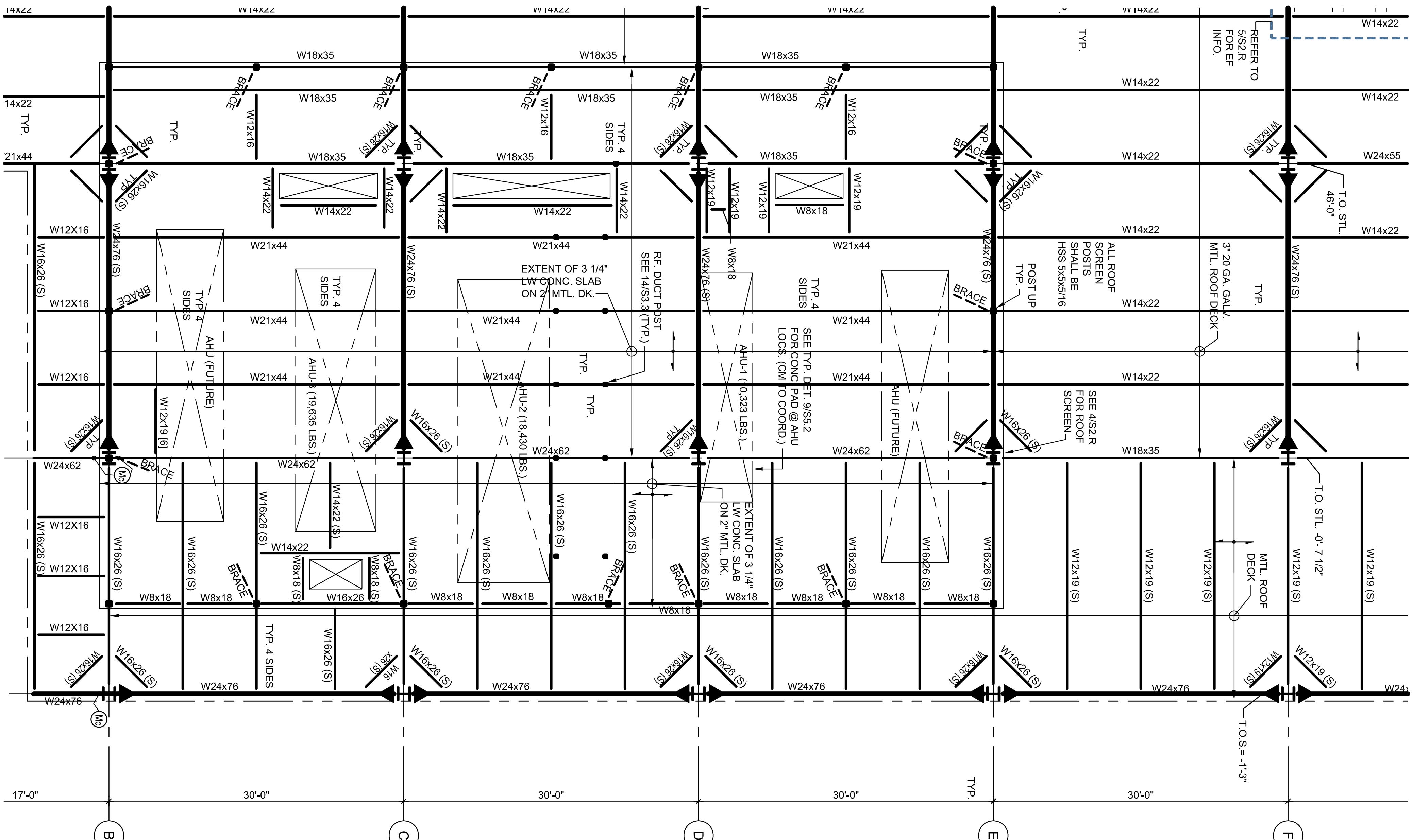
Symbol	Label	Lumens	LLF	Watts
	A	2600	0.91	56
	B	400	1.00	19

STATISTICS

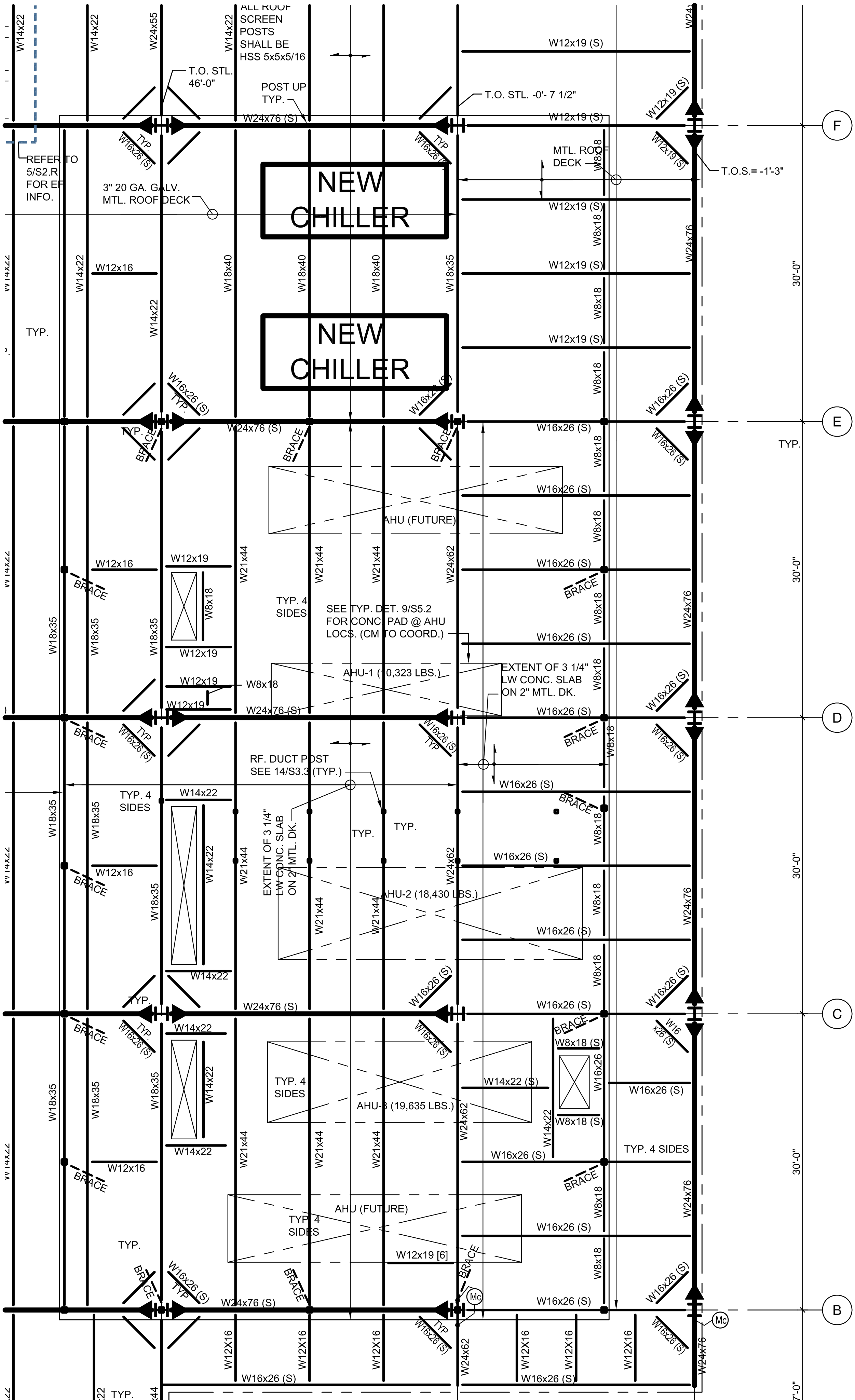
Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
Break Room 280	+	41.5 fc	61.6 fc	14.1 fc	4.4:1	2.9:1
Conference Room 283	+	60.3 fc	80.2 fc	22.3 fc	3.6:1	2.7:1
Office 286	+	42.2 fc	60.2 fc	23.6 fc	2.6:1	1.8:1

Calculated values include direct and interreflected components.

Appendix G
Structural Breadth



EXISTING ROOF DESIGN



NEW ROOF DESIGN

Title : COH
Dsgnr: C. Bratz
Description :

Scope :

Job #
Date: 7:54PM, 9 APR 09

Steel Beam Design

Description Typical Chiller Bay Beam

General Information

Code Ref: LRFD 3rd Edition, 2003 IBC, 2003 NFPA 5000

Steel Section : W18X40

Center Span	30.00 ft	Pinned-Pinned	Fy	50.00 ksi
Left Cant.	0.00 ft	Bm Wt. Added to Loads	Load Duration Factor	1.00
Right Cant	0.00 ft	LL & ST Act Together	Elastic Modulus	29,000.0 ksi
Lu : Unbraced Length	0.00 ft			

Distributed Loads

Note! Short Term Loads Are WIND Loads.

	# 1	# 2	# 3	# 4	# 5	# 6	# 7	
DL	0.804							k/ft
LL	0.120							k/ft
ST								k/ft
Start Location								ft
End Location								ft

Summary

Beam OK

Factored Load Combinations . . . .

(1) 1.4D

Mu	132.943 k-ft	Vu	17.726 k
Phi * Mn	294.000	Phi *Vn	152.240

(2) 1.2D + 1.6L . . .

Mu	135.551	Vu	18.073
Phi * Mn	294.000	Phi * Vn	152.240

(3) 1.2D + 1.6L + 0.8W . . .

Mu	135.551	Vu	18.073
Phi * Mn	294.000	Phi * Vn	152.240

(4) 1.2D + 0.5L + 1.3W . . .

Mu	120.701	Vu	16.093
Phi * Mn	294.000	Phi * Vn	152.240

Force & Stress Summary

<<-- These columns are Dead + Live Load placed as noted -->>

	Maximum	DL Only	LL @ Center	LL+ST @ Center	LL @ Cants	LL+ST @ Cants	
Max. M +	108.46 k-ft	94.96	108.46				k-ft
Max. M -							k-ft
Max. M @ Left							k-ft
Max. M @ Right							k-ft
Shear @ Left	14.46 k	12.66	14.46				k
Shear @ Right	14.46 k	12.66	14.46				k
Center Defl.	-0.990 in	-0.867	-0.990	-0.990	0.000	0.000	in
Left Cant Defl	0.000 in	0.000	0.000	0.000	0.000	0.000	in
Right Cant Defl	0.000 in	0.000	0.000	0.000	0.000	0.000	in
...Query Defl @	0.000 ft	0.000	0.000	0.000	0.000	0.000	in
Reaction @ Left	14.46	12.66	14.46	14.46			k
Reaction @ Rt	14.46	12.66	14.46	14.46			k

Steel Beam Design

Description Typical Chiller Bay Beam

Section Properties W18X40

Depth	17.900 in	Weight	40.08 #/ft
Web Thick	0.315 in	Ixx	612.000 in4
Width	6.015 in	Iyy	19.100 in4
Flange Thick	0.525 in	Sxx	68.400 in3
Area	11.80 in2	Syy	6.350 in3
Rt	1.520 in	R-xx	7.210 in
Values for LRFD Design....		R-yy	1.270 in
J	0.810 in4	Zx	78.400 in3
Cw	1,440.00 in6	Zy	9.950 in3
		K	0.927 in