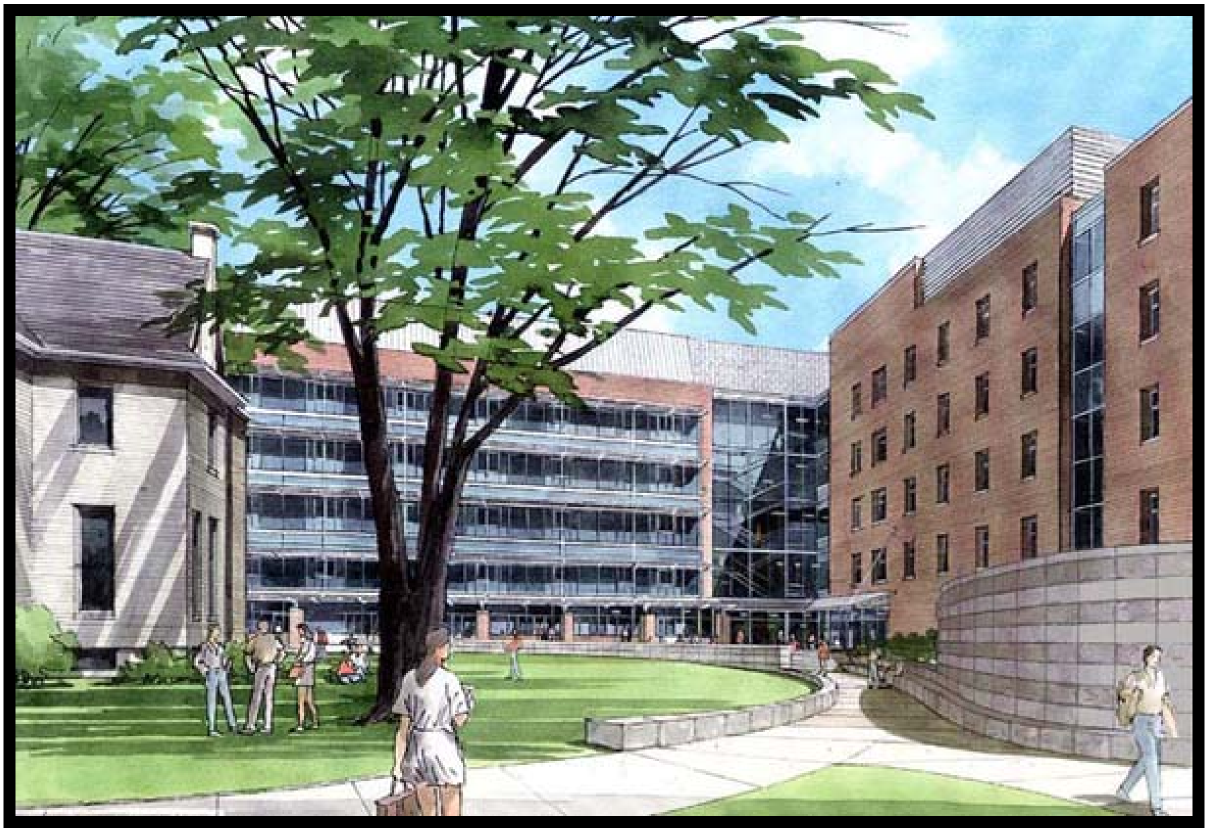
SENIOR THESIS FINAL DESIGN REPORT



THE PENNSYLVANIA STATE UNIVERSITY CHEMISTRY BUILDING

UNIVERSITY PARK, PENNSYLVANIA

PREPARED FOR:
THE PENNSYLVANIA STATE UNIVERSITY
DEPARTMENT OF ARCHITECTURAL ENGINEERING

BY:
ADAM J. SENK
MECHANICAL OPTION
APRIL 3, 2005

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EXECUTIVE SUMMARY

This thesis presents a case study of The Pennsylvania University Chemistry Building. The Chemistry Building is located on the University Park Campus on Shortledge Road, and serves the Pennsylvania State University's Eberly College of Science. The building houses a variety of science laboratories, the majority of the college faculty offices, faculty support staff offices, graduate student offices, conference rooms, a lecture auditorium, and several seminar halls. Architectural aspects of the building include an aluminum hip roof, which encloses a mechanical penthouse; along with a two story enclosed pedestrian bridge that connects the Chemistry Building to its adjacent building, Life Science. Also, one of the university's central chiller plants inhabits the building, which provides 4,050 tons of cooling to the surrounding university buildings. Through thorough analysis of the building, in regards to future energy cost, fire protection, and structural integrity, it is advised that certain adaptations be made to the building.

The Mechanical Focus design will investigate the issue of future energy costs for the Chemistry Building's chilled water plant. Two systems will be evaluated in the focus, the original electric centrifugal chiller system and a two stage absorption chiller system. The systems were evaluated on energy costs for operation and installed equipment cost. Allegheny Power will supply the electric input for the electric centrifugal chillers, while the absorption chiller's input will be supplied by the university coal powered steam plant. The study found that in the future, coal would save $661,431 per year. Moreover, the additional equipment required for the absorption chiller system would have a payback period of less than two years.

The second section of the document is a Fire Protection Breadth. This topic analyzes the atrium, one of the building's architectural elements. During the original design, the atrium was changed from five stories to four stories, as a result a smoke evacuation system was deemed not needed. In this breadth, the atrium was returned back to five stories and a smoke evacuation system was sized and evaluated using a transient model, and computational fluid model. A contamination study was also used to evaluate whether the air supply to other parts of the building, or other surrounding buildings would be contaminated during system use. The system was found to have too long of a delay between fire ignition and fan activation. It was determined that the system was capable of carrying out its function, but needed an automatic detection system that would detect the fire almost instantaneously. Furthermore, the performance of the design was found by the computational fluids model to be capable of further enhancement by using multiple make-up and exhaust locations to entrain the air in the space.

The third and final section of this document evaluates the structural integrity of the building's steel skeleton after the Fire Protection Breadth's centrifugal fans had been placed on the roof of the penthouse. The evaluation was conducted using a RAM Structural model on a gravity load basis and found the structural framing was in need of redesigning to support the additional load. Several beams were moved, and additional structural bracing was added to represent the specific framing needs to support the equipment. However, the columns were found capable of carrying the additional gravity based load.

In conclusion, certain aspects of the Pennsylvania State University Chemistry Building may benefit from further analysis of key issues. Future energy costs, fire protection, and structural redesign, are a few of these aspects. After evaluating these topics, it becomes evident that there are beneficial changes to be made to this building.

THE PENNSYLVANIA STATE UNIVERSITY
CHEMISTRY BUILDING
UNIVERSITY PARK, PA

ADAM J. SENK
MECHANICAL OPTION
WWW.ARCHE.PSU.EDU/THESIS/EPORTFOLIO/CURRENT/PORTFOLIOS/AJS394/

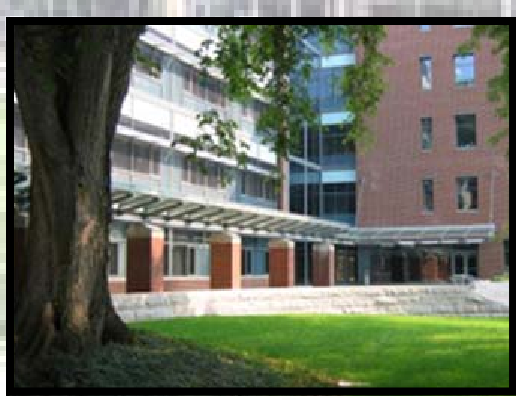
BUILDING: 5 Occupied stories, Basement, Mechanical Penthouse
SIZE: 181,890 Sq Ft
COST: $62.5 Million Total, $57.5 Million State funded, $5 Million Privately funded
COMPLETION: *Phase I-* Started 10/25/01 and was substantially completed 10/01/02, *Phase II-* Started 3/28/02 and was substantially completed 12/28/03

OWNER: The Pennsylvania State University
ARCHITECT: Bower Lewis Thrower Architects, Payette Associates Inc.
LANDSCAPE ARCHITECT: Lager Raabe Skafte Landscape Architects
CM: Reynolds Construction Management, Inc
MECH. ENGINEER: BR+A Consulting Engineers
STRUCTURAL ENGINEER: Gannett Fleming
GENERAL CONTRACTOR PHASE I: L.S. Fiore INC.
GENERAL CONTRACTOR PHASE II: Alexander Building Construction, LLC.
COST CONSULTANT: Becker & Frondorf

MECHANICAL SYSTEMS:
- 4 Interior Air handlers Units
- Variable & Constant Volume Boxes
- Laboratory Hooded Exhaust
- Radiant Ceiling Panels (Heating)
- 4050 Ton Chiller Plant

ELECTRICAL SYSTEMS:
- 3000 AMP, 480/277 V, 3-Phase, 4 Wire
- Emergency Generator: 5000 KW, 480/277 V, 3-Phase, 4 Wire

LIGHTING:
- Typical 277V Lighting System
- Lighting is Primarily Fluorescent



STRUCTURAL SYSTEMS:
- Structural Steel Skeleton

FOUNDATION SYSTEMS:
- Spread footing
- Reinforced Concrete Mat

ARCHITECTURAL FEATURES:
- Enclosed Pedestrian Bridge Connecting Chemistry to Life Sciences.
- Aluminum Clad Hip Roof Enclosing Penthouse
- Combination of Glazing, Metal Panels, and Brick Veneer Facade

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EXISTING CONDITIONS

The Pennsylvania State University Chemistry Building is located in University Park Campus on Shortledge Road. Architectural aspects of the building include an aluminum hip roof, which encloses a mechanical penthouse; along with a two story enclosed pedestrian bridge that connects the Chemistry Building to its adjacent building, Life Science. The building also houses one of the university's central chiller plants situated in the basement of the building. This plant provides 4,050 tons of cooling to the surrounding university buildings.

The Chemistry Building serves the Pennsylvania State University's Eberly College of Science. A variety of science laboratories which range from Organic Chemistry Laboratories, Radio Isotope, Bio-Chemistry Laboratories, and Synthetic Chemistry Laboratories to Small/Medium/Large Instrument Laboratories are contained in this building. In addition to the building's laboratories, a majority of the college faculty offices, graduate student offices, and conference rooms are housed here. Also included in the building are the faculty support staff offices, graduate student recruitment facilities, a lecture auditorium and several seminar halls.

MECHANICAL FOCUS

MECHANICAL FOCUS DESCRIPTION

Due to the buildings being consumed primarily of laboratory space and having a high percentage of glazing, The Pennsylvania State University Chemistry and Life Science buildings are the two most energy intensive buildings on campus. As a result, the buildings require a large yearly budget for overhead cost, for instance the building's cooling. The buildings' cooling is supplied by a central chiller plant located in the basement of the Chemistry Building, composed of three 1,350 ton electric centrifugal chillers. In the new design these three electric centrifugal chillers will be replaced by three absorption chillers. The absorption chillers will be steam driven, and their steam will be supplied by the Pennsylvania State University Steam Plant located on campus. The Chemistry Building already has 50,000 Ibs. per hour of high pressure steam service to the basement mechanical space; therefore, an additional line of similar proportion will have to be run to supply the chillers with their needed steam input. In addition to a steam line being included, more changes will be made to the condenser water side of the system. Because the absorption chillers will reject more condenser water in their process than the electric centrifugal chillers supplementary pumping of that water will be needed along with additional cooling of that water. Two pumps must be incorporated to support the transport of the condenser water. Furthermore an additional two cooling towers will be added to support the cooling of that extra load of the condenser water.

The chilled water side of the system will not be affected by the changing of the chillers. The absorption chillers were sized to support the same cooling load at the same gpm as the original chillers. This will prevent the need to change any of the chilled water equipment. The original flow from each electric centrifugal chiller was 2,022 gpm; the new flow will be 2,082 gpm. This change in flow equates to less than three percent of the original flow.

The best option for cooling will be derived by comparing steam and electric rates along with the additional equipment costs for each option.

EXISTING SYSTEMS SUMMARY USE

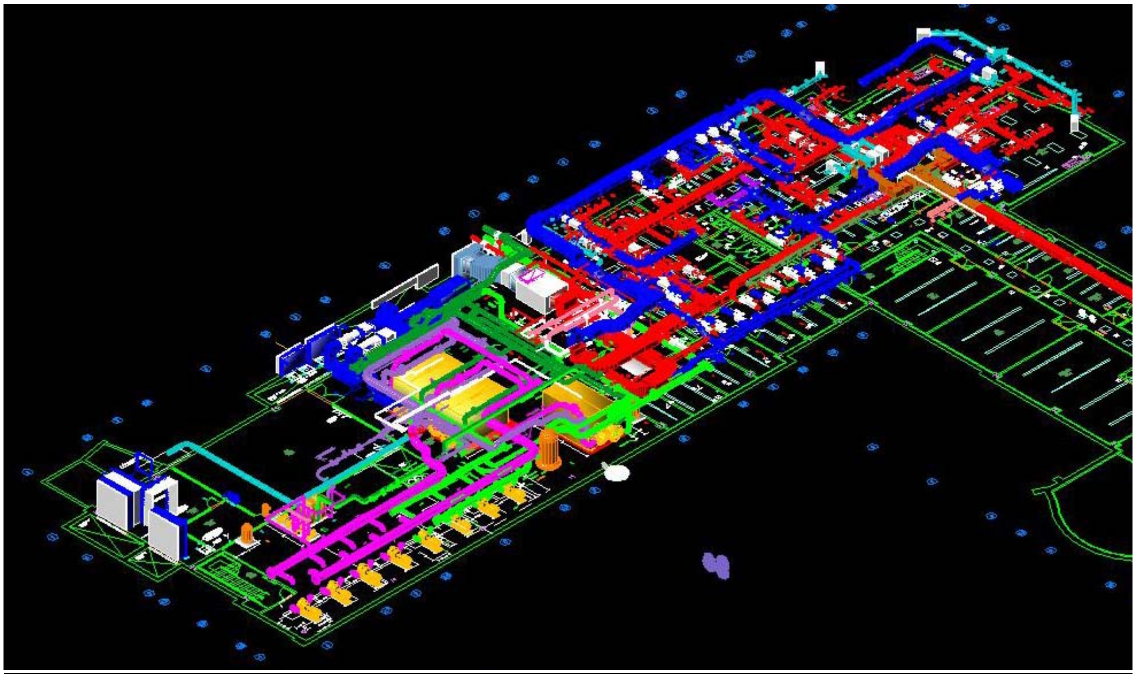


***Figure 1**:* Entire Basement Mechanical Isometric

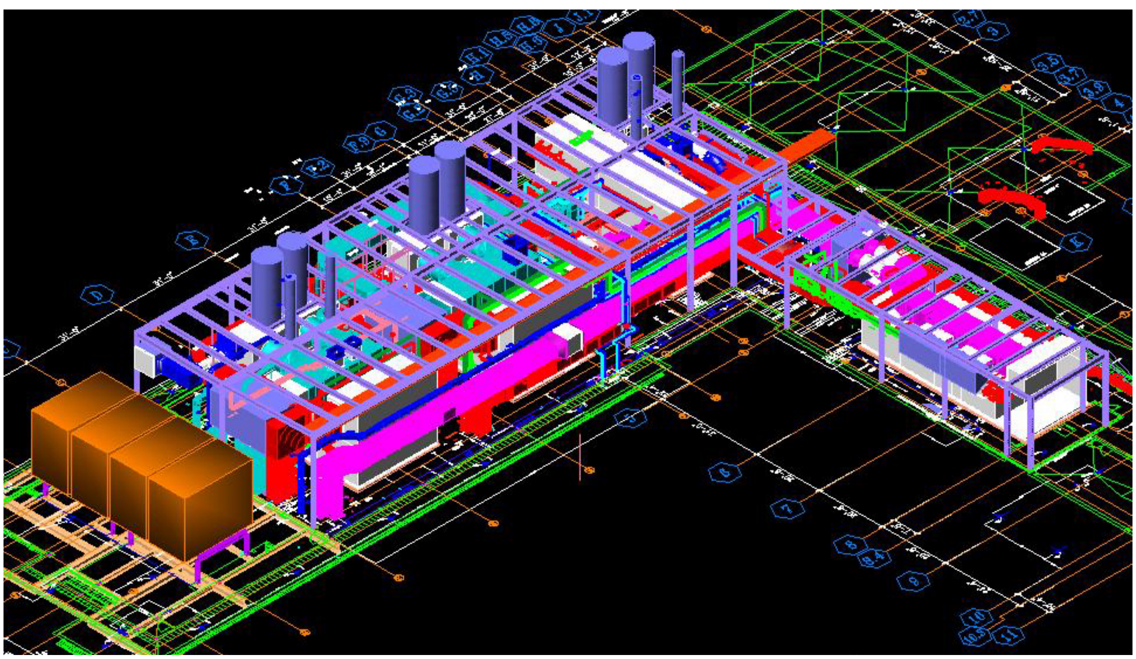


Figure 2: Entire Penthouse Mechanical Isometric

STEAM

Steam service enters through the basement wall as HPS. It first passes through a steam meter; it then stems off into three branches. One branch directly feeds into CP-1. The other two branches travel through a series of pressure reducing valves PRV-1A and PRV-B for LPS, and PRV-2 for MPS. The LPS then travels directly to the penthouse to HE-1 and HE-2(Stand-By). Steam will also be distributed to AHU-1, AHU-2, AHU-3, and AHU-4.

MPS is distributed to HE-3 and HE-4 in the basement for the building hot water, and to the 2^{nd} and 3^{rd} floor for autoclaves to sterilize lab equipment.

Condensate is drained to the basement and pumped back to the cogeneration plant by CP-1 through the service pipe which enters next to the steam service pipe.

HOT WATER

Hot water will be generated at HE-1 and HE-2 by LPS. The hot water will first pass through expansion tank TK-1 and an air separator before entering HWP-1 and HWP-2. HWP-1 and HWP-2 pump the hot water to 6 other hot water pumps and 10 outlets on the six levels of the building which feed VAV and CAV boxes. These six hot water pumps supply the building facade. HWP-3, HWP-4, and HWP-5 supply the North and South facade VAV and CAV boxes; while, HWP-6, HWP-7, and HWP-8 supply the East and West facade VAV and CAV boxes.

CHILLED WATER

Chilled water is generated in the basement of the building by three 1,350 ton centrifugal chillers; CH-1, CH-2, and CH-3. The chilled water is pumped by four 2,022 gpm chilled water pumps; CHP-1, CHP-2, CHP-3, and CHP-4. Next, the water passes through an air separator and expansion tank TK-2 before continuing to one of three options: [1] AHU-1, AHU-2, AHU-3, and AHU-4; [2] PCHP-1 and PCHP-2; or [3] another building such as the Life Science Building. Water traveling to the air handlers will pass through the cooling coils for cooling air supplied by the handler. Water traveling to PCHP-1 and PCHP-2 will travel through an air separator and expansion tank TK-3 before traveling to HE-3 and HE-4 for further cooling before continuation on to the VAV and CAV boxes on the six building levels.

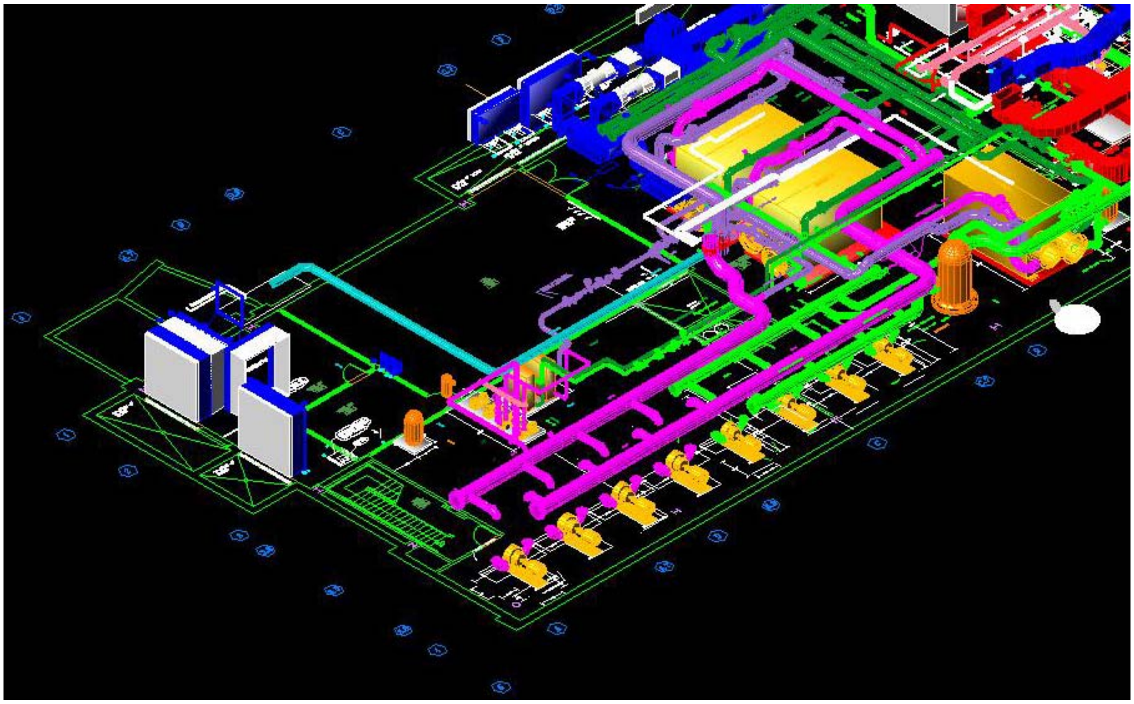


Figure 3: Basement Electric Centrifugal Chillers [Yellow], Chilled Water Pumps [Yellow w/ Magenta], Condenser Water Pumps [Yellow w/ Green] Isometric

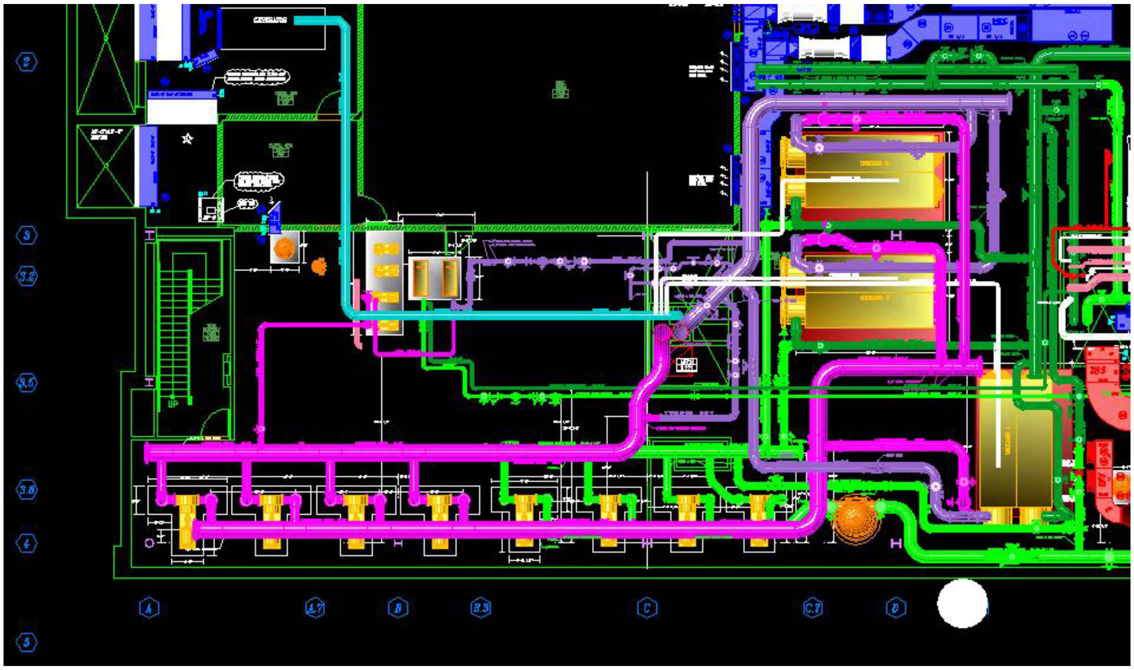


Figure 4: Basement Electric Centrifugal Chillers [Yellow], Chilled Water Pumps [Yellow w/ Magenta], Condenser Water Pumps [Yellow w/ Green] Plan

CONDENSER WATER

Condenser water is supplied to the mechanical equipment in the basement using six pumps. CWP-1, CWP-2 CWP-3, and CWP-4 supply condenser water to CH-1, CH-2, and CH-3. CWP-5 and CWP-6 supply heat exchanger HE-4, which conditions chilled water traveling to the VAV and CAV boxes. Returned condenser water from the mechanical equipment is then pumped to the roof where it will reconditioned by cooling towers CT-1, CT-2, CT-3, and CT-4 before returning to the pump stations.

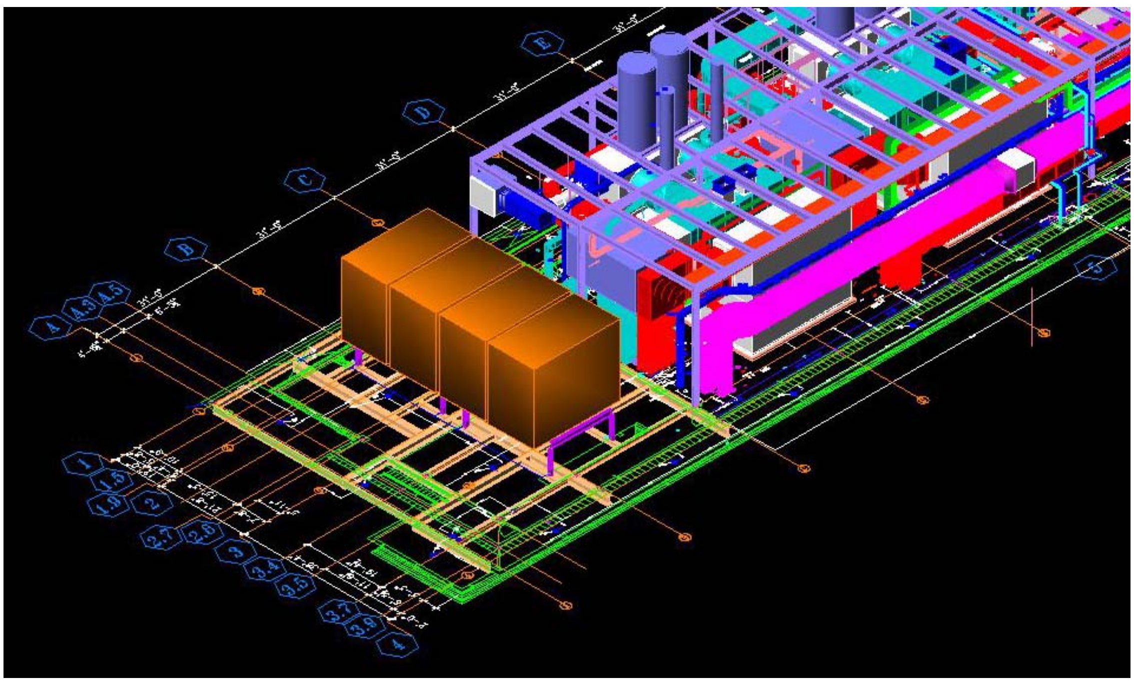


Figure 5: Penthouse Cooling Tower [Gold] Isometric

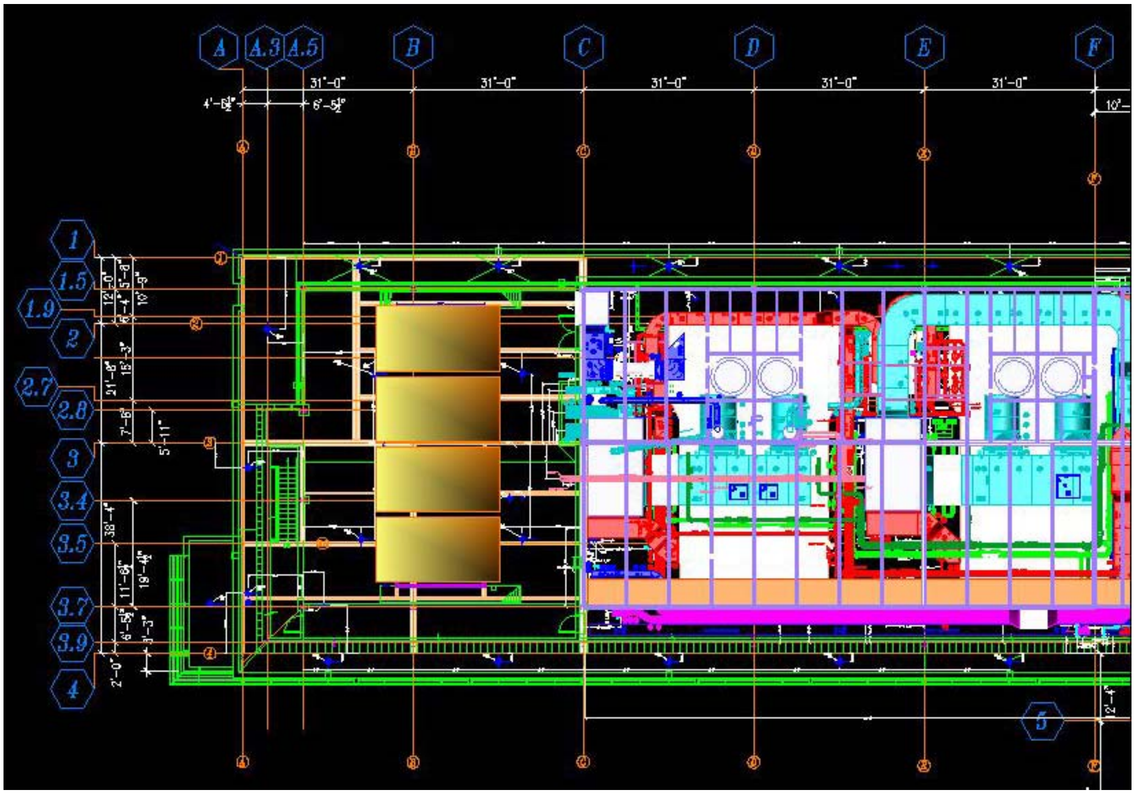


Figure 6: Penthouse Cooling Tower [Gold] Isometric

CONDITIONED/EXHAUSTED AIR

Four air handlers: AHU-1, AHU-2, AHU-3, and AHU-4 supply conditioned air for the system. Each air handler has a designated area which it supplies. Air is supplied to each level through one of three central mechanical shafts. The amount of air supplied to each level can be seen in the Air Flow Schematic.

Air is continuously exhausted from laboratory areas on each level. Each run of exhausted air travels to the penthouse were it is exhausted into a plenum. Via an exhaust stack plenum air is exhausted through the penthouse roof.

NOTE: Schematics for original mechanical setup can be found in the Existing Mechanical Appendix.

EXISTING EQUIPMENT SCHEDULES

The equipment listed in the following section is the equipment which will be analyzed and replaced in the Mechanical Focus Design.

NOTE: Additional equipment not considered in the analysis can be found in the Mechanical Equipment Appendix located at the end of this document.

CENTRIFUGAL CHILLER SCHEDULE																			
UNIT	# TONS	ELEC. DATA		EVAPORATOR							CONDENSOR						COMPRESSOR DATA		
		VOLTS	PHASE	EWT (°F)	LWT (°F)	GPM	FLUID	# PASSES	FOULING FACTOR	ΔP (FT H20)	EWT (°F)	LWT (°F)	GPM	# PASSES	FOULING FACTOR	ΔP (FT H20)	RLA	KW RATING	KW/TON MAX
CH-1	1,350	4,160	3	56	40	2,022	Water	2	0.0005	34	83	93	3,822	2	0.001	24	130	833	0.617
CH-2	1,350	4,160	3	56	40	2,022	Water	2	0.0005	34	83	93	3,822	2	0.001	24	130	833	0.617
CH-3	1,350	4,160	3	56	40	2,022	Water	2	0.0005	34	83	93	3,822	2	0.001	24	130	833	0.617

Figure 7: Centrifugal Chiller Schedule

COOLING TOWER SCHEDULE												
UNIT	TONS	EWT (°F)	LWT (°F)	EAT (°F)	GPM	QUANITY FANS	MOTOR DATA @ 60HZ					
							MHP	RPM	SPEEDS	REVERS.	VOLTS	PHASE
CT-1	1,015	93	83	75	2,867	1	75	X	2	Y	480	3
CT-2	1,015	93	83	75	2,867	1	75	X	2	Y	480	3
CT-3	1,015	93	83	75	2,867	1	75	X	2	Y	480	3
CT-4	1,015	93	83	75	2,867	1	75	X	2	Y	480	3

Figure 8: Cooling Tower Schedule

CONDENSATE PUMP SCHEDULE											
UNIT	LOCATION	MIN. REC. CAPACITY (GAL)	MIN. VENT SIZE (INCH)	GPM	SUCTION TEMP.	DISCH. PRESS. (PSIG)	# PUMPS	MOTOR DATA @ 60HZ			
								MHP EA	RPM	VOLTS	PHASE
CP-2	BASEMENT	52	2.5	45	212	15	2	2	3,500	480	3

Figure 9: Condensate Pump Schedule 1

CONDENSATE PUMP SCHEDULE							
UNIT	LOCATION	#'s/HR	GPM	STEAM PSI	SUCTION TEMP	BACK-PRESS PSI	# OF PUMPS
CP-1	BASEMENT	30000	350	90	212	60	1

Figure 10: Condensate Pump Schedule 2

WATER PUMP SCHEDULE											
UNIT	LOCATION	SERVICE	TYPE	GPM	TOTAL HEAD (FT H20)	MAX. NPSH	MOTOR DATA @ 60HZ				
							BHP	MHP	RPM	VOLTS	PHASE
CMP-1	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-2	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-3	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-4	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-5	Basement	Cond. Water	End Suction	360	70	6	8.5	10	1,750	480	3
CMP-6	Basement	Cond. Water	End Suction	360	70	6	8.5	10	1,750	480	3
HMP-1	Penthouse	Hot Water	End Suction	570	50	7	8.5	10	1,750	480	3
HMP-2	Penthouse	Hot Water	End Suction	570	50	7	8.5	10	1,750	480	3
HMP-3	Penthouse	Zone Façade (N)	In-Line	32	35	4	0.8	1	1,750	480	3
HMP-4	Penthouse	Zone Façade	In-Line	44	35	4	0.8	1	1,750	480	3
HMP-5	Penthouse	Zone Façade (S)	In-Line	44	35	4	0.8	1	1,750	480	3
HMP-6	Penthouse	Zone Façade (E)	In-Line	20	35	4	0.5	0.75	1,750	480	3
HMP-7	Penthouse	Zone Façade	In-Line	25	35	4	0.5	0.75	1,750	480	3
HMP-8	Penthouse	Zone Façade (W)	In-Line	10	35	4	0.5	0.75	1,750	480	3
CHP-1	Basement	Chilled Water	HSC	2,022	110	10	71	100	1,750	480	3
CHP-2	Basement	Chilled Water	HSC	2,022	110	10	71	100	1,750	480	3
CHP-3	Basement	Chilled Water	HSC	2,022	110	10	71	100	1,750	480	3
CHP-4	Basement	Chilled Water	HSC	2,022	110	10	71	100	1,750	480	3
PCHP-1	Basement	Proc. Chilled	End Suction	360	60	6	6.5	10	1,750	480	3
PCHP-2	Basement	Proc. Chilled	End Suction	360	60	6	6.5	10	1,750	480	3

Figure 11: Water Pump Schedule

DESIGN CHANGES

The first major change in design that was considered was the replacing the three 1,350 ton electric centrifugal chillers with three two stage 1,350 ton absorption chillers. The new absorption chillers will be powered by steam produce at the Pennsylvania State University Steam Plant. Each of the chillers will consume 13,891 Ib/hr of steam. Because of this change, parts of the system will have to be resized to accommodate the new chiller type. However, the chilled water side of the system will not change at all, because the sizing of chiller was done not only to meet the cooling load but to do so while meeting the cooling load and generating a comparable chilled water flow. The original chilled water flow was 2,022 GPM, and the new chilled water flow will be 2,082 GPM. This increase equates to less than a three percent change in the chilled water flow. Therefore there is no need to change any of the chilled water side; it is within capacity.

The second major change will be on the condenser water side of the system. Because the chiller has a higher condenser load due to the latent load of the chiller, two additional condenser water pumps will be needed in order to transport the new condenser water load. One will have to be purchased, while one is already hooked up in a standby role. Changing the condenser pumps from three 3,823 GPM pumps to five 3,823 GPM pumps will meet the new load of 6,113 tons. Additionally, cooling towers will have to be added to meet the new load. The original load for the system was 3,823 tons and the towers had the capacity of 4,060 tons. The new design will use the spare cells on the roof for additional cooling towers that were already accounted for structurally. Two additional cooling towers will then be added giving the new system a capacity of 6,324 tons. The new capacity will be achieved with six cooling towers, because the nominal tonnage for the model of cooling towers being used is 1,054 tons.

Other changes requiring to be made in system include the addition of a second high pressure steam line. When the building was erected a steam tunnel was constructed to serve buildings off the main campus loop. The building's steam tunnel brings one 50,000 Ib/hr to service the building's domestic hot water, autoclaves, and heating needs. Another line will have to be brought through the tunnel to service the absorption chillers. The chillers at full capacity will require a service load of 41,673 Ib/hr; therefore, a service line of 50,000 Ib/hr will be required. This is well within the firm capacity of the steam plant at 456,000 Ib/hr without the largest boiler in operation.

The new service line will be brought in and travel immediately to a steam reducing station where two steam reducing valves in parallel will reduce the 175 psi steam down to 120 psi. The steam will then be directly fed to the absorption chillers.

Another issue addressed is the condensate produced by the chillers. The building's condensate pump and tank were designed to withstand only 30,000 Ib/hr. The tank capacity is 53 gallons. The new condensate will be sized to hold the capacity of 80,000 Ib/hr, and the new tank size for the system will be 110 gallons. The pump will be compressed air driven supplied by the university steam plant.

TECHNICAL SUPPORT FOR CHANGES

According to the Energy Information Administration, the official energy statistics from the U.S. Government, coal prices have been on the rise the past few years, but there is evidence that once again they are steadying. Coal will not again be sold at the low premium prices that were seen prior to May 2003; however, the prices will be seen at steady trend and will not float more than 5-7 percent. In addition, SO_2 allowance prices are falling. In December 2005, prices set a record at $1,630 but as recently as February of this year the prices had fallen to $920. This equates to a 44 percent reduction in prices. The only negatives for coal, include a new initiative by the DOE and EPA to retrofit coal powered plants with additional flue-gas scrubbers by 2011.

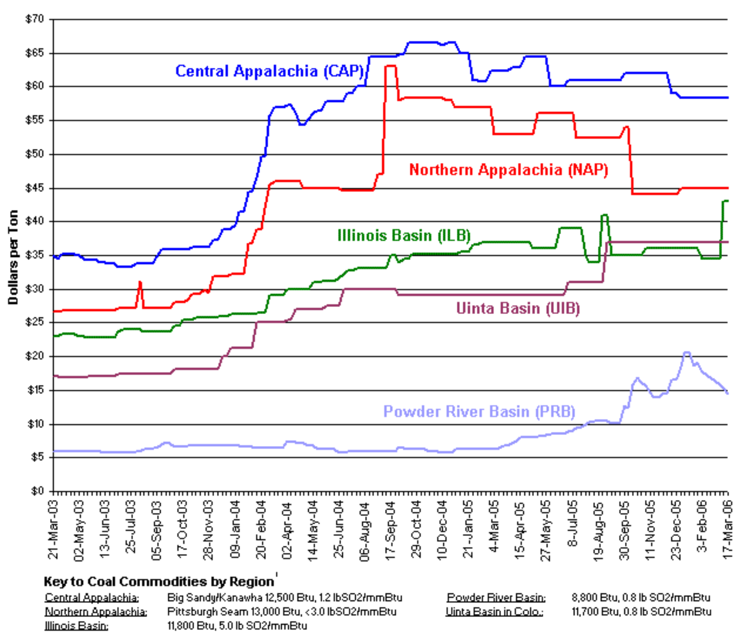


Figure 12: EIA Coal Cost Trends

Other information supporting changes has come from the Energy Information Administration estimating that the average price per kilowatt of electricity for a university is projected to be over $0.12 per kilowatt for the coming year. The Pennsylvania University is currently paying $0.03658 per kilowatt; however, in this coming year they will be renegotiating with Allegheny Power for a new rate. The university could see as much as a 70 percent increase in their electric rate. And according to a resource at Bucknell University, leases for these prices will be harder to find for more than 2-3 year contracts. Also, electric rates are supposed to continue rising because of the deregulating of electricity. The Energy Information Administration has projected them to be as high $0.20 per kilowatt by 2010 for this area.

Due to inflating electric rates and coal becoming more stable in price, a cost comparison in price per unit of energy needs to be taken. However, another factor that needs to be taken into account is the equipment cost, which will make an indepth cost analysis a compelling argument for which fuel source the university should use given that it has availability to each resource.

LOAD PROFILES

The following design profiles are hypothetical in nature. The Chemistry Building has no metering equipment installed to monitor the electricity being consumed by the building or the chiller plant. The load profiles in this section are the load profiles which were used by Bard, Rao plus Athanas Consulting Engineers, LLC to size the chiller plant and chiller configuration. The profile is in nominal tonnage and has been converted to kilowatts. Also the profiles have been graphed on a 24 hour duration. Because the building has not been metered, the design profile has been considered to be the yearly profile.

Chiller Output			
Hours	Tons Total	Tons [310]	Tons [55]
1	557,565.24	1,527.58	1,527.58
2	563,988.88	1,545.18	1,545.18
3	570,412.51	1,562.77	1,562.77
4	567,842.91	1,555.73	1,555.73
5	616,662.03	1,689.49	1,689.49
6	697,035.79	1,939.39	1,742.28
7	804,810.90	2,280.81	1,777.48
8	903,733.82	2,590.54	1,830.28
9	965,558.37	2,780.61	1,883.07
10	1,004,469.27	2,896.76	1,935.87
11	1,037,924.54	2,995.32	1,988.67
12	1,045,896.86	3,012.92	2,034.42
13	1,049,944.81	3,023.48	2,048.50
14	1,074,160.58	3,090.35	2,111.86
15	1,043,714.77	3,005.88	2,034.42
16	1,015,010.89	2,921.40	1,988.67
17	968,462.15	2,780.61	1,935.87
18	911,002.09	2,604.62	1,883.07
19	837,175.27	2,375.84	1,830.28
20	822,268.86	2,337.12	1,777.48
21	785,417.10	2,224.49	1,742.28
22	703,952.14	1,971.07	1,689.49
23	670,620.18	1,876.03	1,619.09
24	630,037.28	1,756.36	1,555.73
Total:	19,847,667.20	56,344.33	43,289.54

Chiller Output			
Hours	kw Total	kw [310]	kw [55]
1	1,959,130.81	5,367.48	5,367.48
2	1,981,701.70	5,429.32	5,429.32
3	2,004,272.58	5,491.16	5,491.16
4	1,995,243.72	5,466.42	5,466.42
5	2,166,780.65	5,936.39	5,936.39
6	2,449,191.94	6,814.48	6,121.90
7	2,827,884.00	8,014.12	6,245.57
8	3,175,471.94	9,102.46	6,431.09
9	3,392,706.39	9,770.30	6,616.60
10	3,529,428.58	10,178.43	6,802.11
11	3,646,981.18	10,524.72	6,987.62
12	3,674,993.74	10,586.55	7,148.40
13	3,689,217.10	10,623.66	7,197.87
14	3,774,304.67	10,858.64	7,420.48
15	3,667,326.47	10,561.82	7,148.40
16	3,566,468.92	10,265.00	6,987.62
17	3,402,909.47	9,770.30	6,802.11
18	3,201,010.64	9,151.93	6,616.60
19	2,941,603.51	8,348.04	6,431.09
20	2,889,226.47	8,212.00	6,245.57
21	2,759,739.54	7,816.24	6,121.90
22	2,473,494.07	6,925.78	5,936.39
23	2,356,374.76	6,591.86	5,689.04
24	2,213,777.62	6,171.37	5,466.42
Total:	69,739,240.46	197,978.47	152,107.52

Figure 13: Chiller Plant Load Profile by Hour Ton & KW

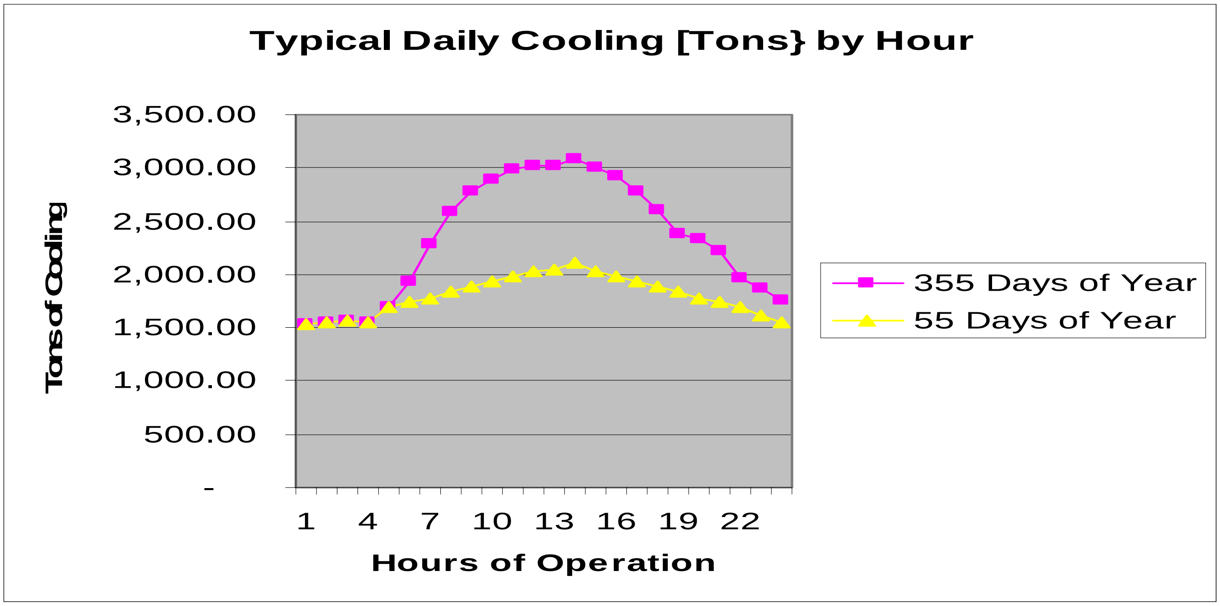


Figure 14: Typical Daily Cooling [Tons] by Hour Profile

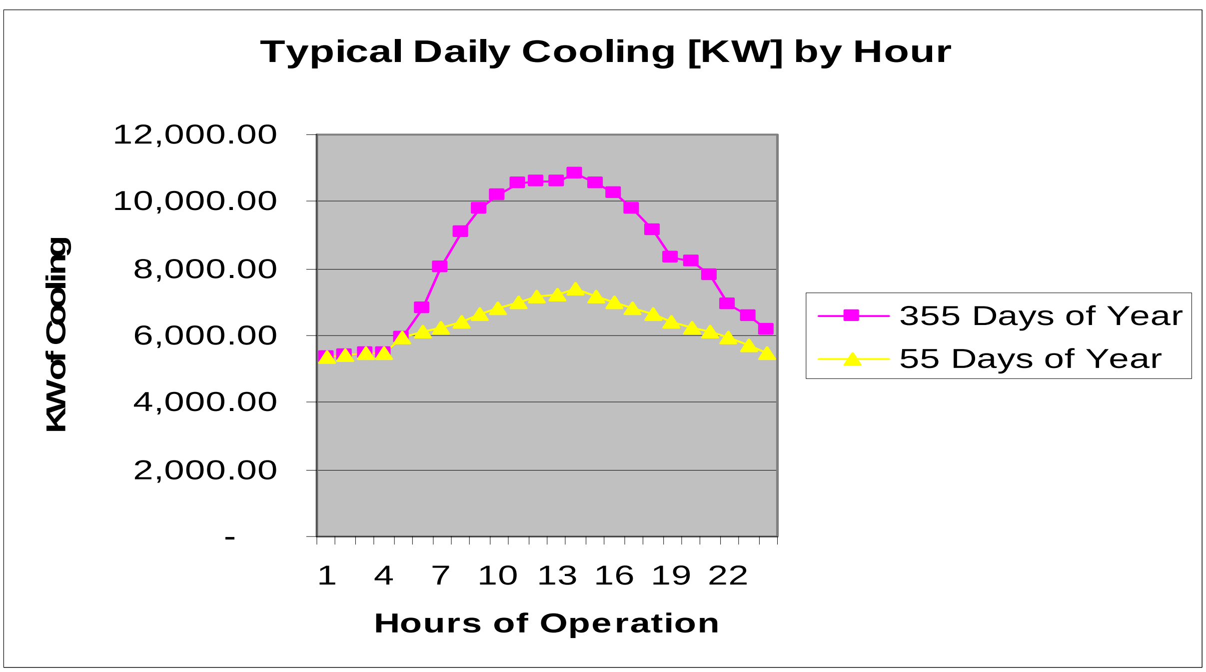


Figure 15: Typical Daily Cooling [KW] by Hour Profile

DESCRIPTION OF SUBSTITUTE EQUIPMENT

The following absorption chiller is a Trane product. It is a two stage absorption chiller sized to the same nominal tonnage as the existing electrical centrifugal chillers. The chiller was also sized to keep the existing chilled water side equipment the same. Further information regarding this piece of equipment can be found in the Absorption Chiller Appendix.

ABSORPTION CHILLER													
Model	Unit Model	Unit tonnage	Unit Energy Source	Cooling Capacity	Absorber			Evaporator			Generator		
					Absorber EWT [F]	Absorber LWT [F]	Absorber Flow [GPM]	Evaporator LWT [F]	Evaporator EWT [F]	Evaporator Flow [GPM]	Steam Pressure [PSI]	Steam Flow [lb/hr]	Steam Rate [lb/ton-hr]
ABFTF1350	Two Stage	1350	Steam	1394.97	83	93	6113.16	40	56	2082.58	120	13891.81	9.96

Figure 16: Absorption Chiller Schedule

The condenser water pumps used in the existing condenser water system are the same water pumps which will be used when the condenser water system is resized. Instead of using three centrifugal water pumps, the system will be resized to use five of the same type and size of pumps. The pumps are manufactured by Bell & Gossett. Further information regarding this piece of equipment can be found in the Condenser Pump Appendix.

WATER PUMP SCHEDULE											
UNIT	LOCATION	SERVICE	TYPE	GPM	TOTAL HEAD (FT H20)	MAX. NPSH	MOTOR DATA @ 60HZ				
							BHP	MHP	RPM	VOLTS	PHASE
CMP-1	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-2	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-3	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-4	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3

Figure 17: Condenser Water Pump Schedule

The cooling towers used in the existing condenser water system are the same cooling towers which will be used when the condenser water system is resized. Instead of using four cooling towers, the system will be using six of the same cooling towers. The cooling towers are manufactured by Baltimore Aircoil Company. Further information regarding this piece of equipment can be found in the Cooling Tower Appendix.

COOLING TOWER SCHEDULE												
UNIT	TONS	EWT (°F)	LWT (°F)	EAT (°F)	GPM	QUANITY FANS	MOTOR DATA @ 60HZ					
							MHP	RPM	SPEEDS	REVERS.	VOLTS	PHASE
CT-1	1,015	93	83	75	2,867	1	75	X	2	Y	480	3
CT-2	1,015	93	83	75	2,867	1	75	X	2	Y	480	3
CT-3	1,015	93	83	75	2,867	1	75	X	2	Y	480	3
CT-4	1,015	93	83	75	2,867	1	75	X	2	Y	480	3

Figure 18: Cooling Tower Schedule

The condensate pump used in the existing system will need to be replaced with a larger pump in order to deal with the new capacity of the additional steam line. This will also service the new absorption chillers. Instead of using a 30,000 Ib/hr pump with a tank capacity of 53 gallons, the system will have to be resized to 80,000 Ib/hr with a tank capacity of 110 gallons. The pump is manufactured by Spirax Sarco.

CONDENSATE PUMP SCHEDULE							
UNIT	LOCATION	#'s/HR	GPM	STEAM PSI	SUCTION TEMP	BACK-PRESS PSI	# OF PUMPS
CP-1	BASEMENT	80000	350	90	212	60	1

Figure 19: Condensate Pump Schedule 1

IMPLEMENTATION OF CHANGES

Figures 20 and 22 show the original mechanical basement plan. Figure 20 depicts the plan in its entirety, while Figure 22 is the plan viewed without any sheet metal work. Figure 21 and 23 similarly show the absorption chiller basement plan. The first major difference noticeable is that the absorption chillers are 1.5 times longer than the original electric centrifugal chillers. The second major difference is that an additional condenser pump has been installed to the condenser pump line. Additional changes will be discussed through the progression of the figures.

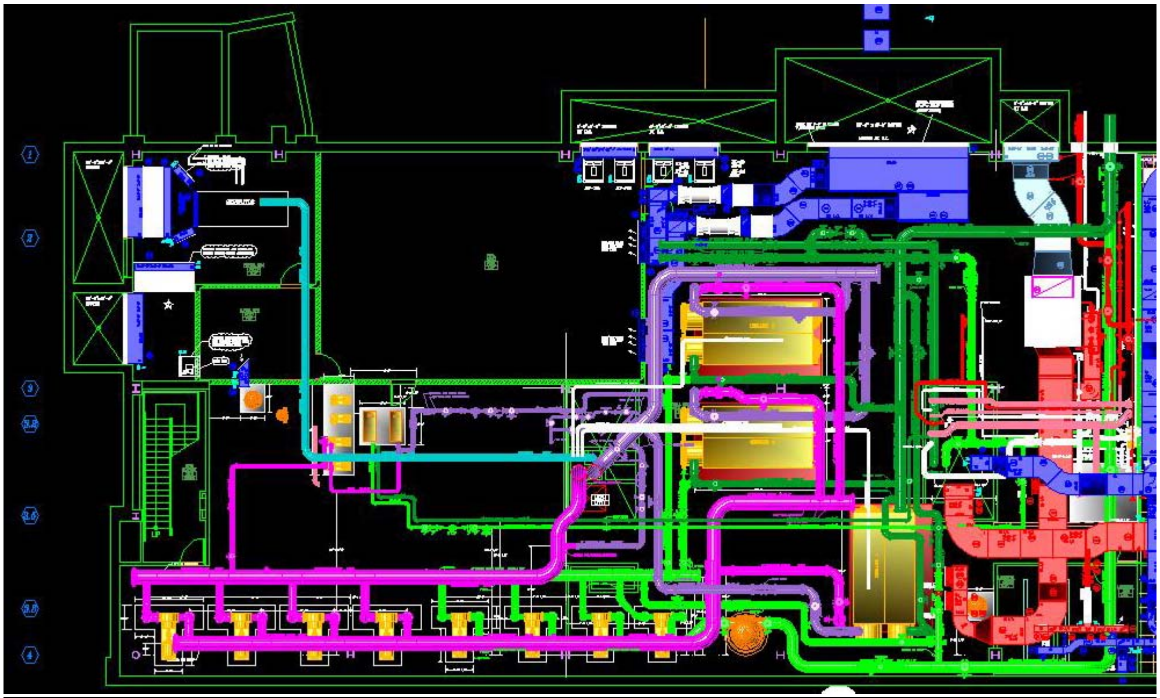


Figure 20: Original Basement Mechanical Plan

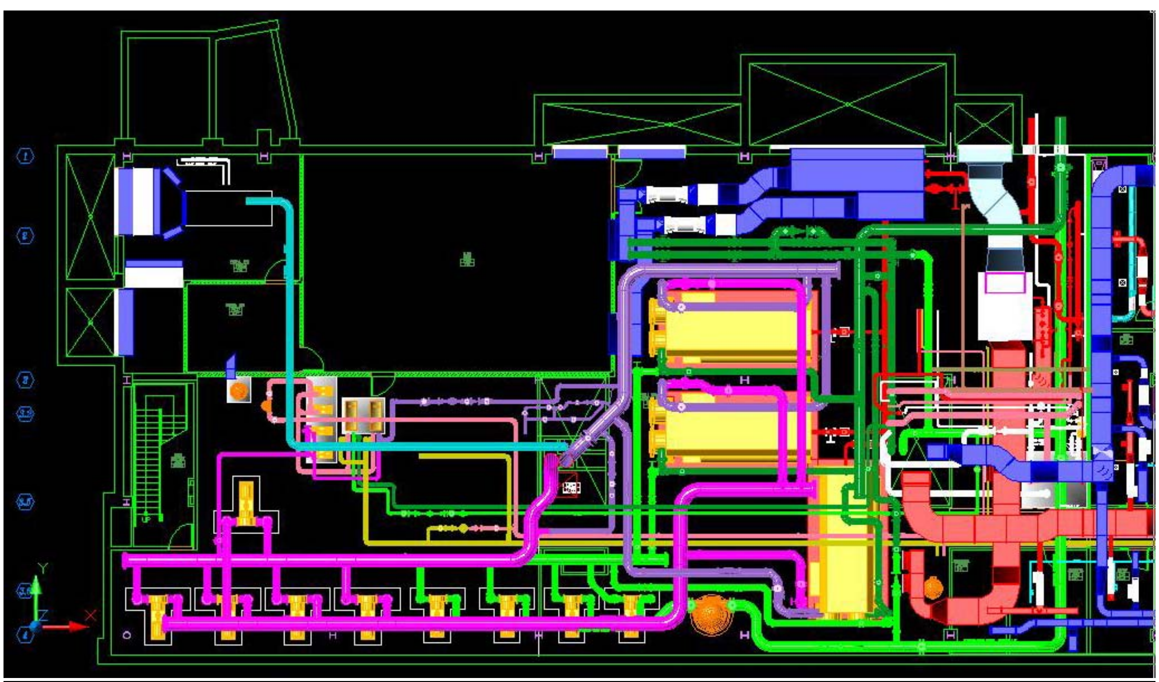


Figure 21: Absorption Chiller Mechanical Plan

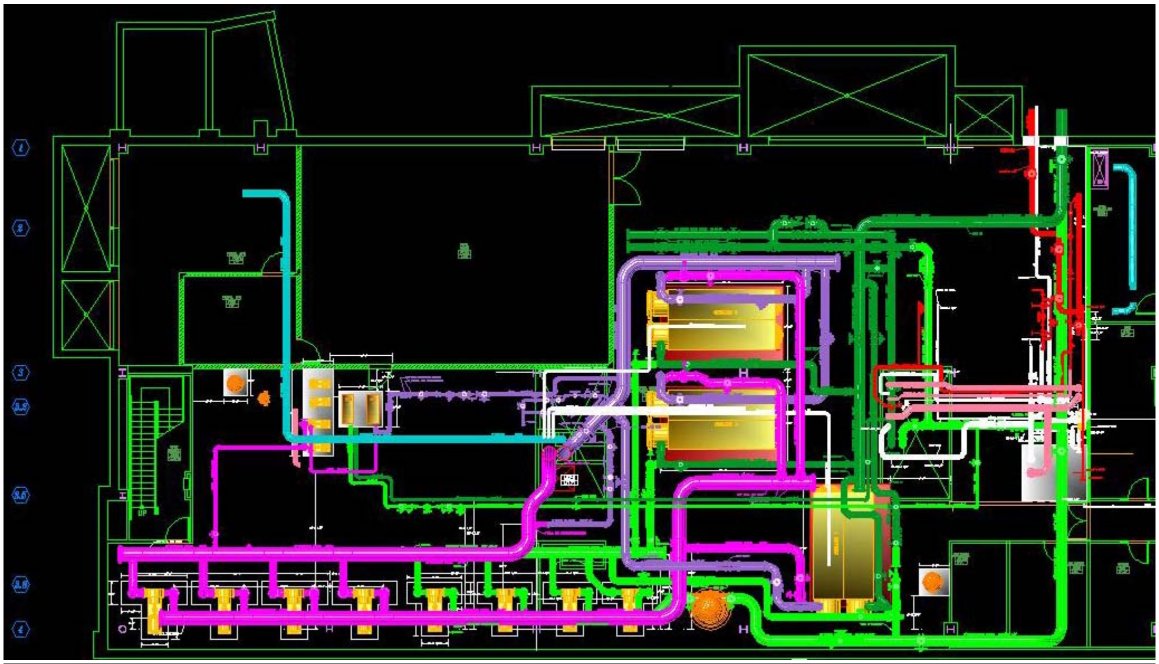


Figure 22: Ductless Original Mechanical Plan

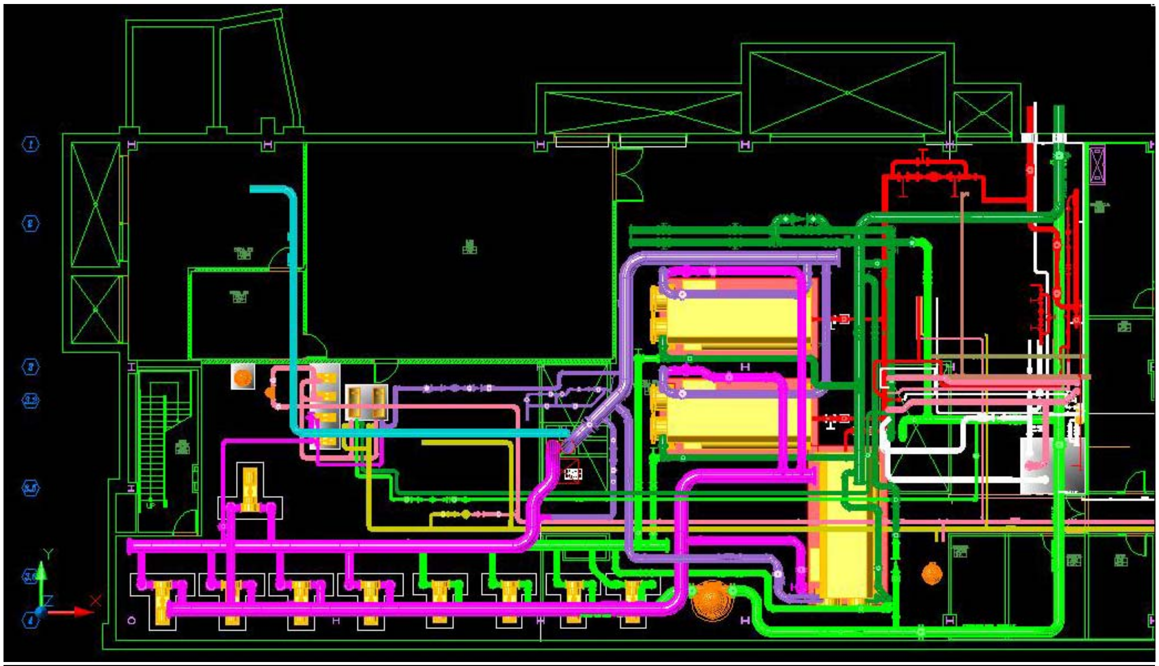


Figure 23: Ductless Absorption Chiller Mechanical Plan

The following plan in Figure 24 shows the new 50,000 Ib/hr steam line which comes in below the original 50,000 Ib/hr steam line that already serviced the building for heating, heating of domestic water, and autoclaves. The steam line comes through the basement wall and travels directly to a steam reducing station where the pressure is reduced from 175 psi to the 120 psi. The reduction in pressure is needed for the two stage absorption chillers.

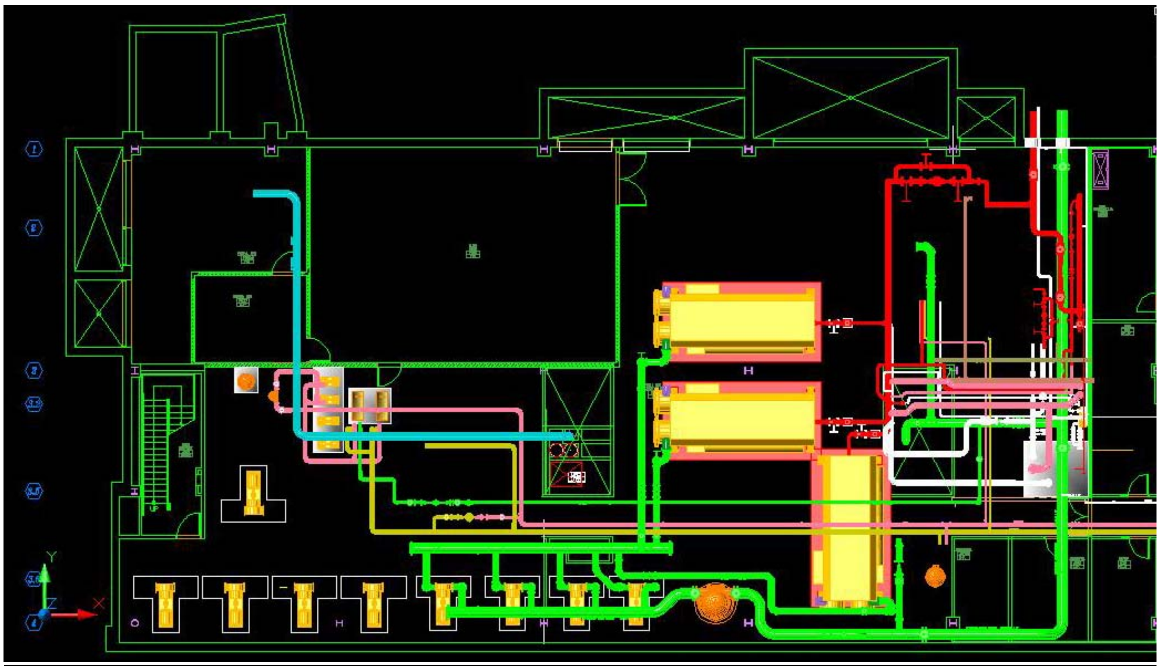


Figure 24: Absorption Chiller Mechanical Plan with Steam Lines, Chilled Water, and Condensate

Figure 25 demonstrates an isometric view of the steam entrance to the building. The steam lines enter the building one above the other. The original steam line which served the building for heating, domestic water heating, and autoclave use is located on top. The new steam line which will serve the absorption chillers is below. Both lines are 50,000 Ib/hr. As mentioned previously, the new steam line enters the building and passes through a steam reducing station to reduce the pressure from 175 psi to 120 psi. From this view however, the setup of the steam reducing station can be observed. The steam line is split into two parallel lines. Each line begins and ends with a gate valve to enable equipment within to be isolated for maintenance or removal of items if necessary. The steam then travels through a strainer turned on its side, and then through the pressure reducing valve.

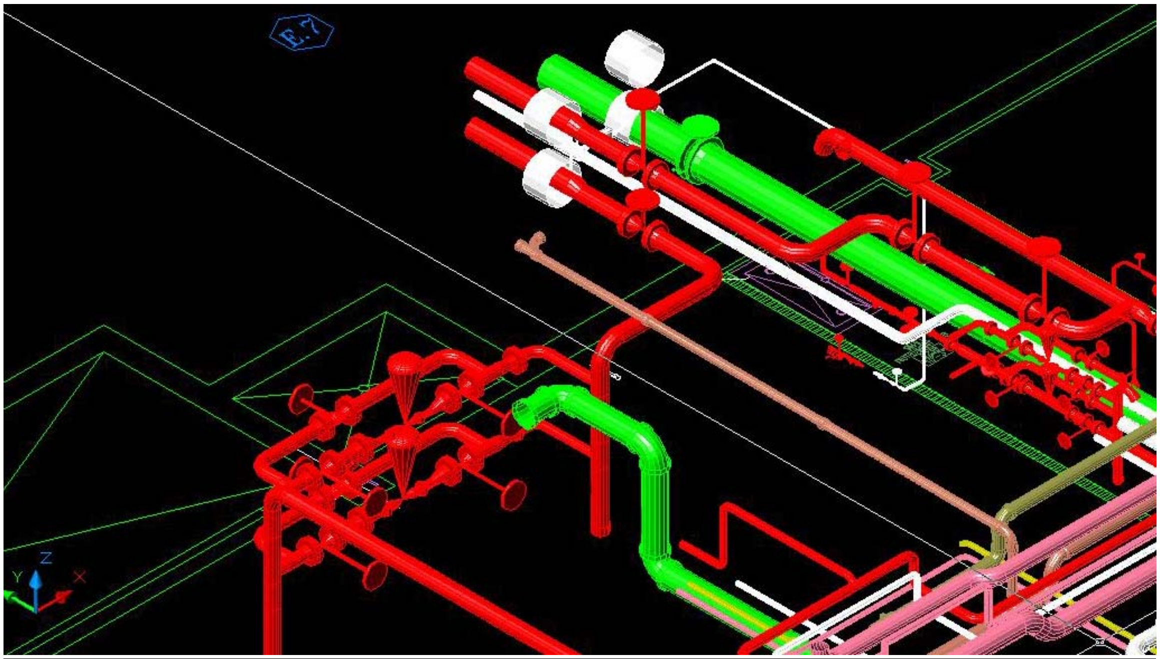


Figure 25: New Steam Service with Steam Pressure Reducing Station

Figure 26 shows the new absorption chillers and their connection to the new steam line and condensate line. The steam is colored red while the condensate is colored white. As seen below the steam comes directly from the steam reducing station at 120 psi. The line "T's" into absorption chiller 1 and absorption chiller 2 before terminating after two "90's"at absorption chiller 3. Also, seen in this plan view is the new condensate line which begins at absorption chiller 1. This plan has been made clearer in Figure 28 by removing the steam lines. Absorption chiller 1 and absorption chiller 2 "T" into the line and travel off this figure where they "90" to the right and travel 30 feet before "90" down where they terminate in the condensate tank. The condensate tank has been resized from 30,000 Ib/hr to 80,000 Ib/hr. Furthermore, the storage tank for the condensate has been resized from 53 gallons to 110 gallons. A flash tank is not needed because the condensate will be below 212 degrees Fahrenheit.

Figure 27 shows the connection to the absorption chiller in isometric view. The steam line is colored red while the condensate line is colored white. As the steam "T's" off the main line, it travels through a gate valve onto a strainer before traveling through the control valve. Below the steam line is the condensate line. The condensate coming from the absorption chillers has a gate valve for isolation followed by an inverted bucket steam trap.

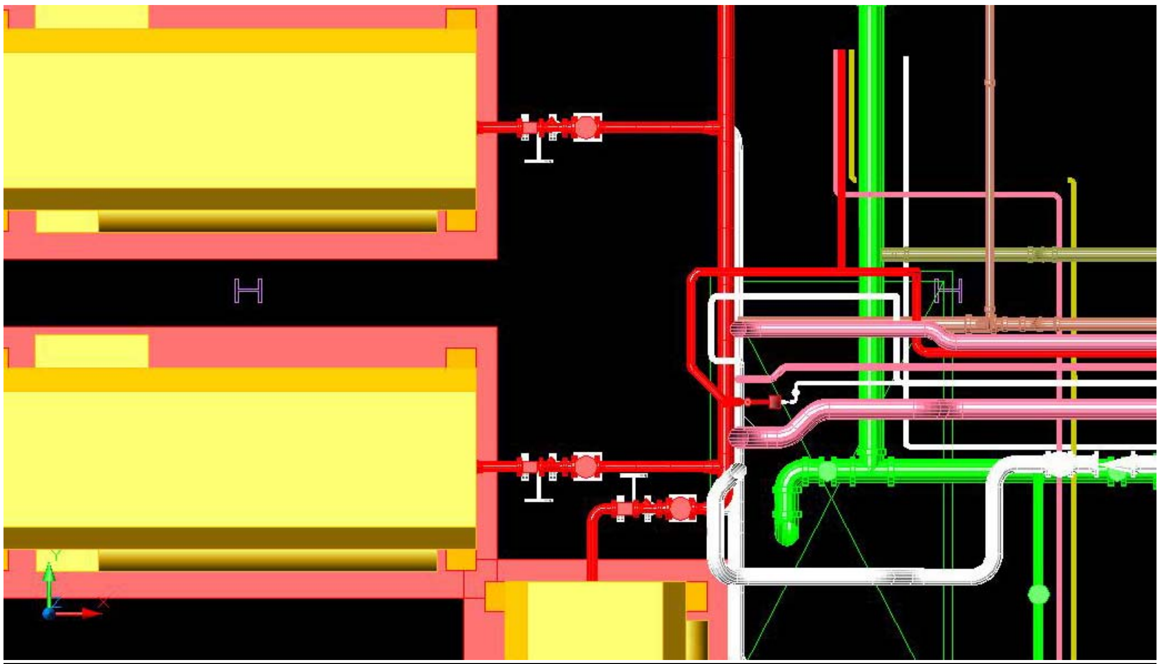


Figure 26: Steam and Condensate Connections to Absorption Chillers Plan

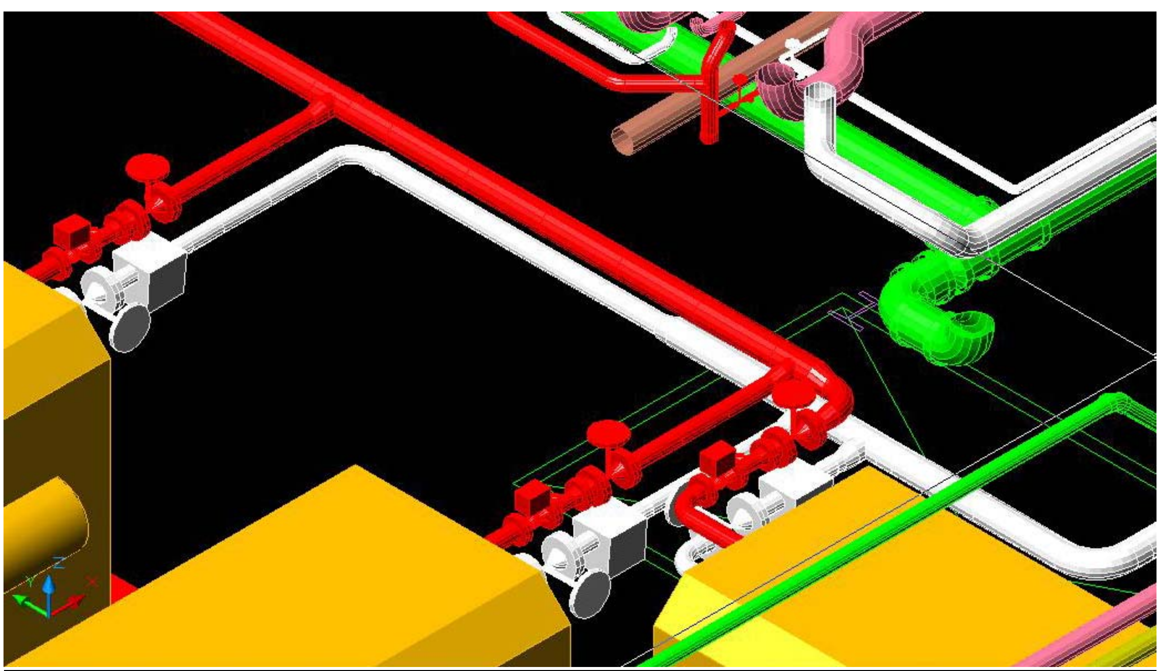


Figure 27: Steam and Condensate Connections to Absorption Chillers Isometric

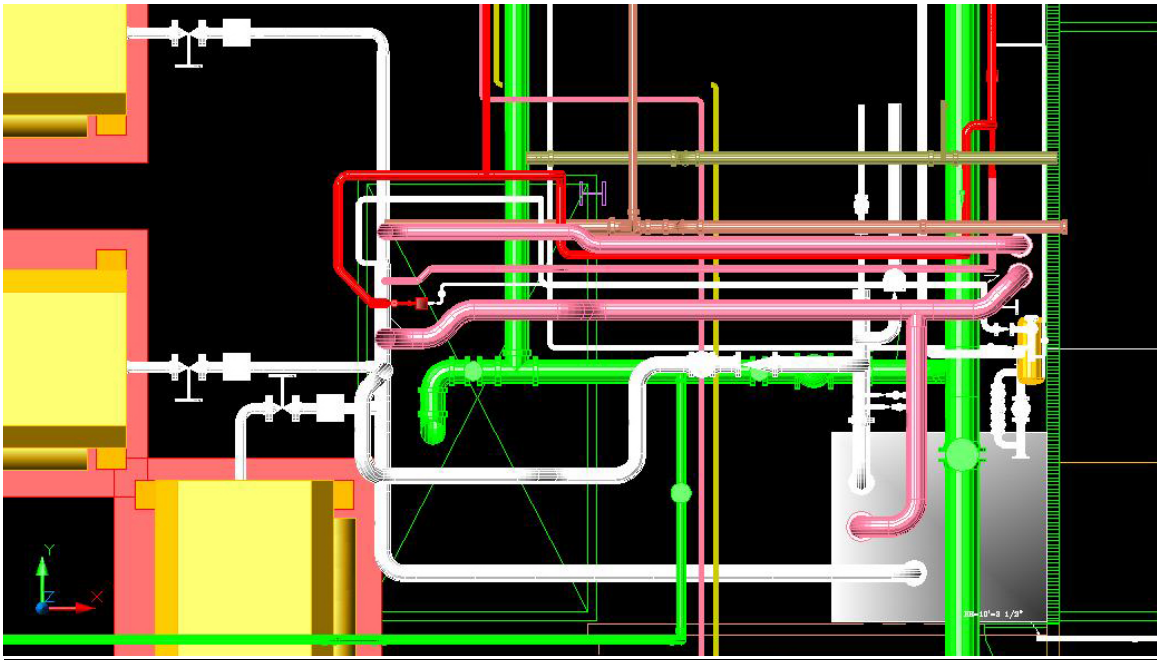


Figure 28: Absorption Chiller Condensate Plan

The final implementation of the new design incorporating absorption chillers is the addition of more cooling towers. The original design of the building required 3,823 tons of cooling, this equated to four 1,015 ton cooling towers. The cooling towers used in that design are manufactured by Baltimore Aircoil Company and are from the Series 3000 Model Line. The model line used is the 31132A this model has the nominal tonnage of 1,132 tons. The new design with the absorption chillers will require additional capacity to compensate for the additional latent load that the absorption chillers will supply. The new nominal tonnage that will need to be met is 6,113 tons. This provides many options when resizing the towers. The Series 3000 Model Line has a single cell capacity of 219-1,350 tons; because of this two options are available. The first is that the load can be met by using five 1,350 ton units. The second option is to keep the original four towers at 1,132 tons and add an additional two 1,132 ton units to them. Both options are viable, due to the original design of the building leaving room and structural support for two additional cells. The second option was chosen because the goal of this design was to be a retrofit design, not a total change of design. Figure 29 shows the original designs four cooling towers, and Figure 30 shows the new absorption design with six cooling towers.

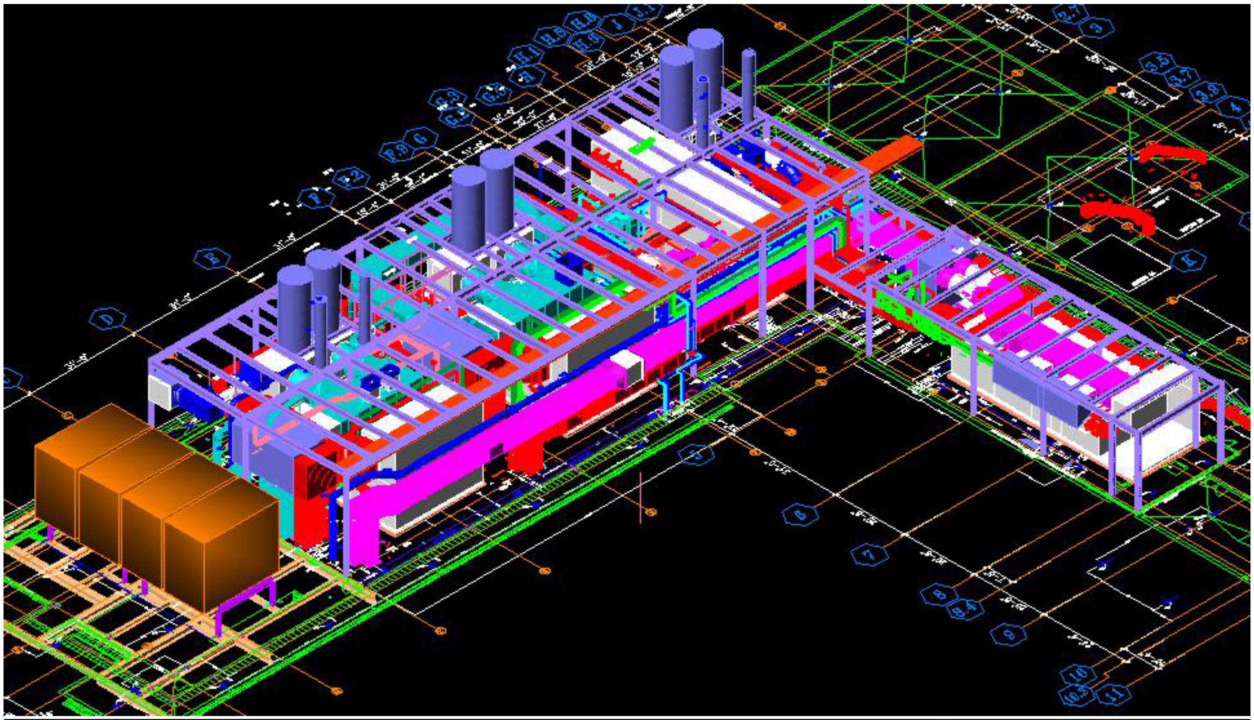


Figure 29: Mechanical Penthouse with Original Cooling Towers

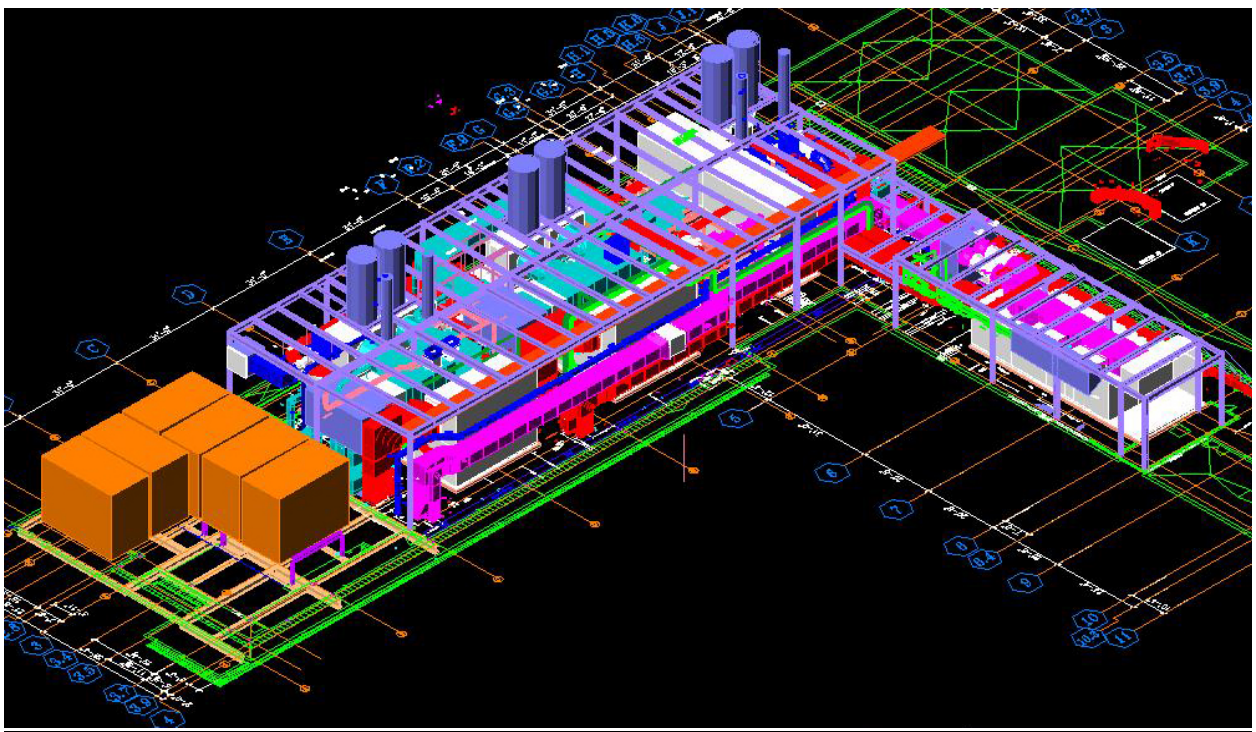


Figure 30: Mechanical Penthouse with Absorption Chiller Cooling Towers

ECONOMIC IMPACT OF CHANGES

The purpose of this redesign is to incorporate a system that will be more beneficial financially to operate than the existing system. As mentioned in the Technical Support for Changes section of this document, coal prices and electrical prices have fluctuated with a large variance. To combat this, the rates of today where compared to the rates of either a past year in the case of the coal, or in the case of the electricity rates of a future year. The electricity is being priced at a future year because the contract that Pennsylvania State University has with Allegheny is expiring and will be renegotiated this coming year. The new expected electric rate for kilowatt hour is expected to be in the range of $0.12 to $0.20. For use of this evaluation, the lower end of the spectrum, $0.12, will be used.

In Figure 31 the chiller load profile has been converted into electrical input for the yield of that load. The today column is calculating the yearly electrical cost based on the current pricing of $8.44 per Kilowatt demand, and $0.03658 per Kilowatt Hour. In the 2007 column the electrical cost is being calculated using the rate of $8.44 per Kilowatt demand, and $0.12 per Kilowatt Hour.

Figure 32 similarly to Figure 31, converts the load profile of the chiller into coal input for the Pennsylvania State University Steam Plant. On the other hand, unlike the electricity input, the plant's efficiency is taken into account along with the type of fuel source. The average efficiency of the steam plant according to William Serenscits, P.E. for the university steam services is 72.5 percent. Bituminous Coal, which comes from the Clarion region of Pennsylvania, is being burned in the plant. This coal has the heating capacity of 12,775 BTU/Ib. The total cost of the coal today with delivery and processing included is $90.00 per ton. As of a year ago the steam plant was receiving it for half the price $45.00 per ton. As discussed earlier in the Technical Support for Changes section of this document coal prices are being forecasted to become stabilized and the coal will be consistently priced around $90.00 per ton.

Moreover, the equipment cost will be analyzed as well. Because of the way the new system was sized, the chilled water side of the system will remain unchanged. The only piping change will be on the condenser water side, which according to John Himmelberger of the Farfield Company will equate to a 7.5 percent increase in those piping cost. However, because an exact number for the piping cost could not be reached the piping cost will not be considered, only equipment cost. The equipment costs are evaluated in Figure 33.

Chiller Electrical Input									
Hours	kw Total	kw [310]	kw [55]	$ kw Total Today	$ kw [310] Today	$ kw [55] Today	$ kw Total 2007	$ kw [310] 2007	$ kw [55] 2007
1	1,214,661.10	947.10	947.10	$12,645.36	$34.64	$34.64	$41,482.85	$113.65	$113.65
2	1,228,655.05	958.01	958.01	$12,791.04	$35.04	$35.04	$41,960.77	$114.96	$114.96
3	1,242,649.00	968.92	968.92	$12,936.73	$35.44	$35.44	$42,438.69	$116.27	$116.27
4	1,237,051.10	964.56	964.56	$12,878.45	$35.28	$35.28	$42,247.51	$115.75	$115.75
5	1,343,404.00	1,047.48	1,047.48	$13,985.65	$38.32	$38.32	$45,879.65	$125.70	$125.70
6	1,518,499.00	1,202.42	1,080.21	$15,808.49	$43.98	$39.51	$51,859.46	$144.29	$129.63
7	1,753,288.08	1,414.10	1,102.04	$18,252.79	$51.73	$40.31	$59,877.93	$169.69	$132.24
8	1,968,792.60	1,606.14	1,134.77	$20,496.32	$58.75	$41.51	$67,237.80	$192.74	$136.17
9	2,103,477.96	1,723.98	1,167.50	$21,898.48	$63.06	$42.71	$71,837.54	$206.88	$140.10
10	2,188,245.72	1,795.99	1,200.24	$22,780.96	$65.70	$43.90	$74,732.51	$215.52	$144.03
11	2,261,128.33	1,857.10	1,232.97	$23,539.71	$67.93	$45.10	$77,221.59	$222.85	$147.96
12	2,278,496.12	1,868.01	1,261.34	$23,720.52	$68.33	$46.14	$77,814.73	$224.16	$151.36
13	2,287,314.60	1,874.55	1,270.07	$23,812.33	$68.57	$46.46	$78,115.89	$224.95	$152.41
14	2,340,068.89	1,916.02	1,309.35	$24,361.53	$70.09	$47.90	$79,917.55	$229.92	$157.12
15	2,273,742.41	1,863.64	1,261.34	$23,671.03	$68.17	$46.14	$77,652.38	$223.64	$151.36
16	2,211,210.73	1,811.27	1,232.97	$23,020.04	$66.26	$45.10	$75,516.81	$217.35	$147.96
17	2,109,803.87	1,723.98	1,200.24	$21,964.33	$63.06	$43.90	$72,053.58	$206.88	$144.03
18	1,984,626.59	1,614.87	1,167.50	$20,661.16	$59.07	$42.71	$67,778.56	$193.78	$140.10
19	1,823,794.18	1,473.02	1,134.77	$18,986.80	$53.88	$41.51	$62,285.84	$176.76	$136.17
20	1,791,320.41	1,449.02	1,102.04	$18,648.73	$53.00	$40.31	$61,176.80	$173.88	$132.24
21	1,711,038.52	1,379.18	1,080.21	$17,812.95	$50.45	$39.51	$58,435.03	$165.50	$129.63
22	1,533,566.33	1,222.06	1,047.48	$15,965.35	$44.70	$38.32	$52,374.04	$146.65	$125.70
23	1,460,952.35	1,163.14	1,003.84	$15,209.40	$42.55	$36.72	$49,894.14	$139.58	$120.46
24	1,372,542.12	1,088.94	964.56	$14,288.99	$39.83	$35.28	$46,874.77	$130.67	$115.75
Total:	43,238,329.09	34,933.49	26,839.51	$663,594.15	$1,277.87	$981.79	$1,690,123.44	$4,192.02	$3,220.74

Figure 31: Chiller Electrical Input [Allegheny Power University Rates]

Chiller Coal Input												
Hours	Steam lbs [Total]	Steam lbs [310]	Steam lbs [55]	Coal lb [TOTAL]	Coal lb [310]	Coal lb [55]	$ Coal [TOTAL] Today	$ Coal [310] Today	$ Coal [55] Today	$ Coal [TOTAL] 2005	$ Coal [310] 2005	$ Coal [55] 2005
1	5,032,026.29	13,786.37	13,786.37	642,186.93	1,759.42	1,759.42	$28,898.41	$79.17	$79.17	$14,449.21	$39.59	$39.59
2	5,089,999.60	13,945.20	13,945.20	649,585.48	1,779.69	1,779.69	$29,231.35	$80.09	$80.09	$14,615.67	$40.04	$40.04
3	5,147,972.90	14,104.04	14,104.04	656,984.03	1,799.96	1,799.96	$29,564.28	$81.00	$81.00	$14,782.14	$40.50	$40.50
4	5,124,782.26	14,040.50	14,040.50	654,024.44	1,791.85	1,791.85	$29,431.10	$80.63	$80.63	$14,715.55	$40.32	$40.32
5	5,565,374.78	15,247.60	15,247.60	710,252.84	1,945.90	1,945.90	$31,961.38	$87.57	$87.57	$15,980.69	$43.78	$43.78
6	6,290,748.00	17,502.98	15,724.10	802,824.93	2,233.73	2,006.71	$36,127.12	$100.52	$90.30	$18,063.56	$50.26	$45.15
7	7,263,418.33	20,584.27	16,041.75	926,957.06	2,626.96	2,047.25	$41,713.07	$118.21	$92.13	$20,856.53	$59.11	$46.06
8	8,156,197.73	23,379.66	16,518.24	1,040,893.52	2,983.71	2,108.06	$46,840.21	$134.27	$94.86	$23,420.10	$67.13	$47.43
9	8,714,164.29	25,095.01	16,994.72	1,112,101.19	3,202.62	2,168.87	$50,044.55	$144.12	$97.60	$25,022.28	$72.06	$48.80
10	9,065,335.16	26,143.29	17,471.21	1,156,917.60	3,336.40	2,229.67	$52,061.29	$150.14	$100.34	$26,030.65	$75.07	$50.17
11	9,367,268.93	27,032.73	17,947.70	1,195,450.37	3,449.92	2,290.48	$53,795.27	$155.25	$103.07	$26,897.63	$77.62	$51.54
12	9,439,219.16	27,191.56	18,360.66	1,204,632.65	3,470.19	2,343.19	$54,208.47	$156.16	$105.44	$27,104.23	$78.08	$52.72
13	9,475,751.87	27,286.86	18,487.72	1,209,294.95	3,482.35	2,359.40	$54,418.27	$156.71	$106.17	$27,209.14	$78.35	$53.09
14	9,694,299.23	27,890.41	19,059.50	1,237,185.96	3,559.37	2,432.37	$55,673.37	$160.17	$109.46	$27,836.68	$80.09	$54.73
15	9,419,525.80	27,128.03	18,360.66	1,202,119.39	3,462.08	2,343.19	$54,095.37	$155.79	$105.44	$27,047.69	$77.90	$52.72
16	9,160,473.24	26,365.64	17,947.70	1,169,059.11	3,364.78	2,290.48	$52,607.66	$151.42	$103.07	$26,303.83	$75.71	$51.54
17	8,740,370.90	25,095.01	17,471.21	1,115,445.67	3,202.62	2,229.67	$50,195.06	$144.12	$100.34	$25,097.53	$72.06	$50.17
18	8,221,793.86	23,506.72	16,994.72	1,049,264.90	2,999.93	2,168.87	$47,216.92	$135.00	$97.60	$23,608.46	$67.50	$48.80
19	7,555,506.81	21,441.95	16,518.24	964,233.38	2,736.42	2,108.06	$43,390.50	$123.14	$94.86	$21,695.25	$61.57	$47.43
20	7,420,976.42	21,092.52	16,041.75	947,064.62	2,691.83	2,047.25	$42,617.91	$121.13	$92.13	$21,308.95	$60.57	$46.06
21	7,088,389.33	20,076.01	15,724.10	904,619.87	2,562.10	2,006.71	$40,707.89	$115.29	$90.30	$20,353.95	$57.65	$45.15
22	6,353,168.02	17,788.87	15,247.60	810,790.97	2,270.21	1,945.90	$36,485.59	$102.16	$87.57	$18,242.80	$51.08	$43.78
23	6,052,347.12	16,931.20	14,612.29	772,400.22	2,160.76	1,864.82	$34,758.01	$97.23	$83.92	$17,379.00	$48.62	$41.96
24	5,686,086.45	15,851.16	14,040.50	725,658.05	2,022.92	1,791.85	$32,654.61	$91.03	$80.63	$16,327.31	$45.52	$40.32
						Total:	$1,028,697.67	$2,920.31	$2,243.68	$514,348.83	$1,460.15	$1,121.84

Figure 32: Chiller Coal Input [Penn State Steam Plant Rates]

Mechanical Equipment Cost					
Initial Equipment	**Initial Cost**	**Multiplier**	**Changed Equipment**	**Changed Cost**	**Multiplier**
Condenser Water Pump [4]	$19,000.00	4	Condenser Water Pump [5]	$19,000.00	5
Electric Centrifugal Chiller	$270,000.00	3	Steam Absorption Chiller	$595,000.00	3
Cooling Tower	$5,400.00	4	Cooling Tower	$5,400.00	6
HPS Steam Line	$200,000.00		HPS Steam Lines	$300,000.00	
Condensate Pumps	$5,000.00		Condensate Pumps	$15,000.00	1
Total:	$1,107,600.00		**Total:**	$2,272,400.00	
Cost Difference in New Equipment:				$1,164,800.00	

Figure 33: Equipment Cost Change

EVALUATION OF CHANGES

Using the today evaluation of the system, the absorption chiller system appears to be very unreasonable as compared to the electric centrifugal chillers. The utility cost shows that the electrical system is $366,003.00 less expensive a year to operate. This in conjunction with the first cost of the equipment would leave a $1,530,883.00 deficit after the first year of operation when compared to the electrical system. Conversely, if the absorption chiller rates were compared to the next years electric cost after the electric rate had been renegotiated, the absorption chiller redesign scenario is considerably much more reasonable. With the new electric rate, the absorption chiller would become $661,431 less expensive. The absorption chiller equipment cost would have a payback period of less than two years.

CONCLUSIONS DRAWN FROM DESIGN

The conclusions drawn from the design include: that the system equipment changes do not drive whether the new design is feasible; the utility rates for the energy service drive whether or not the new design is feasible or not. In addition, utility rates the last few years have been very unsteady making it very unclear which system in the long run will be the most beneficial from a financial point of view. At the time of the buildings original design 1999-2000, it can be seen why the electrical centrifugal chiller design would be chosen with a low first cost, and a low electric rate locked in for the next five years.

FIRE PROTECTION BREADTH

DESCRIPTION OF FIRE PROTECTION BREADTH

When a fire occurs within an enclosed space, a smoke layer will accumulate at the ceiling and begin to descend toward the floor. If this smoke layer descends into exit paths, the toxic elements in the smoke and the reduction in visibility will be hazards to persons leaving the building. Exhaust fans are frequently required to maintain the smoke layer above the exit paths for a sufficient time to allow occupants to leave safely. The function of this breadth is to calculate the exhaust fan capacity required to accomplish this task.

The design of the Chemistry Building was not always envisioned as it was constructed. Due to lack of mechanical space and funding for the building the atrium space was reduced from five stories to four stories. This redesign led to the approval by the fire marshal to be acceptable without a smoke evacuation system.

For the Fire Protection Breadth the atrium will be returned back to its original state making it a five story atrium space. The space will be evaluated to size the fans needed to keep the smoke level at an acceptable height so that one could pass through the space in case of a fire. The make-up air for the smoke evacuation system will be supplied at the base of the space. The air will be supplied by the opening of two exterior doors by door openers connected to the fire detection system. The fans, because of lack of space in the mechanical penthouse will be placed on the roof of the building.

Other notable information considered during the smoke evacuation design, is that the system will have to be tested on an annual basis. Because of this it is possible that the system will be tested during cold weather when the outdoor temperatures are below the freezing point. The major concern deriving from this event would be the potential freezing the exposed sprinkler pipes. However, in this case freezing is not a concern due to the usage of a preaction sprinkler system, meaning there is no water in the sprinkler pipe until the sprinkler head is activated. At that point a valve opens and water is pumped to that region of sprinkler.

The design will further be evaluated with a contamination study which will allow the smallest ratio of contamination to air to be 1:1000. This action will eliminate contamination of air supplies for other parts of the building or other nearby buildings. The method for doing this was outlined in the 1997 ASHRAE Fundamentals.

REVIEW OF CODE REQUIREMENTS FOR ATRIA SMOKE EVACUATION

The NFPA and IBC codes define an atrium space as an uncompartmented space two or more stories. This does not include warehouses. The code defines that the space should be maintained in the following manner. The height of the lowest horizontal surface of the accumulating smoke layer shall be maintained at least 10 feet (3048 mm) above any walking surface which forms a portion of a required egress system within the smoke zone. The required exhaust rate for the zone shall be the largest of the calculated plume mass flow rates for the possible plume configurations. Provisions shall be made for natural or mechanical supply of air from outside or adjacent smoke zones to make up for the air exhausted. Makeup airflow rates, when measured at the potential fire location, shall not exceed 200 feet per minute (60,960 mm per minute) toward the fire. The temperature of the makeup air shall be such that it does not expose temperature-sensitive fire protection systems beyond their limits.

DESIGN CHANGES MADE TO ATRIUM BY ARCHITECT

Figure 34 shows the Atrium space to be evaluated in its original design by the architect on the left and its final design on the right. Originally when the Chemistry Building was designed it was supposed to contain a five story atrium space entrance with an architectural monumental stair spanning those five stories. However, as the building developed with mechanical equipment and structural framing, the architectural element of a five story atrium became harder and harder to keep. Other problems which accelerated the idea of value engineering this space came in when the budget of the building was evaluated. These two reasons rooted in the redesign of the atrium space to be a four story atrium area. Because of the redesign the fire marshal deemed the atrium space to be acceptable as was, without a smoke evacuation system.

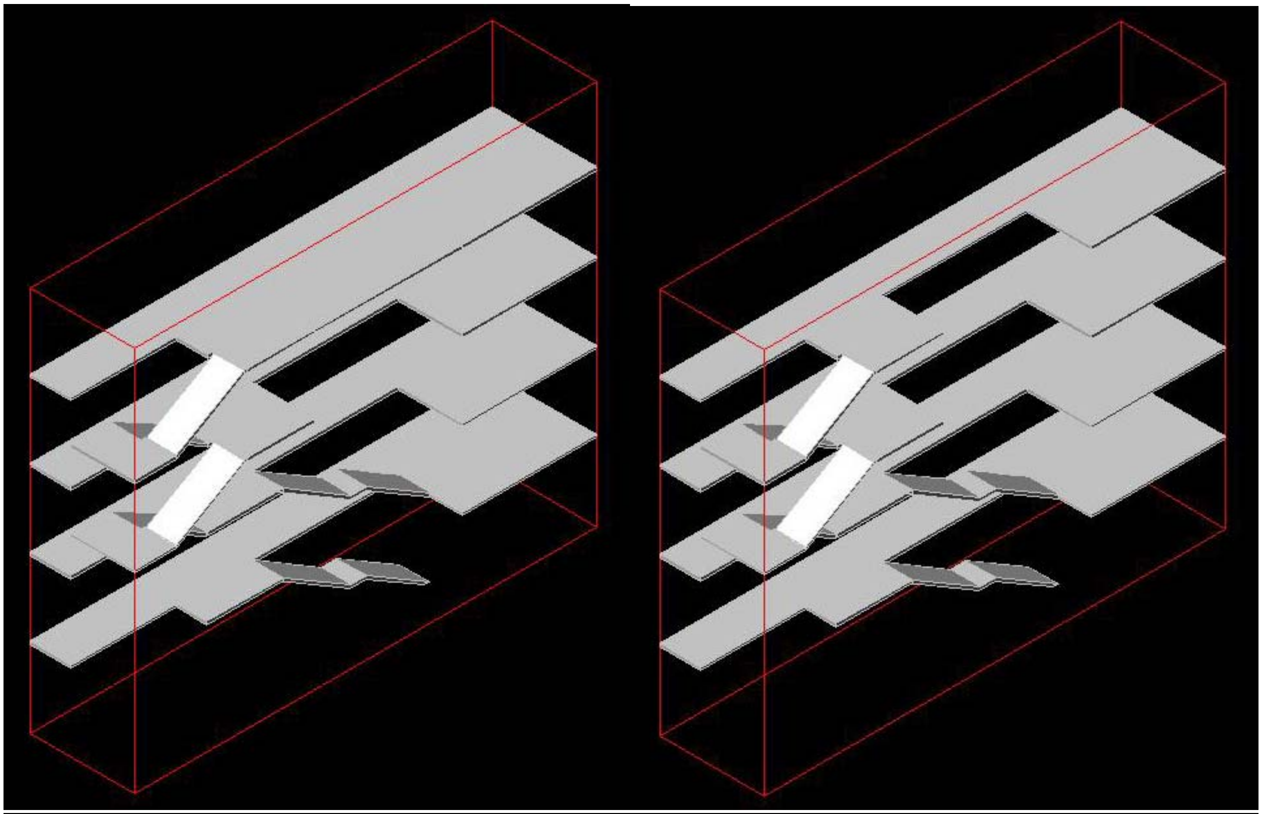


Figure 34: Equipment Cost Change

DESRIPTION OF ATRIUM SMOKE DESIGN

The atrium smoke design will stem from three centrifugal fans located on the roof. Three fans were selected due to the volume of air which was needed to be evacuated. This amount of air could not be handled by one or two fans. The fans are Greenheck's Series 21 Backward Inclined Single Width. The fans have a 150 hp weather guarded motor to drive the fan assembly. The assembly will be belt driven with multiple belts as required by the IBC code. Also the fan will be fire rated to withstand temperatures of 500 degrees Fahrenheit. Each fan is sized to be 100,000 cfm with 2.75 inches of static pressure (2 inches for the louver located in the atrium and 0.75 inches for the duct) as will be seen in the following section. The stack height for the fans is 18 feet, which matches the surrounding exhaust stacks.

Intakes for the fans will be located in the center of the space that opens on all five floors. The intake will consist of three 4'x 4' louvers, and will be connected to 5 foot round ductwork. Each run of ductwork will have 100,000 cfm traveling through it as mentioned before. The velocity of the smoke traveling through the duct work will be on the high end of the spectrum allowed by code for exhaust flow rates at 4,000 fpm.

Make-up air for the fans will be generated from the opening of two exterior doors located at the base of the structure by door openers. The make-up can consist primarily of outdoor air according to code as long as there is no water sensitive fire equipment exposed. This is in place to prevent the freezing of sprinkler pipes and heads in cold weather testing and utilization in case of a fire. The system passes qualification because the fire protection system used for the sprinkler is a preaction system in which the sprinkler pipe supplying the area is empty until the head is activated. At that point, a valve will open allowing water to flow to the designated sprinkler area.

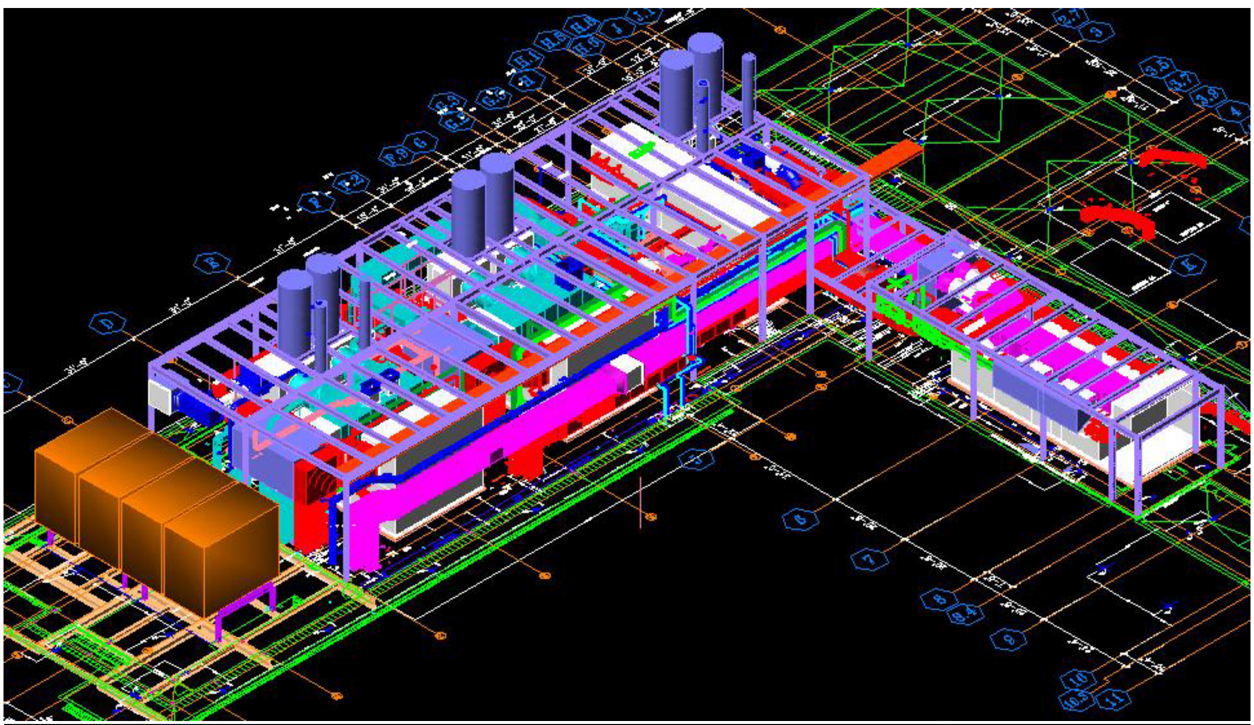


Figure 35: Original Design Mechanical Penthouse

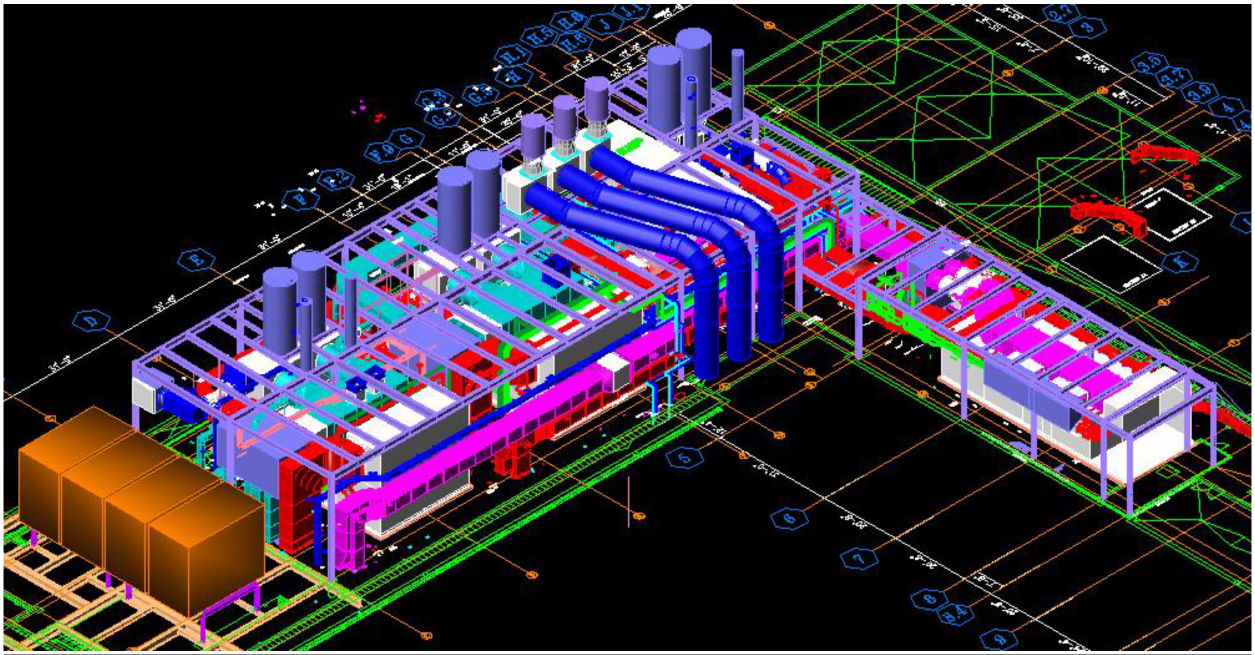


Figure 36: Atrium Smoke Exhaust Fans Design Mechanical Penthouse

TRANSIENT MODEL DESIGN & RESULTS

The transient model design was done using a program developed by Newcomb and Boyd's Lee Watson, P.E., who specializes in Atrium Smoke Design. Watson has developed a transient program whose function is to calculate the exhaust fan capacity under the following conditions. When a fire occurs within an enclosed space, a smoke layer will accumulate at the ceiling and begin to descend toward the floor. If this smoke layer descends into exit paths, the toxic elements in the smoke and the reduction in visibility will be hazardous to persons leaving the building. Exhaust fans are frequently required to maintain the smoke layer above the exit paths for a sufficient time to allow occupants to leave safely. The program does this by using several simplifying assumptions for the analysis:

- Heat losses from the hot gas layer to the adjoining ceiling and wall surfaces are modeled as a simple percentage of the fire heat release rate.
- The smoke plume is modeled as point source. The effect of a "virtual origin" for the fire plume is ignored.
- The space is always at a constant pressure.

- The space has an ample supply of oxygen for combustion so that the fire is not oxygen-limited.

- The fan starts automatically upon activation of a smoke detector or sprinkler.

The program uses a two-zone fire model consisting of a hot gas layer in the upper portion of the space and a cool air layer in the lower part of the space. The design fire is entered by the user into the model, and may be a t^2 type. The t^2 fire may have a maximum heat release value and a decay period if input by the user. The t^2 fire grows proportionally to the square of the time from ignition and is categorized as "slow", "medium", "fast", or "ultra-fast". The fire in this model was modeled to be a fast type fire at 5,000 BTU/sec.

NOTE: Additional information on the transient program used and the equations that apply to this program can be found in the Atrium Evacuation Appendix.

The following is the input needed to run the program:

- Space Area……………………….1,596 Square Feet

- Ceiling Height…………………..…………70 Feet

- Total Simulation Time……………..…1200 Seconds

- Ambient Temperature……………...……75 deg-F

- Maintain Smoke Layer Above………………62 Feet

The following is what the program yielded:

- Total Smoke Exhaust Capacity……..…280,000 cfm

- Estimated Fans Starting Time………..220 Seconds

- Estimated Smoke Layer Temp……….…..93 deg-F

The fans that were implemented in the design were sized to 100,000 cfm to accommodate for duct losses, additionally it was the closest size that met the needed cfm. The model results can be seen in Figure 35 in table form and in graphical form in Figure 36.

SMOKE CONTROL ANALYSIS			
Time [sec]	Heat Release [Btu/sec]	Smoke Layer [Height-Ft]	Smoke Layer [Temp-F]
		69.8	75
10	4	67.7	75
20	18	63.8	75
30	40	58.9	75
40	71	53.6	76
50	111	48.4	76
60	160	43.3	76
70	218	38.6	77
80	284	34.3	77
90	360	30.5	78
100	444	27	79
110	538	23.9	80
120	640	21.2	81
130	751	18.7	82
140	871	16.5	83
150	1000	14.5	85
160	1138	12.7	87
170	1284	11.1	89
180	1440	9.6	91
190	1604	8.2	93
200	1778	6.9	96
210	1960	5.7	99
220	2151	8	102
230	2351	32.6	105
240	2560	49.5	101
250	2778	59.4	92
260	3004	64.4	88
270	3240	66.6	88
280	3484	67.1	88
290	3737	66.9	89
300	4000	66.2	89
310	4271	65.3	90
320	4551	64.4	91
330	4840	63.4	92
340	4987	62.6	93
1200	4987	62.1	94

Figure 35: Newcomb & Boyd Transient Model Result

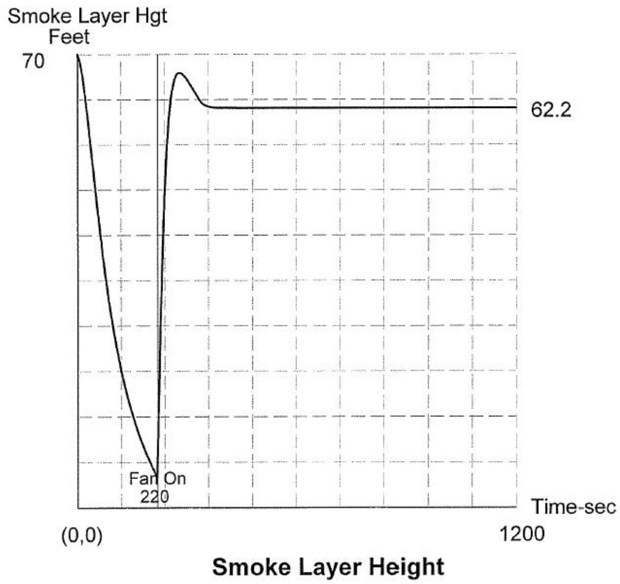


Figure 36: Newcomb & Boyd Transient Model Result Graph

From the table and graph in Figure 35 and Figure 36 the fans are not activated until 220 seconds after the fire had been ignited. This allows the smoke to build and make the atrium impassible for 240 seconds; as soon as the fan starts the atrium becomes passable in 20 seconds. From this analysis it can be seen the design works once the fans are activated; however, there is too much of a lag between the ignition and fan activation. This could be corrected using a more sophisticated fire detection system such as automatic fire detection system. There are three options: Ionization Detection and Photoelectric Detection, which rely on air sampling; and UV Infrared Detection, which relies on flame detection. These three options give almost instantaneous detection and would correct the lag problem in the model. The program being used does not have the capabilities to model instantaneous detection. However, it can be assumed that instantaneous detection can be modeled by ignoring the modeling from 40 secs to 250 secs.

COMPUTATIONAL FLUIDS MODEL DESIGN & RESULTS

When designing a smoke evacuation system, there are several problems which need to be avoided in order to have a successful working system. The first problem to avoid is allowing the smoke to come in contact with the walls of the space. A constant but sensible velocity is needed to avoid having build up of smoke making the area impassible. The second is "plug holing", a term used to describe when air is evacuated at a high rate and forms vortexes within the smoke layer which only evacuates the smoke in that particular vortex. The remaining smoke will be left at a stagnate state. To analyze if these problems are happening in the Chemistry Building atrium space a Computational Fluid Model was developed. The program used to model this space is Phoenics VR.

To accurately depict the atrium air movement; a three dimensional model of the space was developed. The model can be seen in the following figures or in the Design Changes Made to the Atrium by Architect section of this document. Exterior walls are not needed in the space, because the Phoenics program accounts for these as boundaries. The model is inserted into the space at a one to one scale. This was accomplished using AutoCAD to develop the model and then inserting it as a .STL file type. After the model was inserted into the space, air inlet and outlets were introduced for the smoke evacuation analysis.

It is important to note that smoke is not being modeled by the computational fluid model. The computational fluid model is evaluating air moving through the space. The results from how air is moving through the space will determine whether or not smoke will be successfully evacuated or not.

With the inlets inserted the proper air and flows were attached to the spaces. Phoenics does not associate inlet and outlet rates as air volumes such as a cfm. Instead, Phoenics associates them with a velocity per area of surface.

The final step, before allowing the program to run through its iterations and determine whether a result exists, is to choose a cell size for the model. 8 inches x 8 inches will be the cell size for this model. The cell size is the sample element the program will do its calculations on as it moves through the model. Iterations for the model where set to 2,000 iterations. This means that each cell in the model will be calculated 2,000 times. The total number of cells for the model is 251,370. Therefore, Phoenics will have to do 251,370 calculations per iteration or about 502,740,000 calculations total for all 2,000 iterations. The calculation time needed for the program to run these calculations was 16 hours.

From Figure 37 the result for the model which was developed for the atrium can be seen to have convergence on the right side, and after checking the results the error of the model is 0.08%, which for educational purposes is acceptable. If this was not for educational purposes an error result of less than 0.01% would have needed to be met before accepting the results.

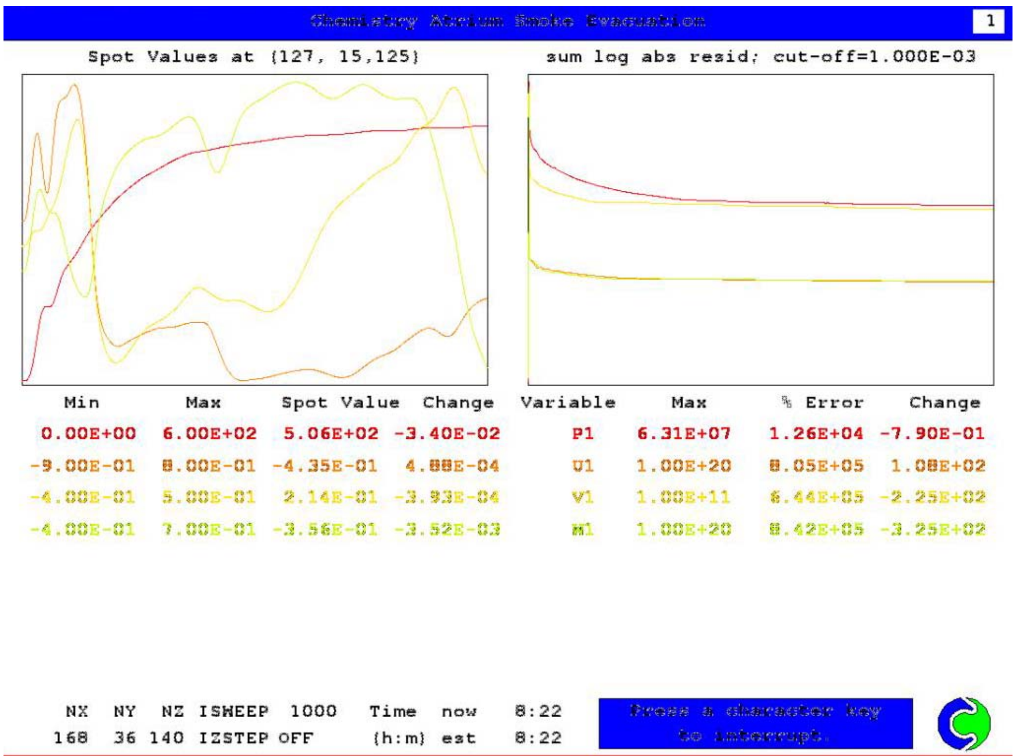


Figure 37: Phoenics Result

Figures 38-49 show slices of the result pressure and velocity files of the Phoenics program. The result for the pressure file will be analyzed first followed by the velocity file for the model. Figures 38-43 show the results of the pressure result file.

<u>NOTE</u>: Additional slices for the Computational Fluid Model can be seen in the Phoenics CFD Slices Appendix

Figures 38-40 show the X axis cuts of the pressure result. Figure 39 and Figure 40 are taken directly through the air intakes, while Figure 38 is taken through the center of the air outlet. On the left side of the figures is a color scale for the pressure. It can be seen that at the back wall of the model in each of the figures there is a large pressure build up under the over hang of the model. A difference in pressure can be seen as high as 200 Pascals throughout the cut. This finding illustrates that the smoke may build up in these regions. The velocity cuts will have to be analyzed further to assure that air is circulating through these regions.

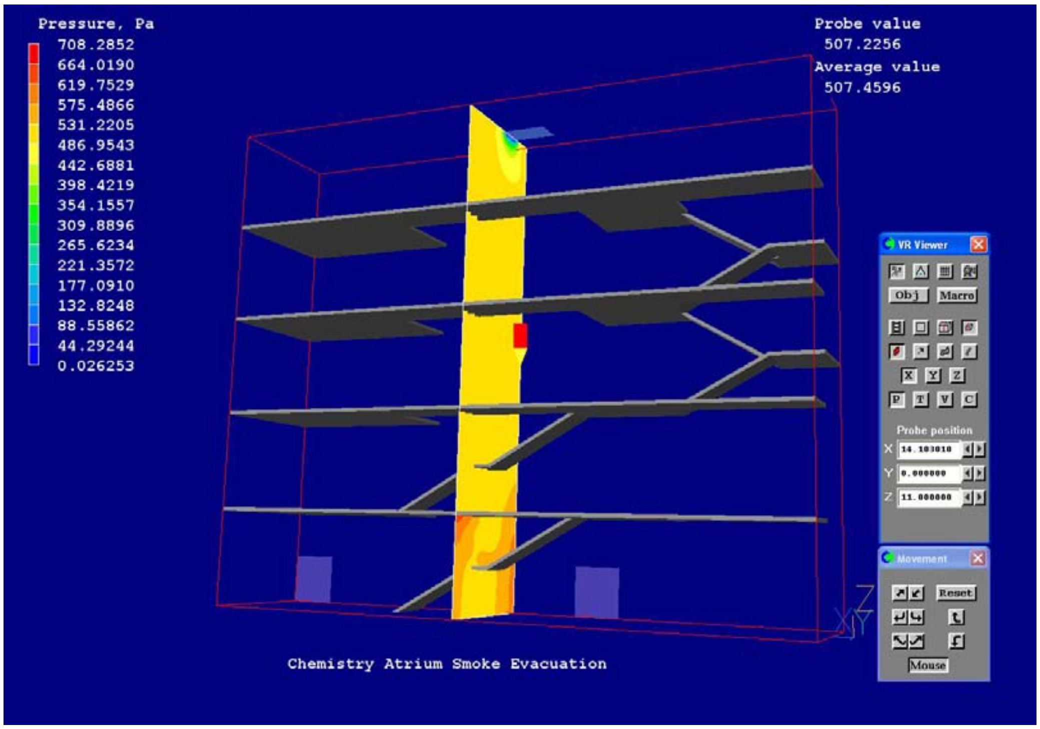


Figure 38: Phoenics Pressure X Slice 1

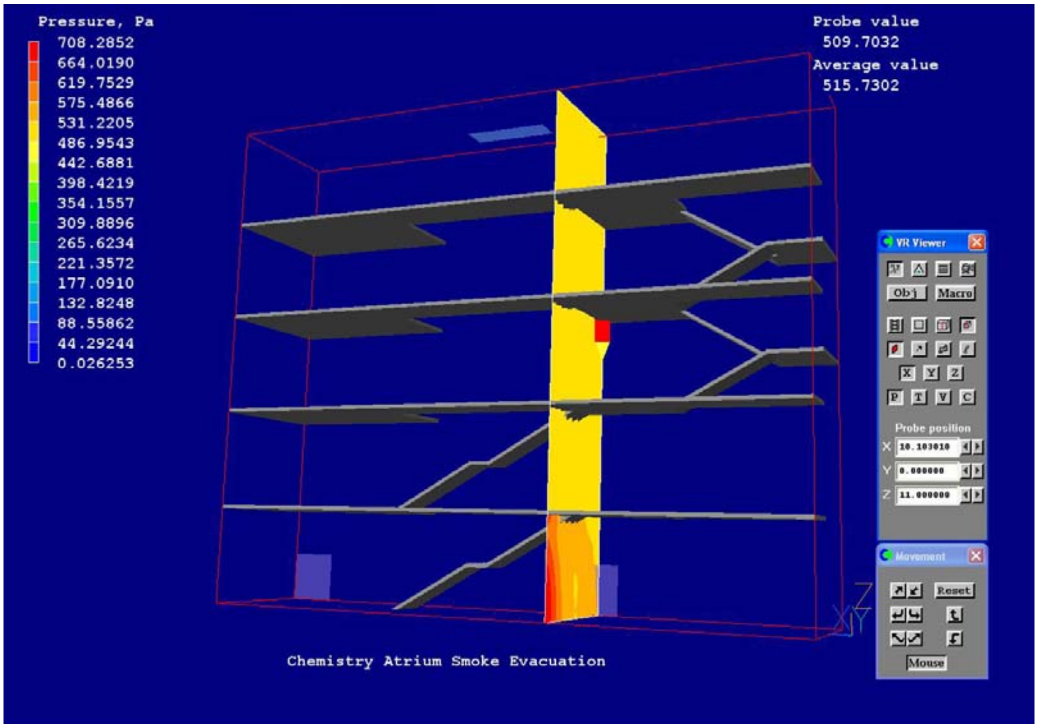


Figure 39: Phoenics Pressure X Slice 2

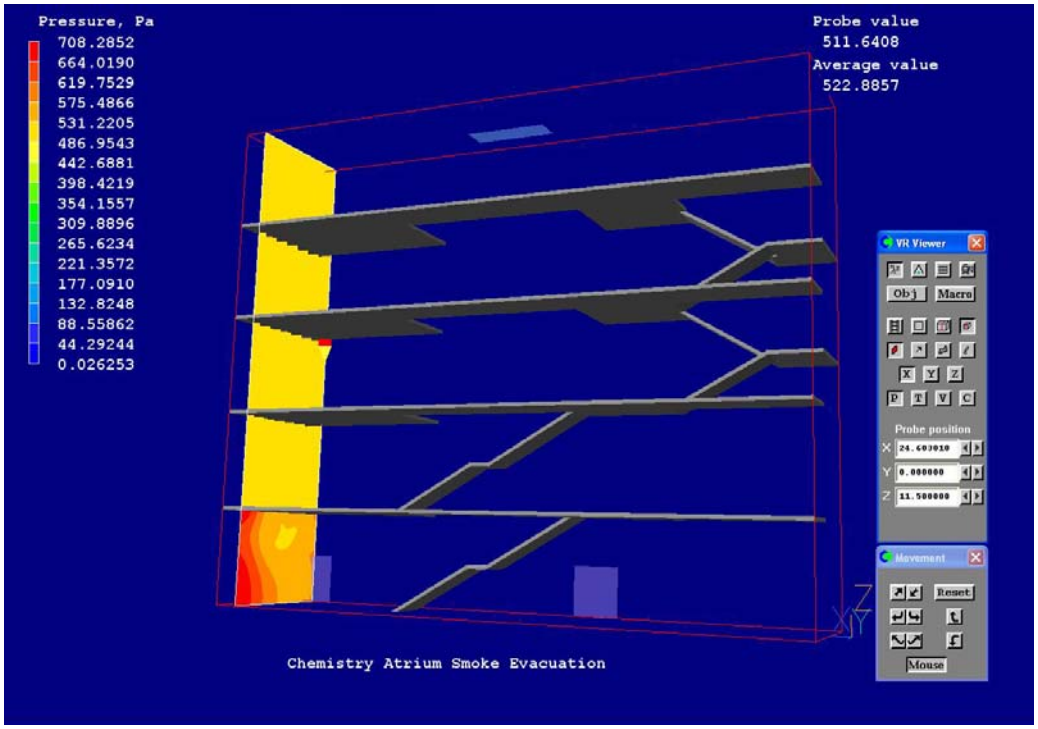


Figure 40: Phoenics Pressure X Slice 3

Figure 41 is sliced along the Y axis. The slice is centered in the middle of the air outlet. Examining the results from this cut show that the air pressure in this area seems to be very well distributed in an even manor. The pressure differences for the cut are in the range of 50 Pascals. The past two results have shown a large difference in findings; the X slices have shown that there is a large pressure against the wall across from the air intakes under the balconies, while the Y slice through the center of space has shown the pressure to be evenly distributed. More cuts will have to be examined to determine the pressure distribution of the space.

Figure 42 and Figure 43 display cuts taken along the Z direction. From these figures there appears to be a pressure build up along the wall across from the air intakes in particular the right corner of the figures. The far right corner displays a large pressure build up; however, the pressure appears to dissipate as the slices are taken at higher elevation. Other than a few areas pointed out above, the pressures appear to be evenly distributed in all directions.

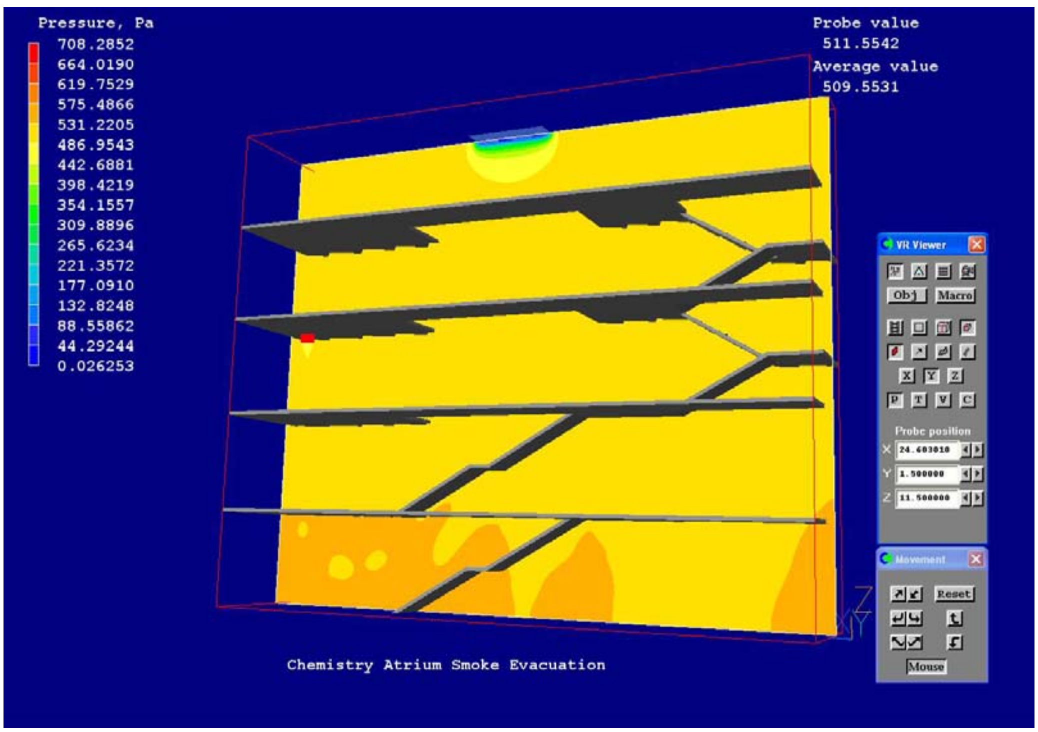


Figure 41: Phoenics Pressure Y Slice 1

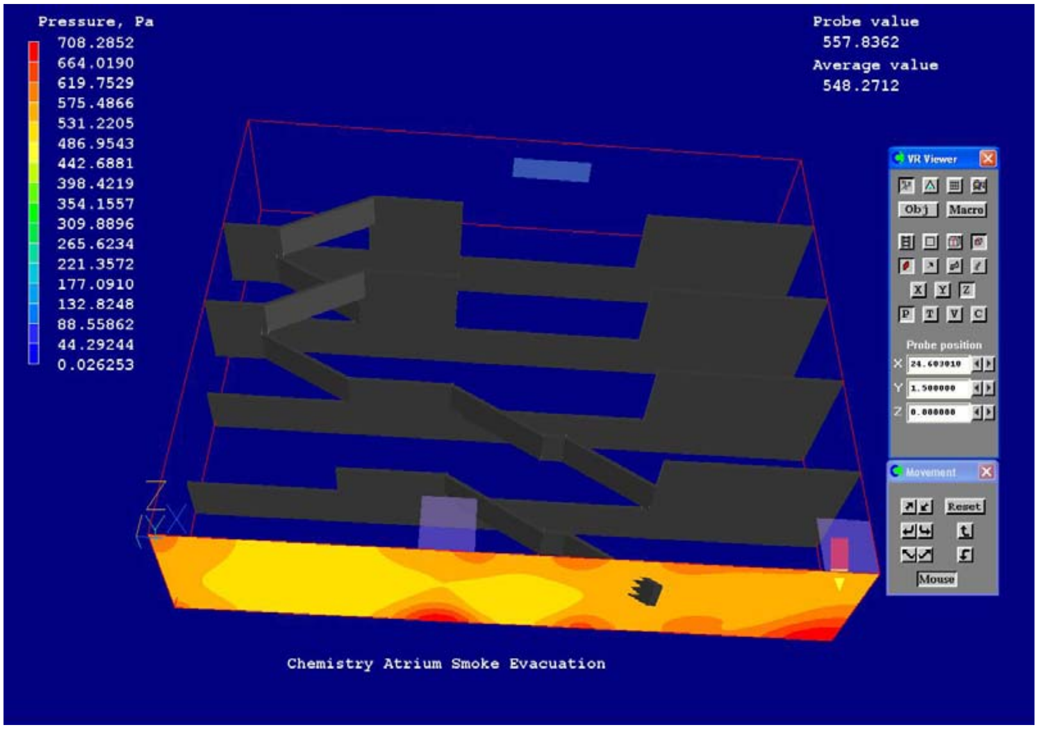


Figure 42: Phoenics Pressure Z Slice 1

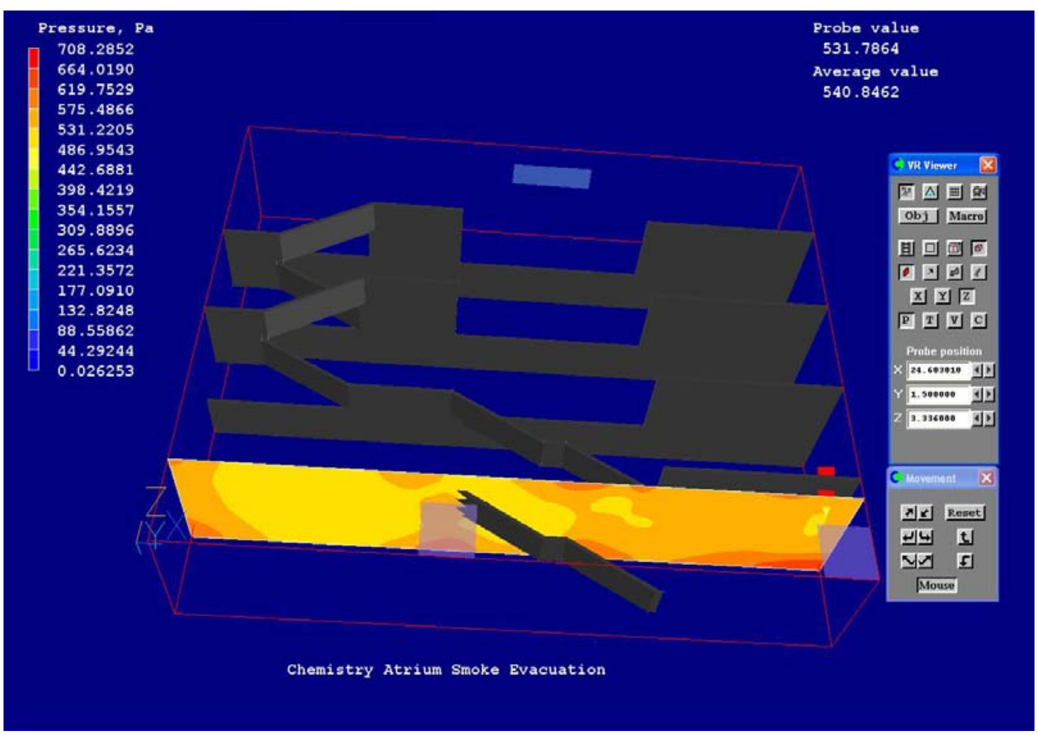


Figure 43: Phoenics Pressue Z Slice 3

With the conclusion of the pressure result file, analyzing the velocity result file is now applicable. Figures 44-49 display the results of the velocity result file. One important area to analyze, which does not apply to this atrium, is that a minimum of 200 fpm is needed across all openings into the space. This does not apply to this atrium because all of the openings are closed to the atrium by fire doors. These results will enable the analysis of whether or not the velocity is moving smoke away from the walls of the space. Secondly, that the air velocity is somewhat evenly distributed, so that the problem of "plug holing" does not exist.

Figure 44 and Figure 45 are slices along the X axis. The slices are taken in the center of the air intakes. As expected the initial velocity of the air coming through the intake is at a high velocity and diffuses into the space. The air speed can be analyzed using the color coded chart on the left of the figure. Using that chart the air coming through the intake opening is in the range of 10-12 meters per second. This will equate to a wind speed of 35 feet per second, or 24 mile per hour wind, which is very capable of being walked through. In addition, there is a high velocity against the back wall from which the pressure file was shown to be at a high pressure. There appears to be a large amount of circulation in the regions where pressure was high from the pressure slices. Conversely, the upper regions of the slices do not show a large amount of air movement. The air velocity at the upper region of slices is at the lower end of the spectrum moving 0-1.7 meters per second. However, the air does show some circulation. Figure 46 is the X axis slice which is centered on the air outlet. The slice shows the air is circulating through the space at a higher range than the other two previous figures especially at the upper regions of the slice. The air moving in the regions of this slice ranges from 1.7-10 meters per second.

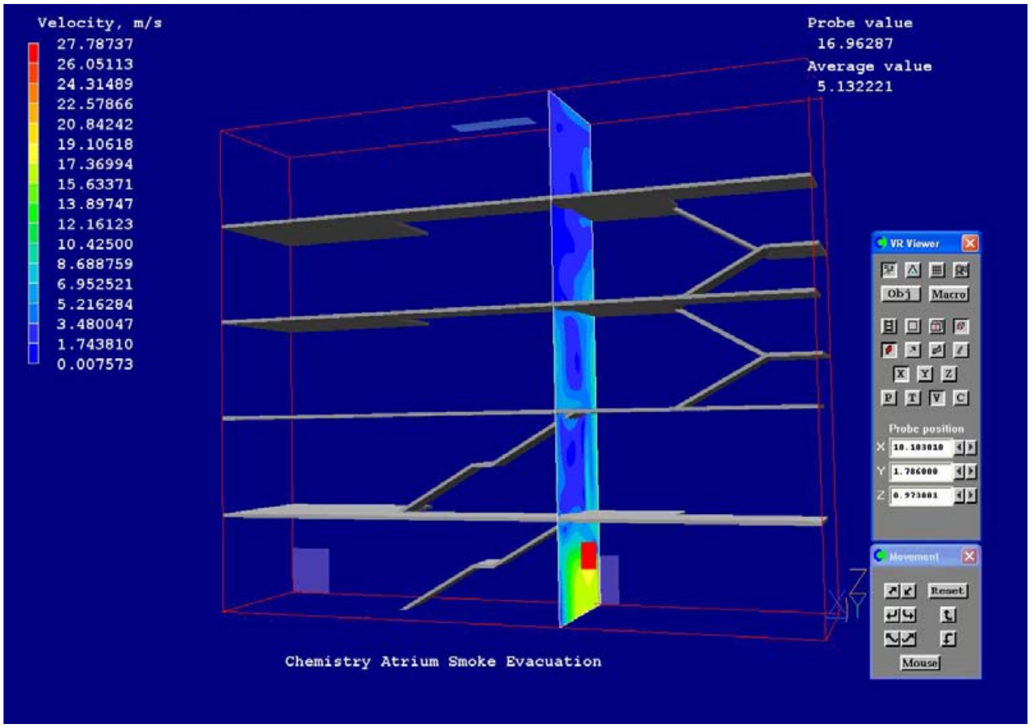


Figure 44: Phoenics Velocity X Slice 1

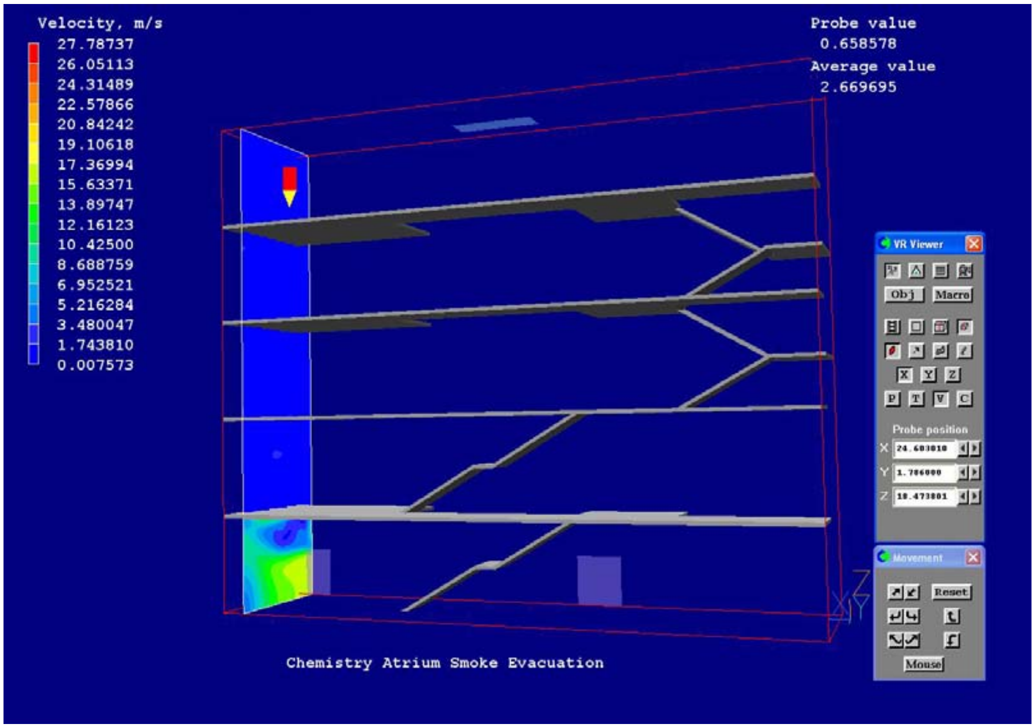


Figure 45: Phoenics Velocity X Slice 2

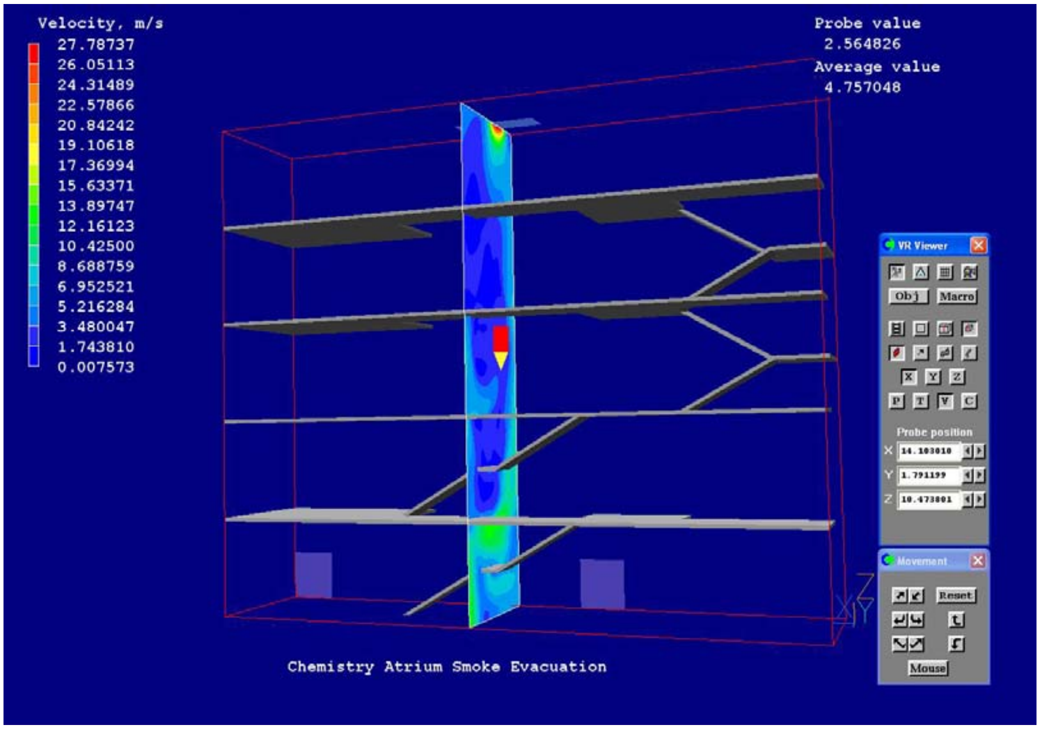


Figure 46: Phoenics Velocity X Slice 3

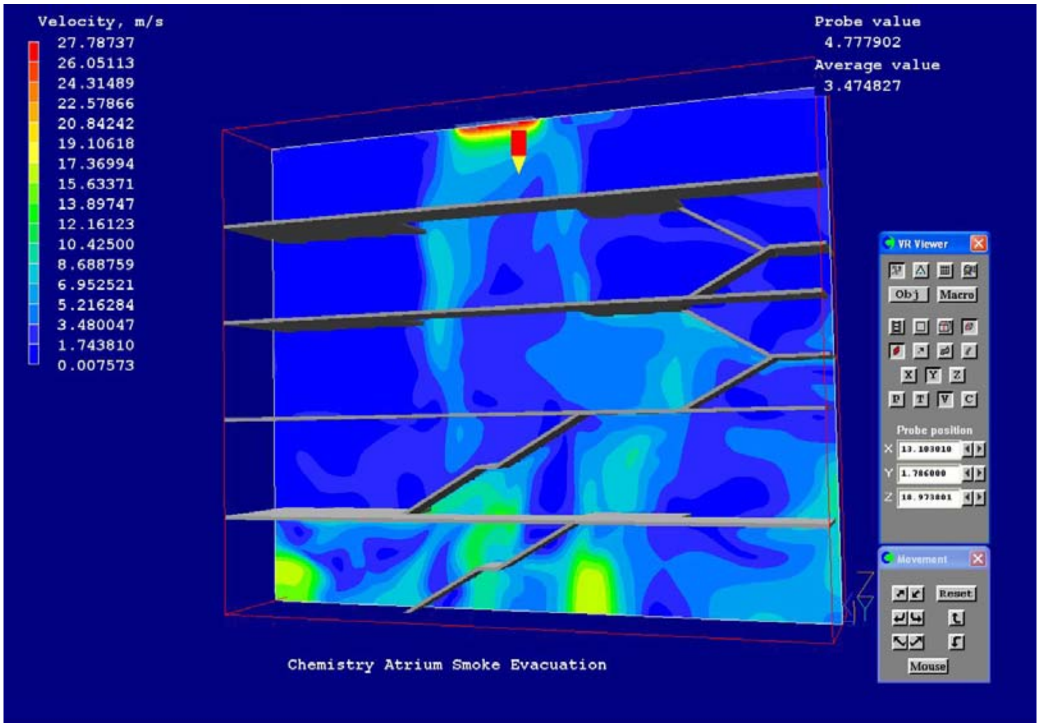


Figure 47: Phoenics Velocity Y Slice

The above Figure 47 is the Y slice through the center of the air outlet. This slice shows the high velocity areas from the air intakes and the very high velocity at the center of the air outlet. The majority of the air taken into account by the cut shows some air movement. Furthermore, more cuts must be taken in order to analyze whether or not the air is actually moving in the above troublesome regions.

Figure 48 and Figure 49 are cuts taken along the Z axis. The cuts taken in this direction show much of what the cuts in the other directions have shown. The air appears to be moving well through the space in some regions; however, in other regions the air seems to be moving little or not at all.

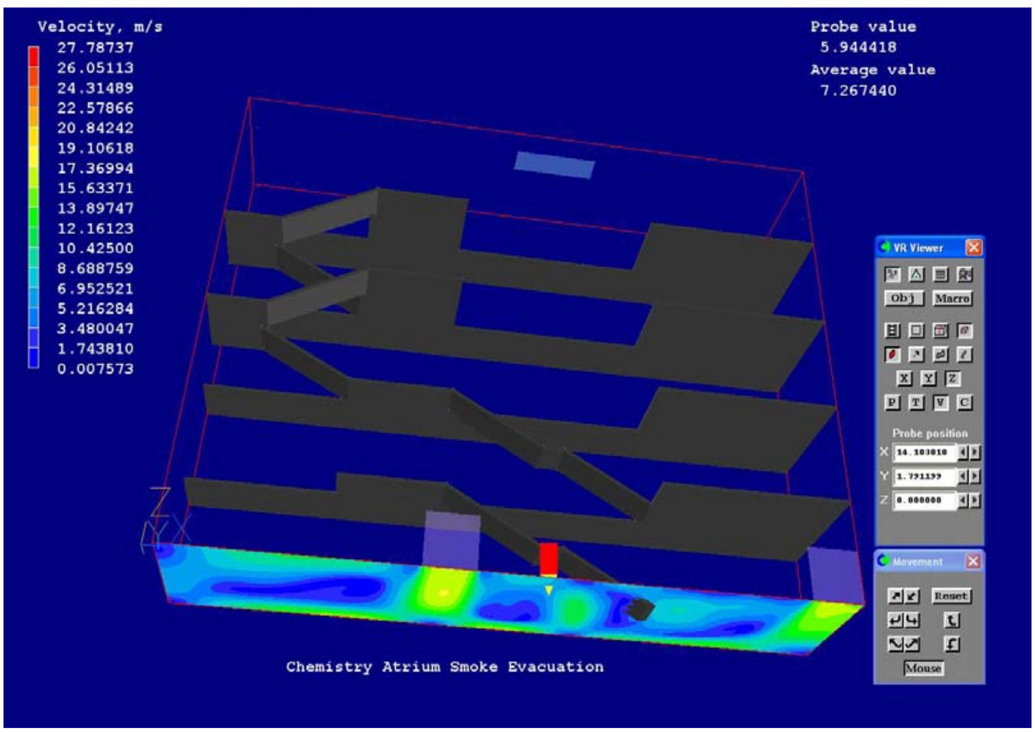


Figure 48: Phoenics Velocity Z Slice 2

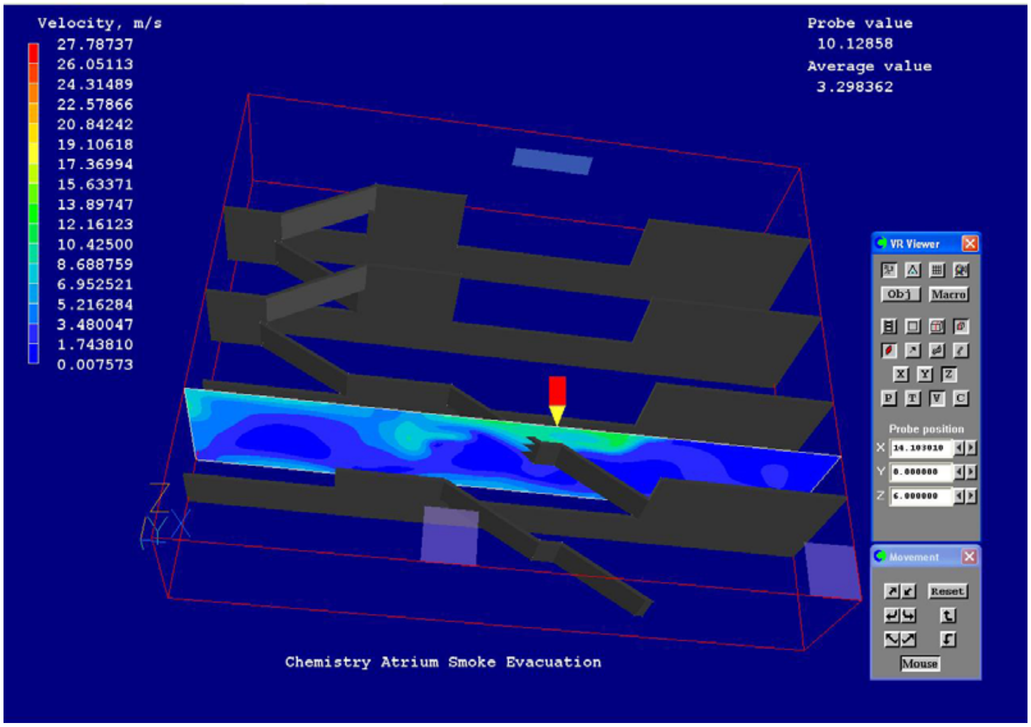


Figure 49: Phoenics Velocity Z Slice 3

CONTAMINATION STUDY

The final area requiring examination when designing a smoke evacuation system pertains to where the contaminants exhausting out of your building are traveling to, and whether they are recontaminating your building or any of the other surrounding buildings. This contamination study was prepared using the 1997 ASHRAE Fundamentals example which follows the IBC code.

The first variable to examine when conducting this study is the air pattern for the region where the building is located. The direction of the wind and speed of the wind will need to be evaluated and checked. The narrative in the Fundamentals demonstrates the process of calculating which air speed to use. The second calculation, dependent on the information gathered previously, is the plume trajectory. The Fundamentals recommends the default value of 15 degrees for calculation of the trajectory angle considering that the air usually oscillates between 0-30 degrees from the stack.

The rest of the information is simple input information which will have to be researched, such as the height of the stack. Code requires a minimum height of eight feet; for our study the stack height will be eighteen feet. Eighteen feet was chosen to match the surrounding stack height of the laboratory exhausts. The rest of the inputs are as follows:

- String Distance to Air Intake……………………………56 feet
  Shortest Distance to Air Intake
- Cross Sectional Area of Stack ………………………78.54 ft^2
- Exhaust Jet Trajectory Factor………………………….0.059
  Default Value Using 15 Degrees
- Velocity of Discharge Air…………………….………4,000 fpm
- Height of Stack……………………………….………18 feet

The minimum contamination ratio that needs to be met by the IBC code is 1000 parts air to 1 part of contaminates. The contamination study conducted for this design can be seen in the Atrium Contamination Appendix. The result yielded from the study well surpassed the minimum contaminates. A ratio of 150,563 parts air to one part contaminates was found.

EVALUATION OF CHANGES

Overall, the redesign of the atrium does not have a huge impact on the aesthetics of the atrium space, but with the proper design the life safety of the atrium would be dramatically increased. Moreover, because the majority of the make-up air is coming from two central locations, and the exhaust is taking place at one central location the air moving equally through the space is not probable. The air in the space has several almost stagnant regions where the air is moving very little, which is not ideal for the evacuation of the smoke. In addition there are several areas which have quite intense flows, also undesirable in design.

The transient model shows that the smoke level could be as low as twenty feet by the time the fans are activated to evacuate the contaminated air. A more sophisticated method of detection used will shorten the response time so that the smoke level can be held at 63 feet above the lowest floor of the atrium, allowing all occupied floors the ability to withdraw through the space in case of an emergency.

This was discussed at a greater length in the Transient Model Results and Design section of this document.

From the computational fluid model the design appears to be able to fulfill its purpose; however, the design is not operating at an optimum efficiency. There are several factors which could have been adjusted that would make the design more efficient such as the number of outlets and intakes and their locations. These factors were not able to be adjusted due to the lack of space for the system. Furthermore, the layout of the zones surrounding the atrium was already designed to carry out a different function rather than provide make-up air. If this would have been part of the original design the mechanical engineer could have designed a much more efficient system by using make-up air from the surrounding areas and exhausting the air from multiple locations. The use of multiple locations would cause entraining of all the air of the space so that no dead spots would exist.

The last section to be discussed is the Contamination Study. The results yielded in this section far surpassed the minimum requirement by code. This is due to the discharge rate of the contaminates out of the stack being on the upper limit of the 4,000 fpm allotment. Because the system does not run continuously through out the day, this could be done. The only time it would be in operation would be when there was an emergency so acoustics and vibrations were not a concern in the design.

CONCLUSIONS DRAWN FROM DESIGN

Because there is no volume which can be filled with smoke before the activation of the fans is triggered, detection needs to be almost immediate. This will drive the price of a system up. On the other hand, it will enable the existing structure to remain unchanged, while still allowing the system to function properly exhausting the contaminates from the space.

Conclusions drawn from the CFD design are that as mentioned in the previous section. Air inlet and outlets need to range in a large number of areas throughout the design in order to entrain as much of the air in the space as possible. Having one outlet and two inlets does not allow the air to be entrained in all areas of the design. The presented design in this document shows that several high and stagnate regions of air exist, presenting not the most favorable method to exhaust the contaminated air.

STRUCTURAL BREADTH

DESCRIPTION OF NEED FOR REDESIGN

During the redesign of the atrium space three centrifugal fans were added to the roof structure of the penthouse, each of those fans weighed 4,370 Ibs or 2.2 tons. That makes the total load added to the existing roof 13,110 Ibs or 6.6 tons. The redesign of the steel framing of the structure was needed to verify that the new gravity loads were carried by the existing columns.

EXISTING STRUCTURAL SYSTEM

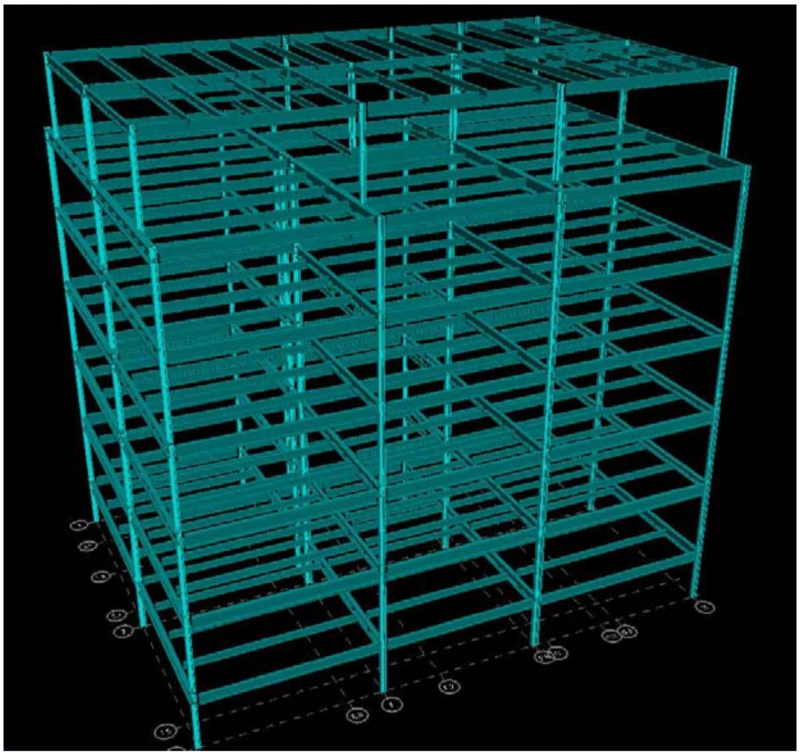


Figure 50: RAM 3D Entire Structure

The existing structure is a structural steel skeleton supported by spread footings and a concrete mat.

RAM REDESIGN

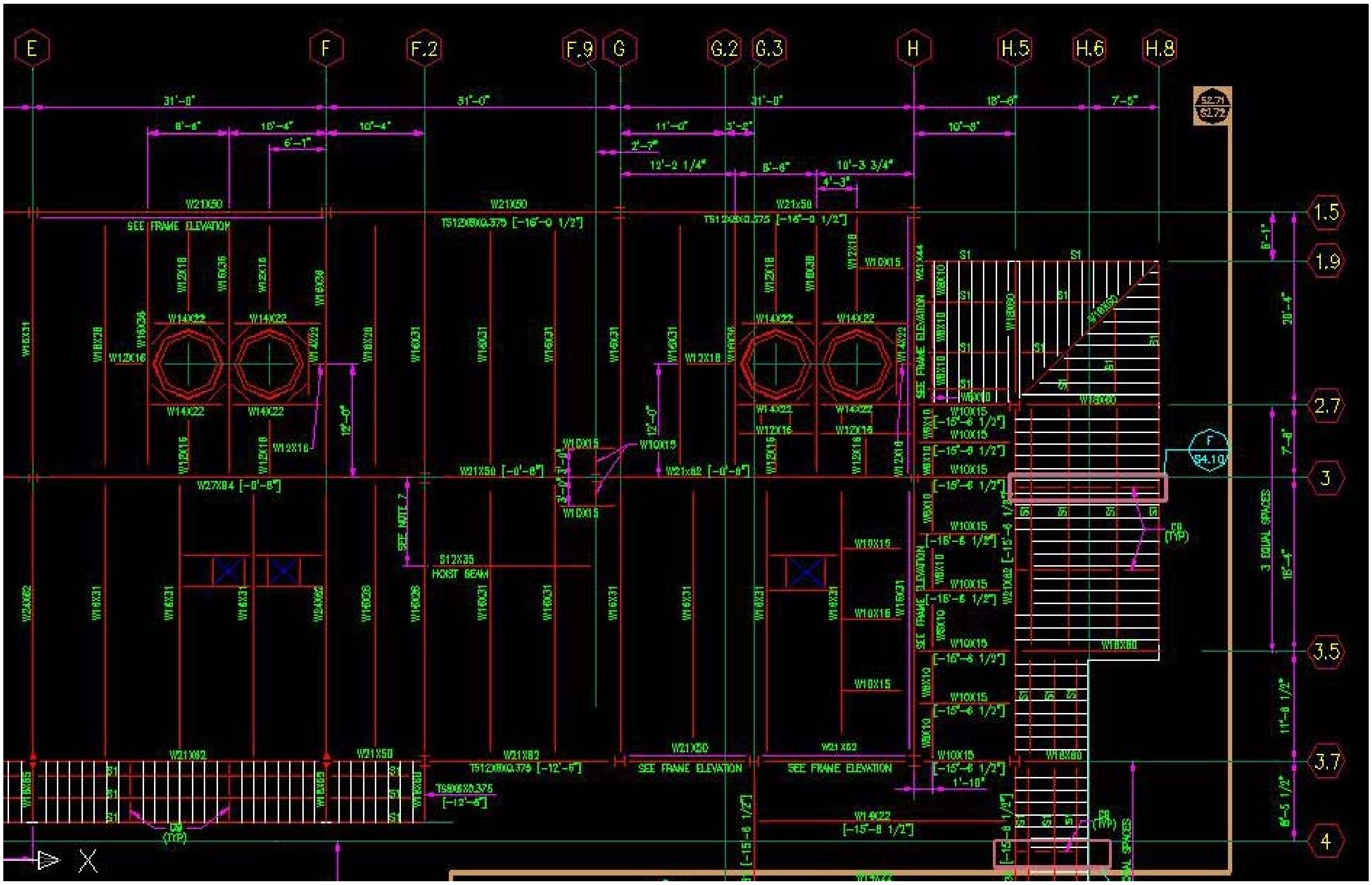


Figure 51: AutoCAD Structural Framing Plan

The figure above is the original framing plan for the building. The original building did not take into account any equipment gravity loads being placed on the roof of the structure. To verify that the existing columns could carry the additional gravity loads of the centrifugal fans the structure was erected in the program RAM Structural System. The loads were applied to the building using ASCE-7-02 and IBC codes. Additional analysis on beam sizes and capacity was calculated using the Manual of Steel Construction LRFD Method, Third Edition. The structure was only analyzed on a gravity base due to the new loads were insignificant to lateral analysis. This was assumed because the drift of the structure would be increased at an insignificant amount. The error which would be calculated would be negligible.

Figure 52 and the enlarged plan in Figure 53 shows the revised framing plan to accommodate for the new load of the centrifugal fans. Several beams were moved to allow the load from the fans to be directly carried to a column. They were moved and aligned with columns on the interior of the building because the exterior columns do not sit on top of columns but on top of beams because of the building setback. The frame was further modified to support the load by adding structural bracing to represent specific framing needed to support the fans. All the new beam's sizes were sized using the RAM program. Also several other beams in the plan were sized up around the new load by the program, due to the fact they failed in tension.

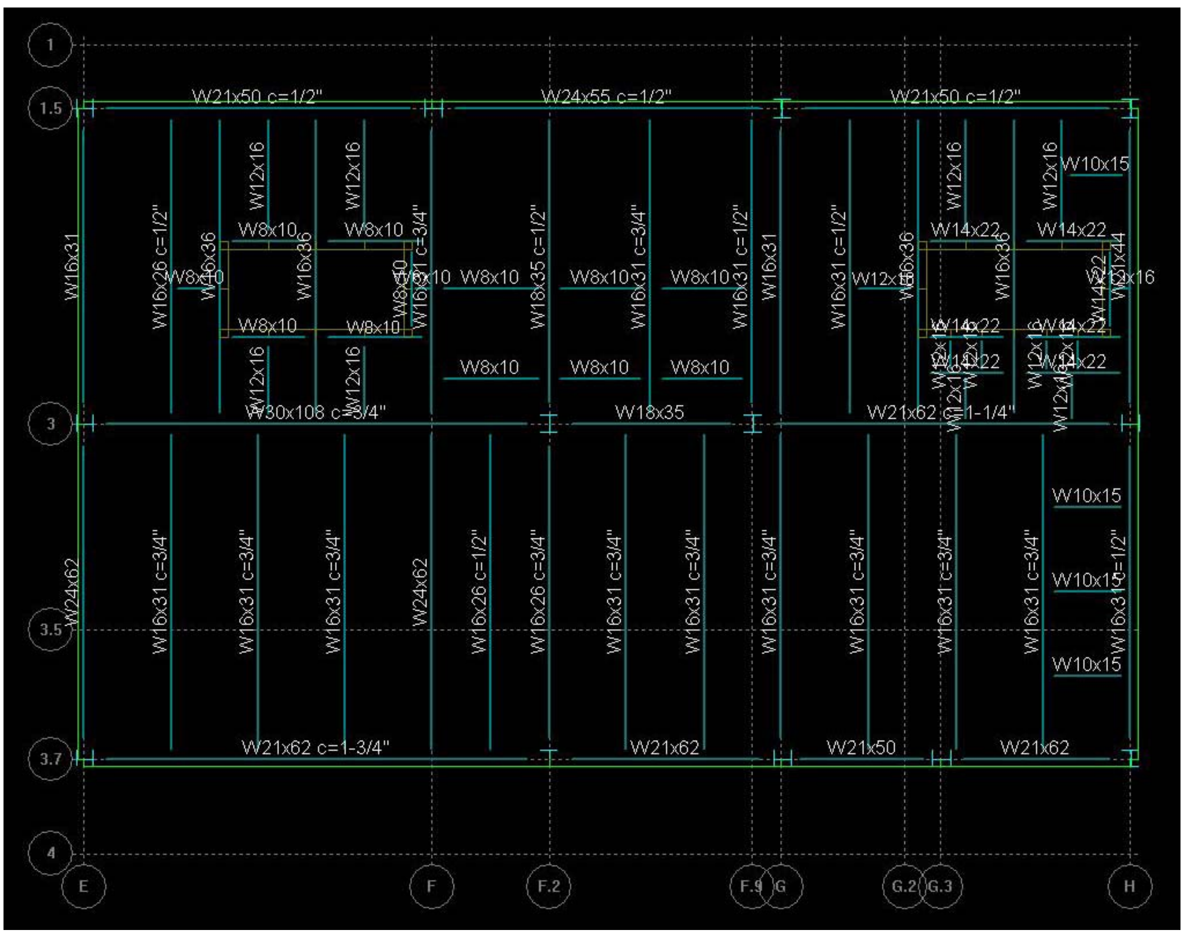


Figure 52: RAM Structural Redesign and Resize of Members for Atrium Smoke Evacuation Fans

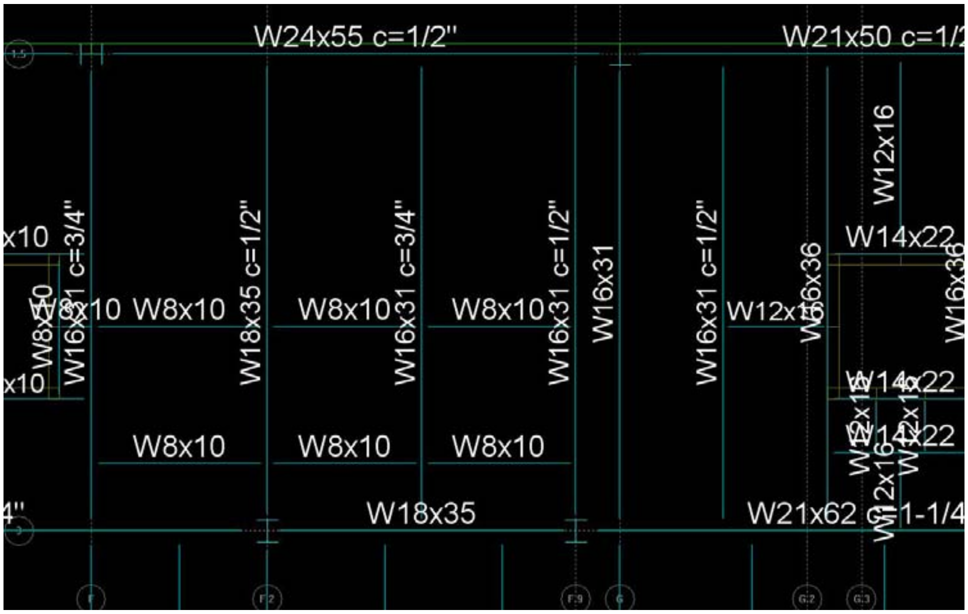


Figure 53: RAM Enlarged Structural Redesign and Resize of Members for Atrium Smoke Evacuation Fans

With the beams resized that supported the roof of the structure, the analysis of the columns began. After running the analysis it became evident that the existing columns where not sized based on gravity loads because they did not fail during the analysis. This can be seen in Figure 54. Figure 55 displays the percentage of capacity the columns are loaded to.

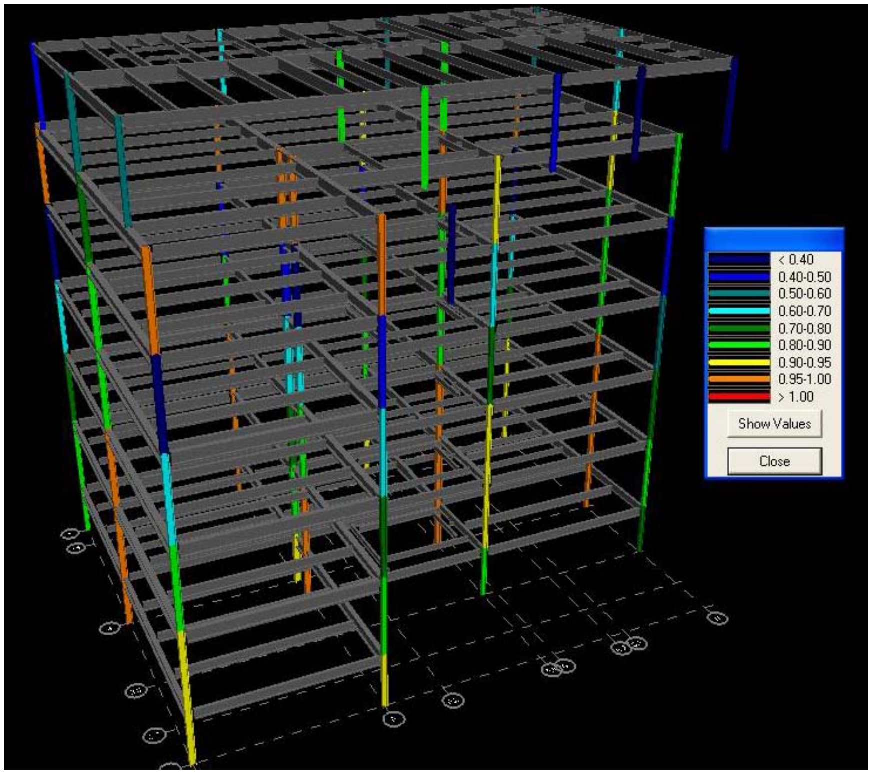


Figure 54: RAM 3D Column Load Evaluation

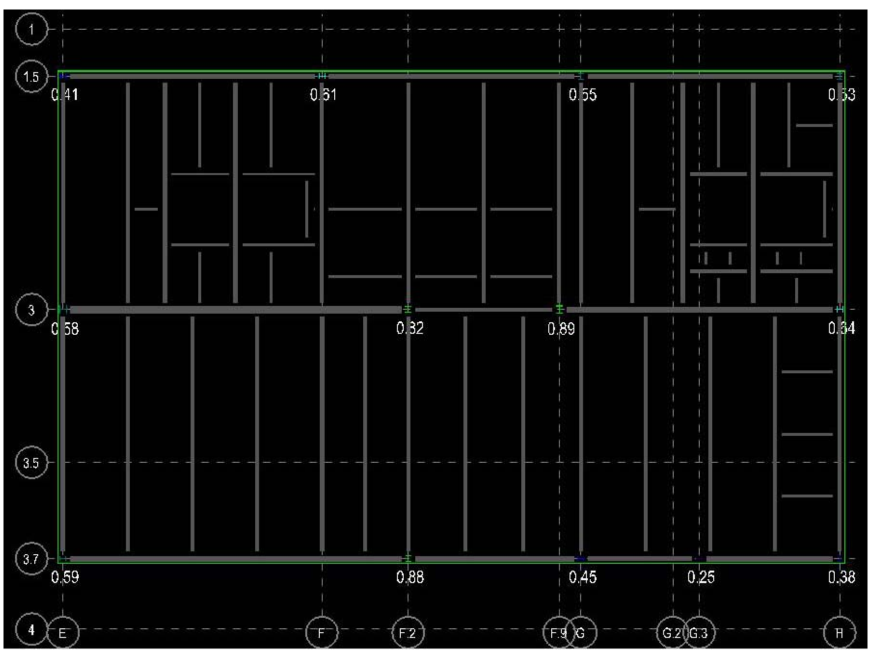


Figure 55: RAM Column Plan Load Evaluation

RAM RESULTS

The RAM structural analysis verifies that the columns are adequate in design to carry the additional load supplied by the centrifugal fans.

CONCLUSIONS DRAWN FROM DESIGN

After running an analysis on the columns and their new gravity load it has become evident the existing columns where not sized based on gravity loads because the columns did not fail; however, they are still capable of carrying the additional gravity based load. Also, when deciding where to put mechanical equipment on the roof of a building it is important to analyze the column lines so the load can be carried directly to them. In addition, it is also important to consider what type of equipment is being added so that additional structural bracing can be included to the framing to represent the specific framing needed to support the equipment.

APPENDIX A: MECHANICAL IMAGES

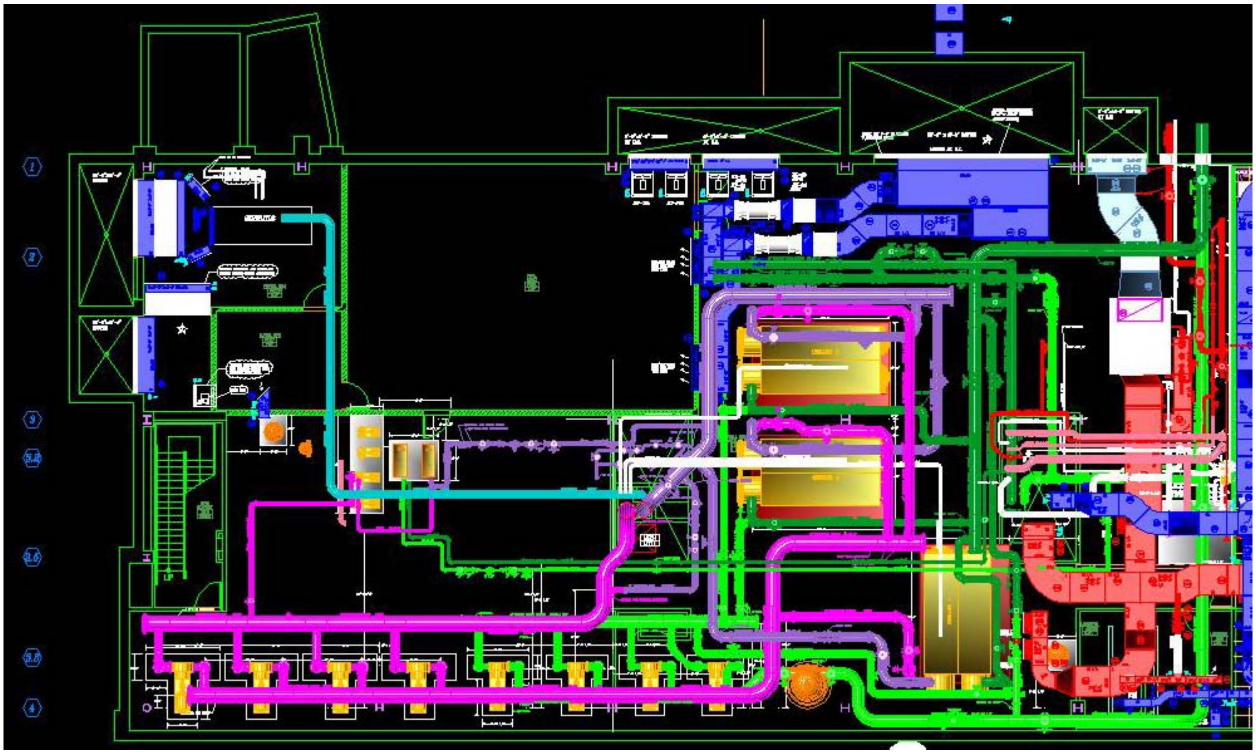


Figure 1: Original Mechanical Plan

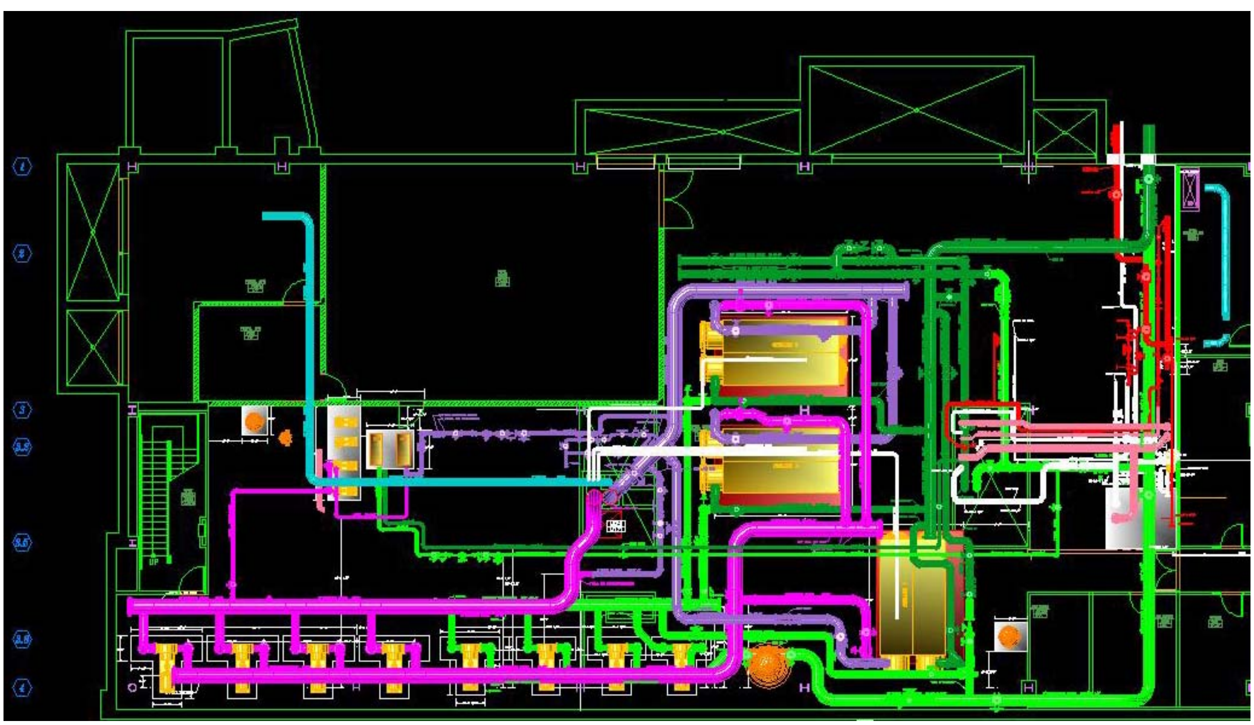


Figure 2: Ductless Original Mechanical Plan

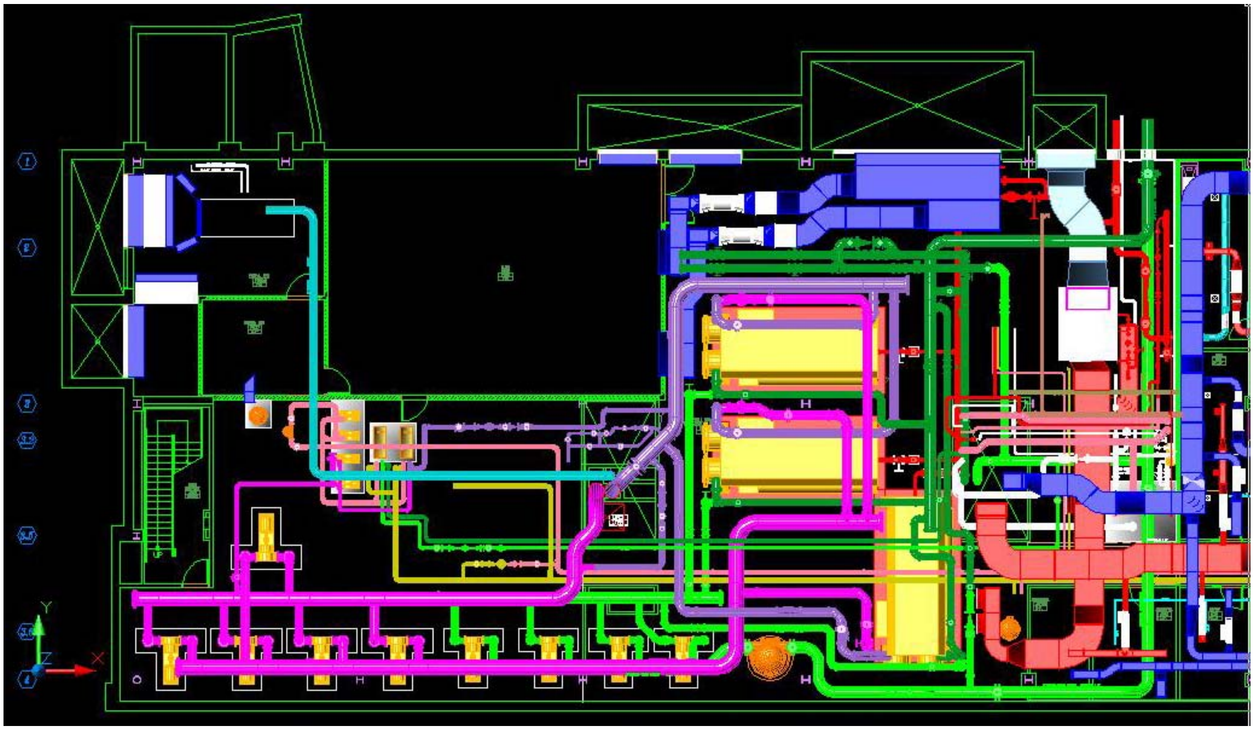


Figure 3: Redesign Mechanical Plan

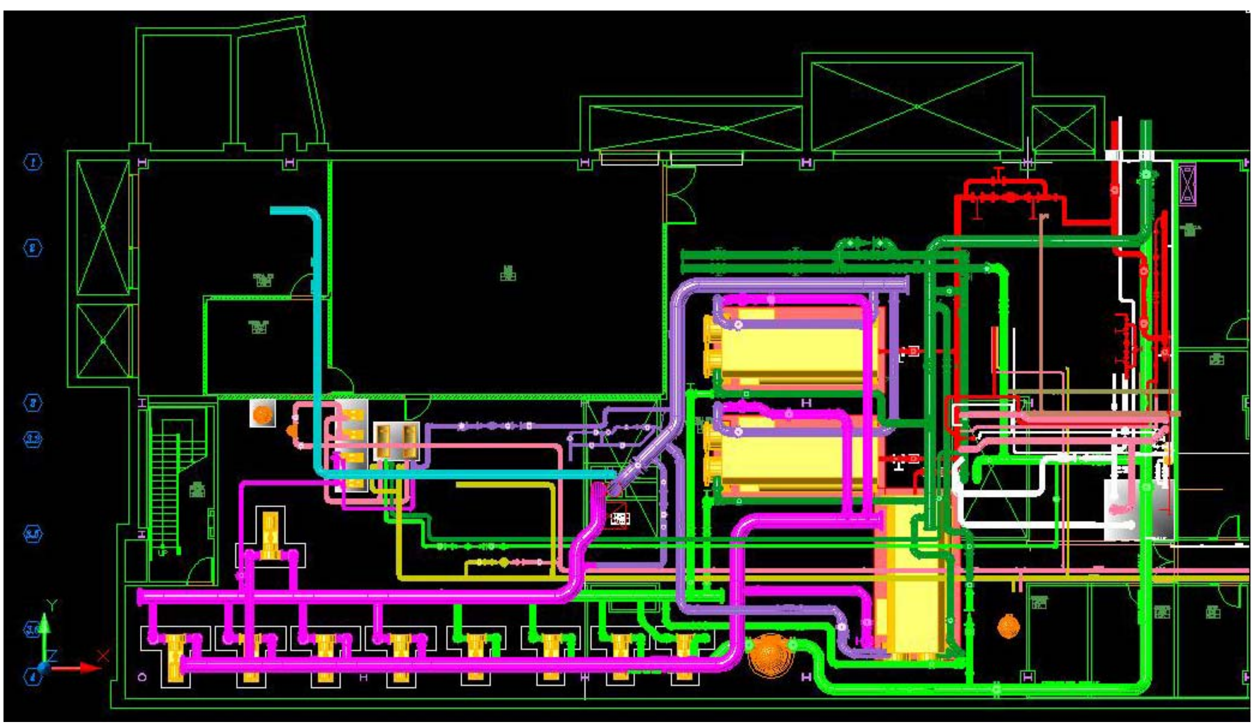


Figure 4: Ductless Redesign Mechanical Plan

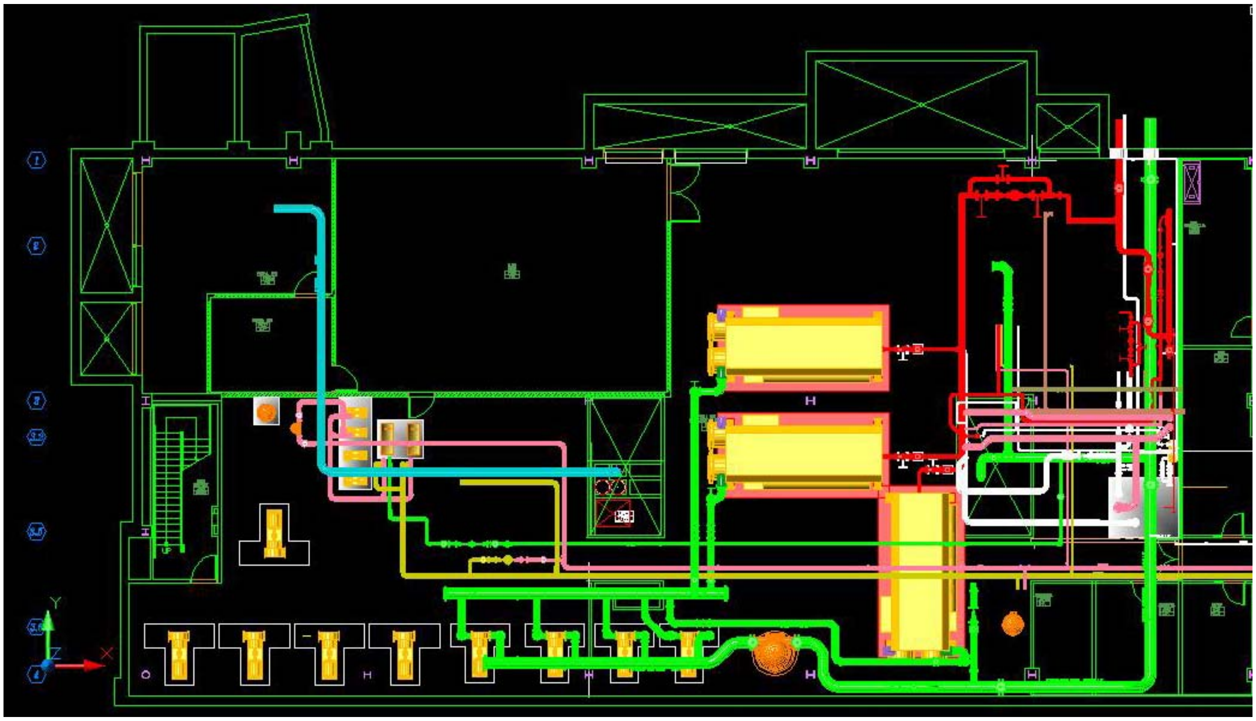


Figure 5: Steam and Condensate Redesign Mechanical Plan

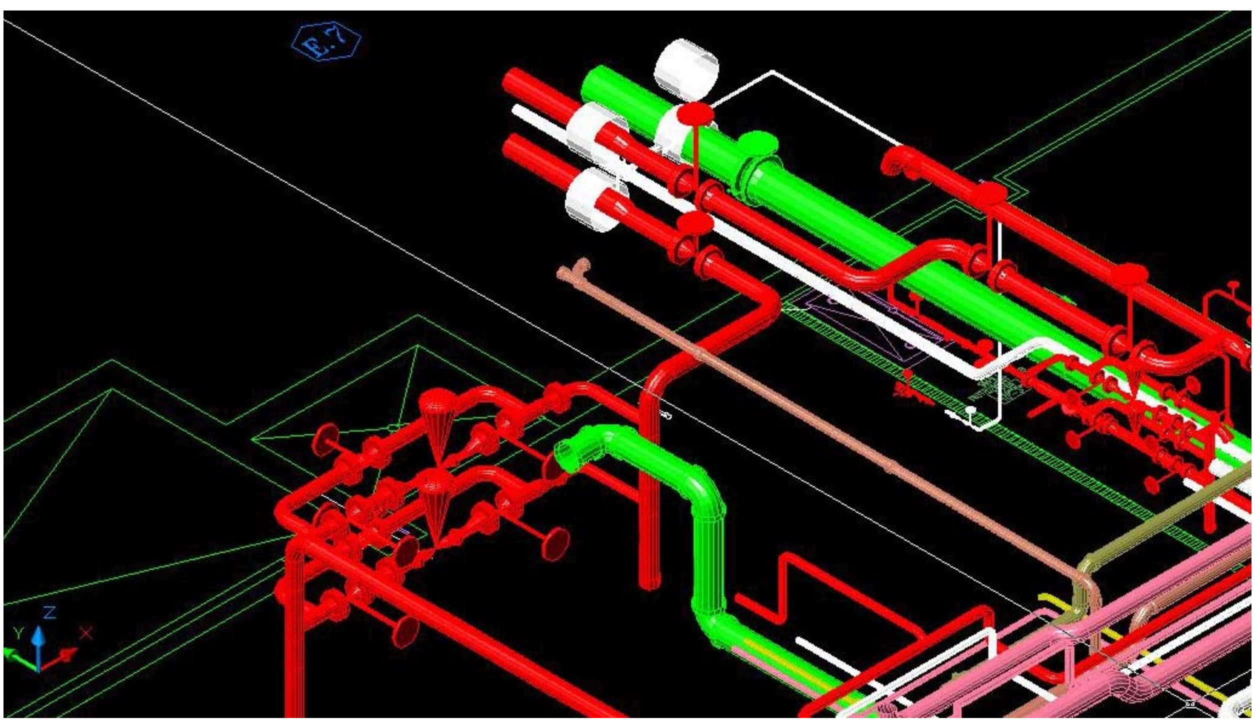


Figure 6: Redesign Steam Reducing Station and Additional Service Line Isometric

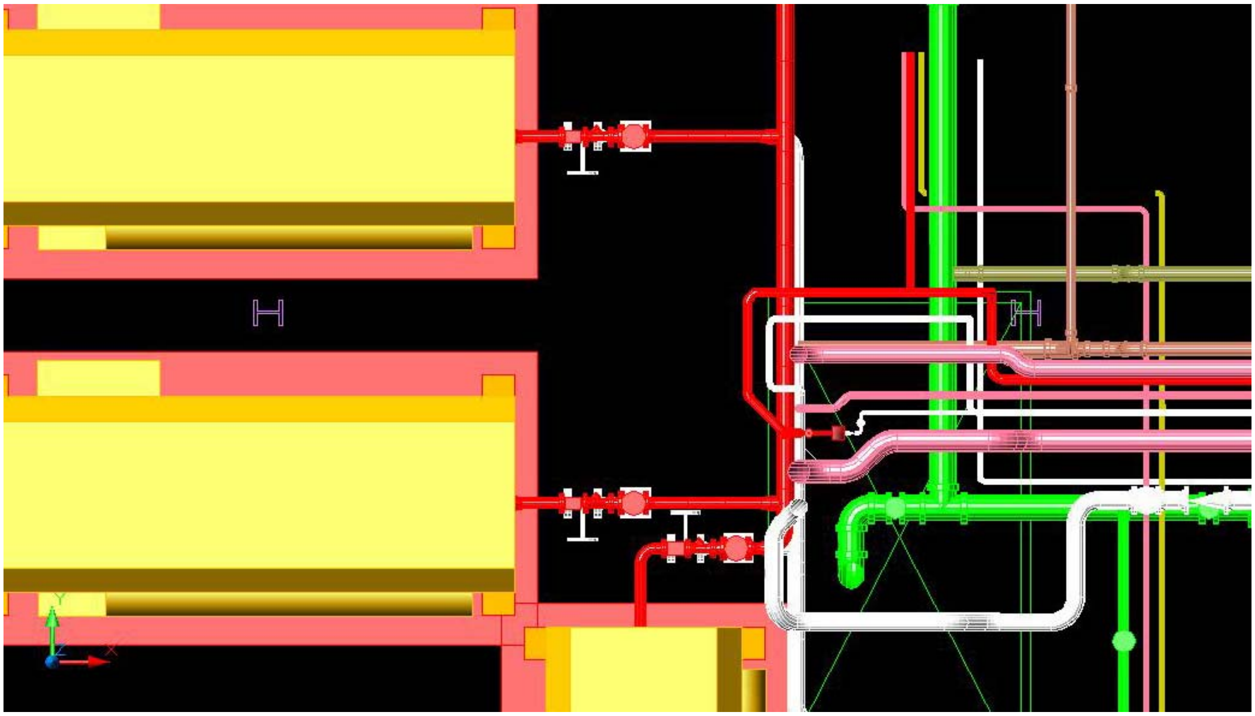


Figure 7: Enlarged Steam and Condensate Connection to Absorption Chillers

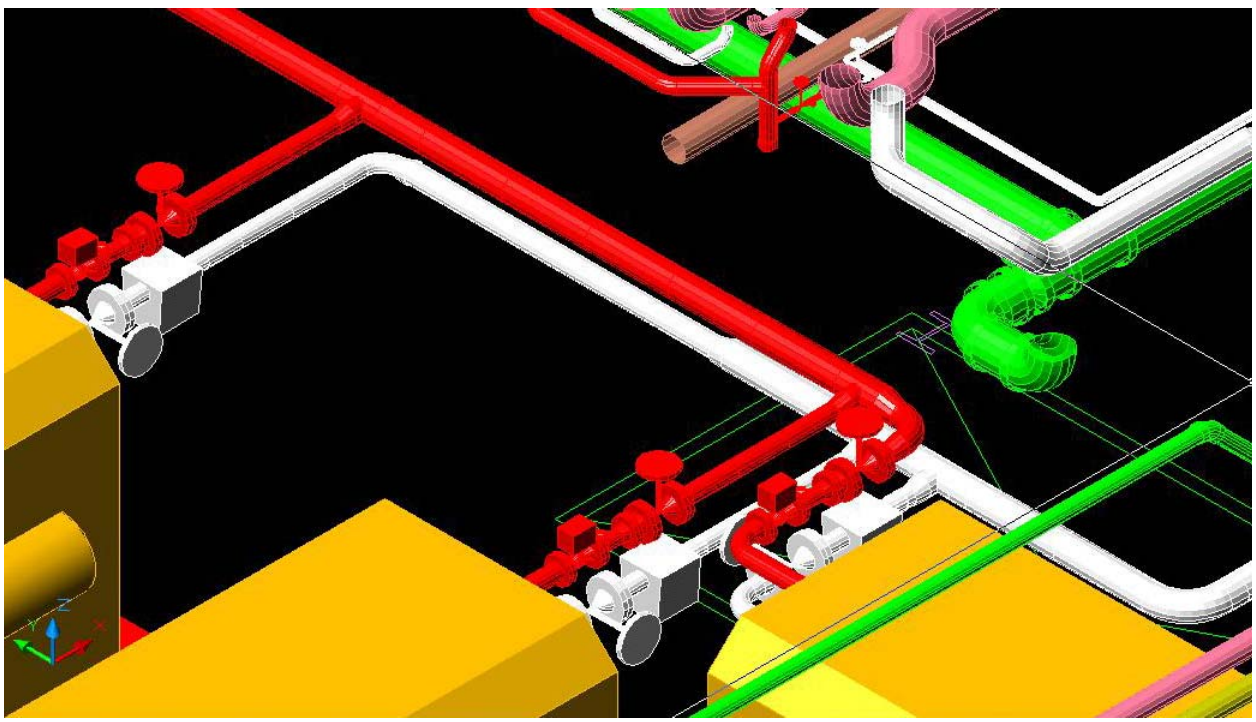


Figure 8: Steam and Condensate Connection to Absorption Chillers Isometric

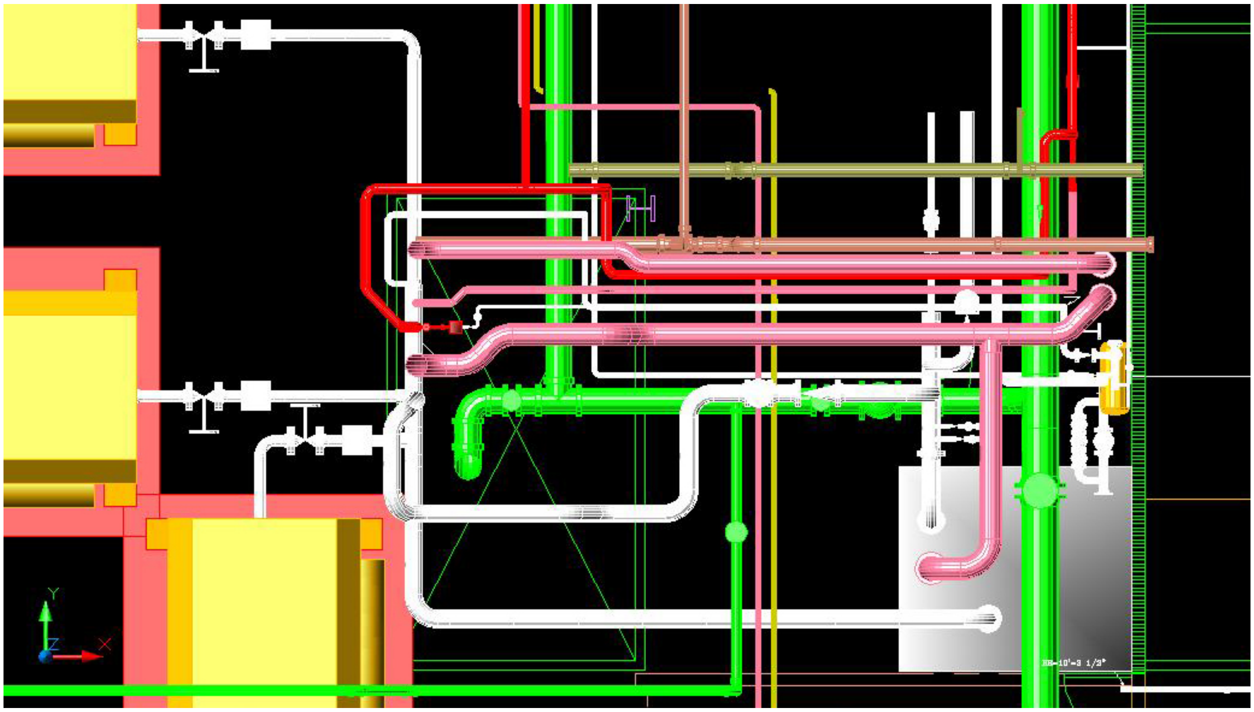


Figure 9: Enlarged Condensate Redesign Mechanical Plan

APPENDIX B: CHILLER PLANT LOAD SUMMARY

Chiller Output			
Hours	**Tons Total**	**Tons [310]**	**Tons [55]**
1	557,565.24	1,527.58	1,527.58
2	563,988.88	1,545.18	1,545.18
3	570,412.51	1,562.77	1,562.77
4	567,842.91	1,555.73	1,555.73
5	616,662.03	1,689.49	1,689.49
6	697,035.79	1,939.39	1,742.28
7	804,810.90	2,280.81	1,777.48
8	903,733.82	2,590.54	1,830.28
9	965,558.37	2,780.61	1,883.07
10	1,004,469.27	2,896.76	1,935.87
11	1,037,924.54	2,995.32	1,988.67
12	1,045,896.86	3,012.92	2,034.42
13	1,049,944.81	3,023.48	2,048.50
14	1,074,160.58	3,090.35	2,111.86
15	1,043,714.77	3,005.88	2,034.42
16	1,015,010.89	2,921.40	1,988.67
17	968,462.15	2,780.61	1,935.87
18	911,002.09	2,604.62	1,883.07
19	837,175.27	2,375.84	1,830.28
20	822,268.86	2,337.12	1,777.48
21	785,417.10	2,224.49	1,742.28
22	703,952.14	1,971.07	1,689.49
23	670,620.18	1,876.03	1,619.09
24	630,037.28	1,756.36	1,555.73
Total:	19,847,667.20	56,344.33	43,289.54

Figure 1: Chiller Output [Tons]

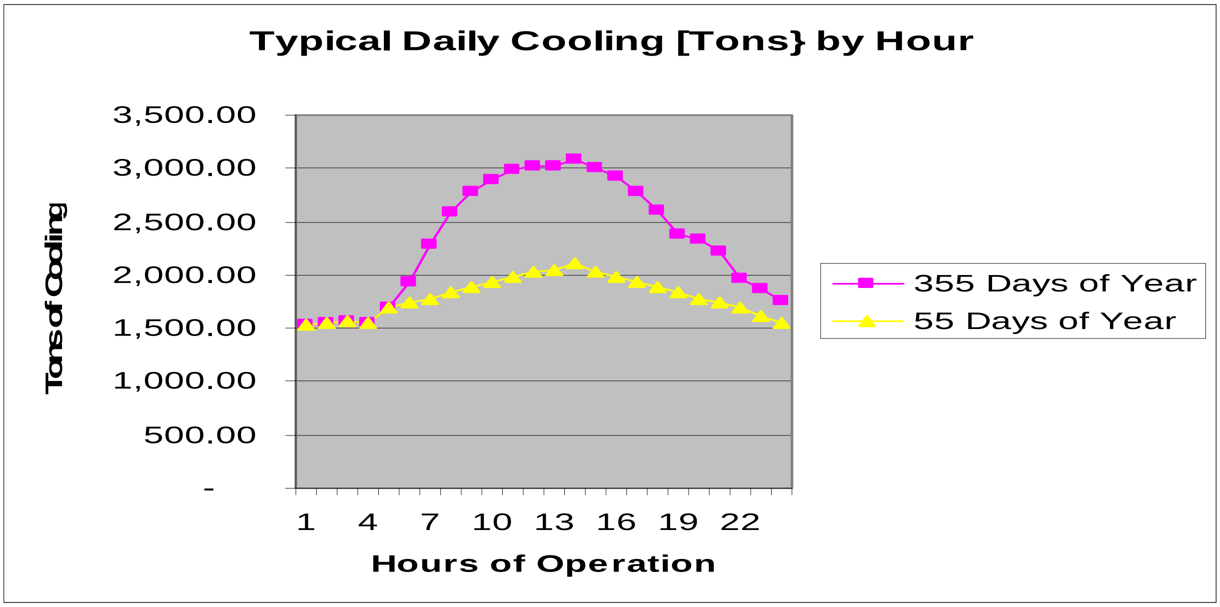


Figure 2: Typical Daily Cooling [Tons] by Hour Profile

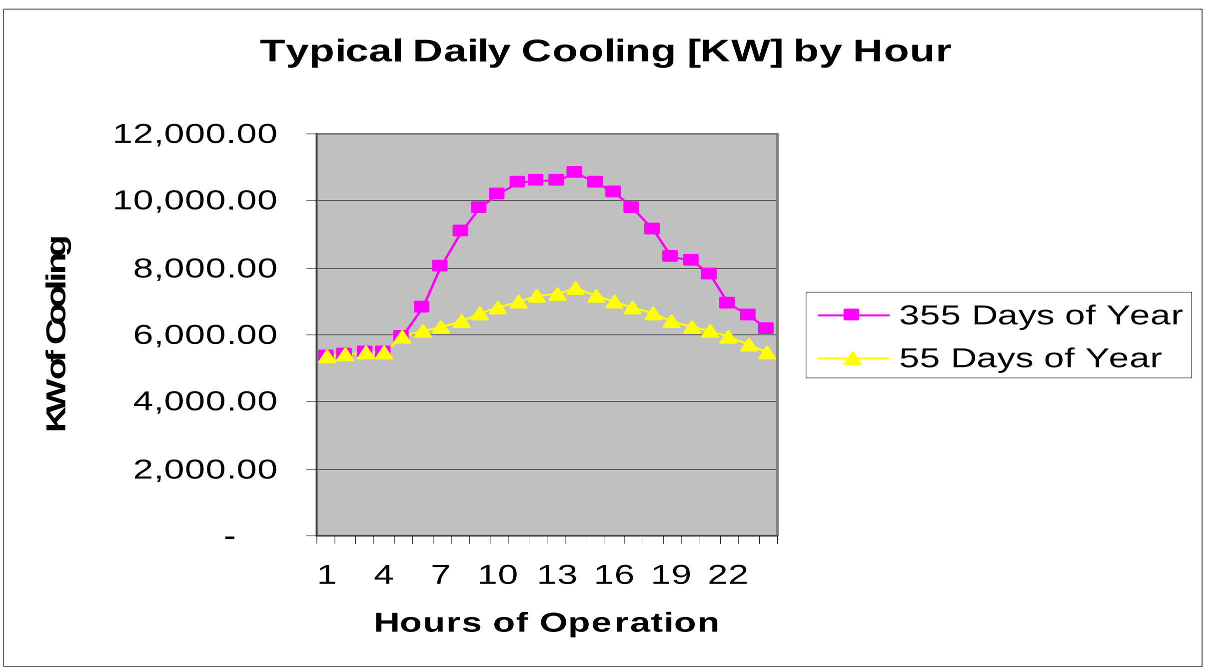


Figure 3: Typical Daily Cooling [KW] by Hour Profile

Chiller Output			
Hours	kw Total	kw [310]	kw [55]
1	1,959,130.81	5,367.48	5,367.48
2	1,981,701.70	5,429.32	5,429.32
3	2,004,272.58	5,491.16	5,491.16
4	1,995,243.72	5,466.42	5,466.42
5	2,166,780.65	5,936.39	5,936.39
6	2,449,191.94	6,814.48	6,121.90
7	2,827,884.00	8,014.12	6,245.57
8	3,175,471.94	9,102.46	6,431.09
9	3,392,706.39	9,770.30	6,616.60
10	3,529,428.58	10,178.43	6,802.11
11	3,646,981.18	10,524.72	6,987.62
12	3,674,993.74	10,586.55	7,148.40
13	3,689,217.10	10,623.66	7,197.87
14	3,774,304.67	10,858.64	7,420.48
15	3,667,326.47	10,561.82	7,148.40
16	3,566,468.92	10,265.00	6,987.62
17	3,402,909.47	9,770.30	6,802.11
18	3,201,010.64	9,151.93	6,616.60
19	2,941,603.51	8,348.04	6,431.09
20	2,889,226.47	8,212.00	6,245.57
21	2,759,739.54	7,816.24	6,121.90
22	2,473,494.07	6,925.78	5,936.39
23	2,356,374.76	6,591.86	5,689.04
24	2,213,777.62	6,171.37	5,466.42
Total:	69,739,240.46	197,978.47	152,107.52

Figure 4: Chiller Output [KW]

Chiller Electrical Input									
Hours	kw Total	kw [310]	kw [55]	$ kw Total Today	$ kw [310] Today	$ kw [55] Today	$ kw Total 2007	$ kw [310] 2007	$ kw [55] 2007
1	1,214,661.10	947.10	947.10	$12,645.36	$34.64	$34.64	$31,112.14	$85.24	$85.24
2	1,228,655.05	958.01	958.01	$12,791.04	$35.04	$35.04	$31,470.58	$86.22	$86.22
3	1,242,649.00	968.92	968.92	$12,936.73	$35.44	$35.44	$31,829.02	$87.20	$87.20
4	1,237,051.10	964.56	964.56	$12,878.45	$35.28	$35.28	$31,685.63	$86.81	$86.81
5	1,343,404.00	1,047.48	1,047.48	$13,985.65	$38.32	$38.32	$34,409.74	$94.27	$94.27
6	1,518,499.00	1,202.42	1,080.21	$15,808.49	$43.98	$39.51	$38,894.60	$108.22	$97.22
7	1,753,288.08	1,414.10	1,102.04	$18,252.79	$51.73	$40.31	$44,908.45	$127.27	$99.18
8	1,968,792.60	1,606.14	1,134.77	$20,496.32	$58.75	$41.51	$50,428.35	$144.55	$102.13
9	2,103,477.96	1,723.98	1,167.50	$21,898.48	$63.06	$42.71	$53,878.16	$155.16	$105.08
10	2,188,245.72	1,795.99	1,200.24	$22,780.96	$65.70	$43.90	$56,049.39	$161.64	$108.02
11	2,261,128.33	1,857.10	1,232.97	$23,539.71	$67.93	$45.10	$57,916.19	$167.14	$110.97
12	2,278,496.12	1,868.01	1,261.34	$23,720.52	$68.33	$46.14	$58,361.04	$168.12	$113.52
13	2,287,314.60	1,874.55	1,270.07	$23,812.33	$68.57	$46.46	$58,586.92	$168.71	$114.31
14	2,340,068.89	1,916.02	1,309.35	$24,361.53	$70.09	$47.90	$59,938.16	$172.44	$117.84
15	2,273,742.41	1,863.64	1,261.34	$23,671.03	$68.17	$46.14	$58,239.28	$167.73	$113.52
16	2,211,210.73	1,811.27	1,232.97	$23,020.04	$66.26	$45.10	$56,637.61	$163.01	$110.97
17	2,109,803.87	1,723.98	1,200.24	$21,964.33	$63.06	$43.90	$54,040.19	$155.16	$108.02
18	1,984,626.59	1,614.87	1,167.50	$20,661.16	$59.07	$42.71	$50,833.92	$145.34	$105.08
19	1,823,794.18	1,473.02	1,134.77	$18,986.80	$53.88	$41.51	$46,714.38	$132.57	$102.13
20	1,791,320.41	1,449.02	1,102.04	$18,648.73	$53.00	$40.31	$45,882.60	$130.41	$99.18
21	1,711,038.52	1,379.18	1,080.21	$17,812.95	$50.45	$39.51	$43,826.27	$124.13	$97.22
22	1,533,566.33	1,222.06	1,047.48	$15,965.35	$44.70	$38.32	$39,280.53	$109.99	$94.27
23	1,460,952.35	1,163.14	1,003.84	$15,209.40	$42.55	$36.72	$37,420.61	$104.68	$90.35
24	1,372,542.12	1,088.94	964.56	$14,288.99	$39.83	$35.28	$35,156.08	$98.00	$86.81
Total:	43,238,329.09	34,933.49	26,839.51	$663,594.15	$1,277.87	$981.79	$1,320,956.83	$3,144.01	$2,415.56

Figure 5: Chiller Electrical Input [Allegheny Power University Rates]

Chiller Coal Input											
Hours	**Steam lbs [Total]**	**Steam lbs [310]**	**Steam lbs [55]**	**Coal lb [TOTAL]**	**Coal lb [310]**	**Coal lb [55]**	**$ Coal [TOTAL] Today**	**$ Coal [310] Today**	**$ Coal [55] Today**	**$ Coal [TOTAL] 2005**	**$ Coal [310] 2005**	**$ Coal [55] 2005**
1	5,032,026.29	13,786.37	13,786.37	642,186.93	1,759.42	1,759.42	$28,898.41	$79.17	$79.17	$14,449.21	$39.59	$39.59
2	5,089,999.60	13,945.20	13,945.20	649,585.48	1,779.69	1,779.69	$29,231.35	$80.09	$80.09	$14,615.67	$40.04	$40.04
3	5,147,972.90	14,104.04	14,104.04	656,984.03	1,799.96	1,799.96	$29,564.28	$81.00	$81.00	$14,782.14	$40.50	$40.50
4	5,124,782.26	14,040.50	14,040.50	654,024.44	1,791.85	1,791.85	$29,431.10	$80.63	$80.63	$14,715.55	$40.32	$40.32
5	5,565,374.78	15,247.60	15,247.60	710,252.84	1,945.90	1,945.90	$31,961.38	$87.57	$87.57	$15,980.69	$43.78	$43.78
6	6,290,748.00	17,502.98	15,724.10	802,824.93	2,233.73	2,006.71	$36,127.12	$100.52	$90.30	$18,063.56	$50.26	$45.15
7	7,263,418.33	20,584.27	16,041.75	926,957.06	2,626.96	2,047.25	$41,713.07	$118.21	$92.13	$20,856.53	$59.11	$46.06
8	8,156,197.73	23,379.66	16,518.24	1,040,893.52	2,983.71	2,108.06	$46,840.21	$134.27	$94.86	$23,420.10	$67.13	$47.43
9	8,714,164.29	25,095.01	16,994.72	1,112,101.19	3,202.62	2,168.87	$50,044.55	$144.12	$97.60	$25,022.28	$72.06	$48.80
10	9,065,335.16	26,143.29	17,471.21	1,156,917.60	3,336.40	2,229.67	$52,061.29	$150.14	$100.34	$26,030.65	$75.07	$50.17
11	9,367,268.93	27,032.73	17,947.70	1,195,450.37	3,449.92	2,290.48	$53,795.27	$155.25	$103.07	$26,897.63	$77.62	$51.54
12	9,439,219.16	27,191.56	18,360.66	1,204,632.65	3,470.19	2,343.19	$54,208.47	$156.16	$105.44	$27,104.23	$78.08	$52.72
13	9,475,751.87	27,286.86	18,487.72	1,209,294.95	3,482.35	2,359.40	$54,418.27	$156.71	$106.17	$27,209.14	$78.35	$53.09
14	9,694,299.23	27,890.41	19,059.50	1,237,185.96	3,559.37	2,432.37	$55,673.37	$160.17	$109.46	$27,836.68	$80.09	$54.73
15	9,419,525.80	27,128.03	18,360.66	1,202,119.39	3,462.08	2,343.19	$54,095.37	$155.79	$105.44	$27,047.69	$77.90	$52.72
16	9,160,473.24	26,365.64	17,947.70	1,169,059.11	3,364.78	2,290.48	$52,607.66	$151.42	$103.07	$26,303.83	$75.71	$51.54
17	8,740,370.90	25,095.01	17,471.21	1,115,445.67	3,202.62	2,229.67	$50,195.06	$144.12	$100.34	$25,097.53	$72.06	$50.17
18	8,221,793.86	23,506.72	16,994.72	1,049,264.90	2,999.93	2,168.87	$47,216.92	$135.00	$97.60	$23,608.46	$67.50	$48.80
19	7,555,506.81	21,441.95	16,518.24	964,233.38	2,736.42	2,108.06	$43,390.50	$123.14	$94.86	$21,695.25	$61.57	$47.43
20	7,420,976.42	21,092.52	16,041.75	947,064.62	2,691.83	2,047.25	$42,617.91	$121.13	$92.13	$21,308.95	$60.57	$46.06
21	7,088,389.33	20,076.01	15,724.10	904,619.87	2,562.10	2,006.71	$40,707.89	$115.29	$90.30	$20,353.95	$57.65	$45.15
22	6,353,168.02	17,788.87	15,247.60	810,790.97	2,270.21	1,945.90	$36,485.59	$102.16	$87.57	$18,242.80	$51.08	$43.78
23	6,052,347.12	16,931.20	14,612.29	772,400.22	2,160.76	1,864.82	$34,758.01	$97.23	$83.92	$17,379.00	$48.62	$41.96
24	5,686,086.45	15,851.16	14,040.50	725,658.05	2,022.92	1,791.85	$32,654.61	$91.03	$80.63	$16,327.31	$45.52	$40.32
						Total:	$1,028,697.67	$2,920.31	$2,243.68	$514,348.83	$1,460.15	$1,121.84

Figure 6: Chiller Coal Input [Penn State Steam Plant Rates]

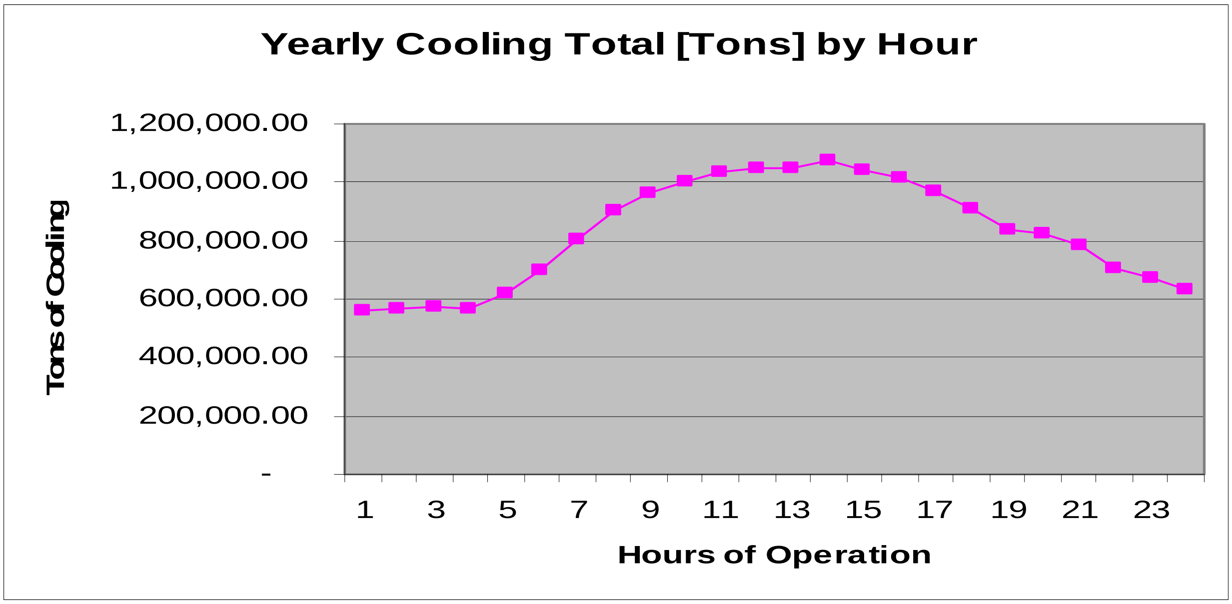


Figure 7: Yearly Cooling Total [Tons] by hour Profile

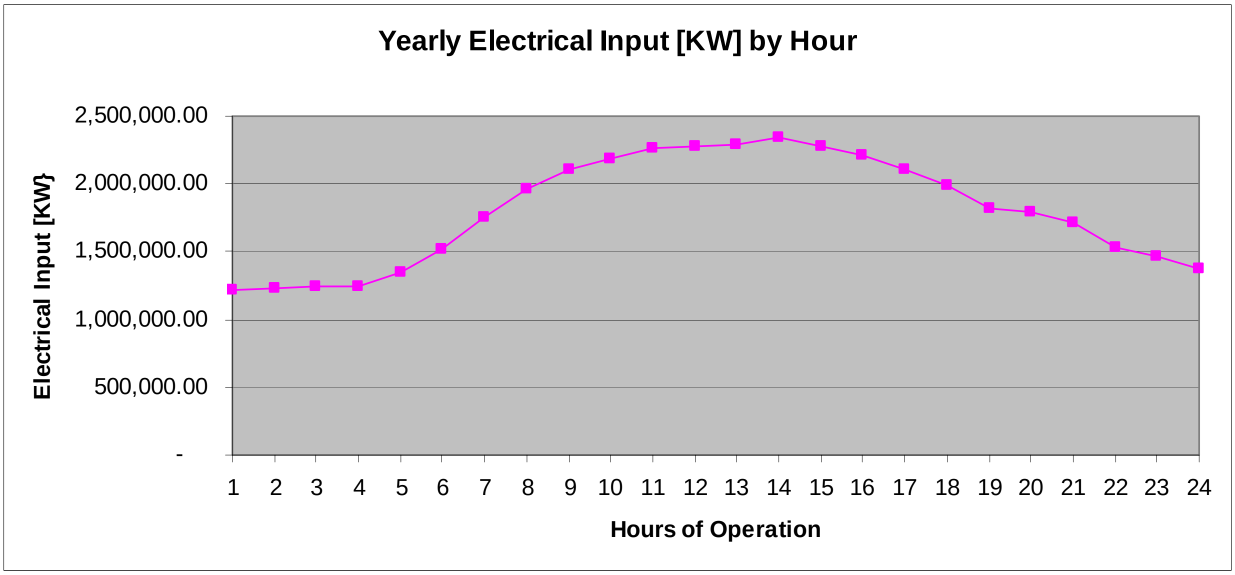


Figure 8: Yearly Electrical Input [KW] by Hour Profile

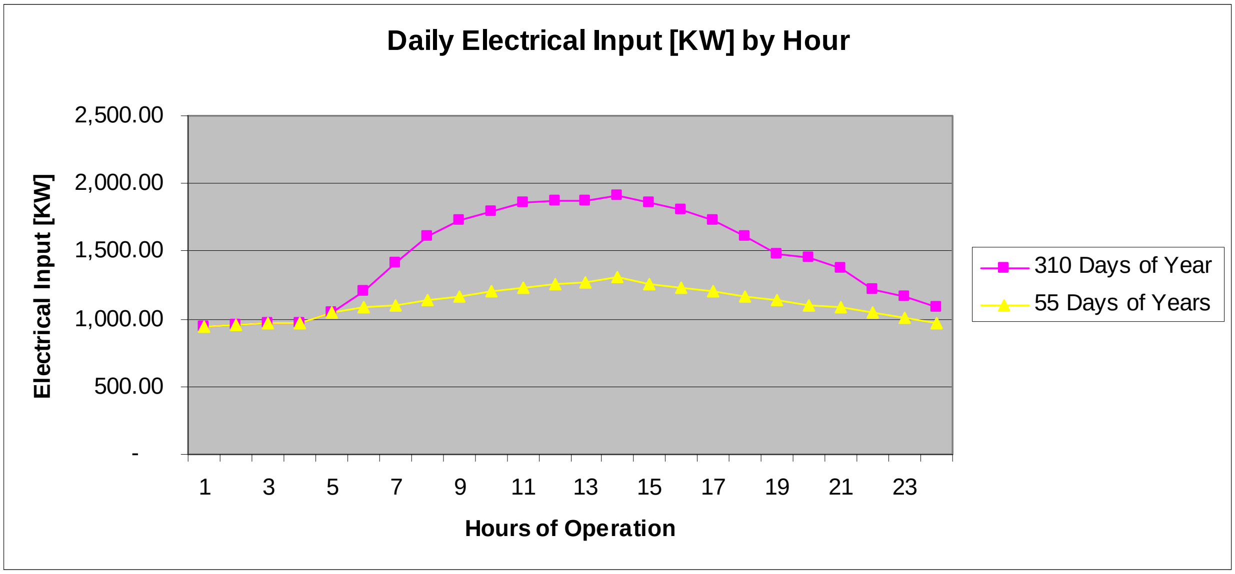


Figure 9: Daily Electrical Input [KW] by hour Profile

APPENDIX C: ABSORPTION CHILLER

Absorption Chiller
Trane, ABTF1350
1350 Nominal Tonnage, Two Stage
Cost: $595,000

Tim Sample
Trane
Pittsburgh, PA Sales Office
400 Business Center Dr.
Pittsburgh, PA 15205

Horizon Absorption Units

Job Information

empty
Johnstown
(C04)Johnstown Sales Team

Unit Information

Model number	ABTF1350
Tag	Absorber
Quantity	1
Absorption unit model	Two stage
Unit nominal tonnage	1350
Unit energy source	Steam
Cooling capacity	1394.97 tons
Unit coefficient of performance	1.18 COP
Elevation	Sea Level

Evaporator Information

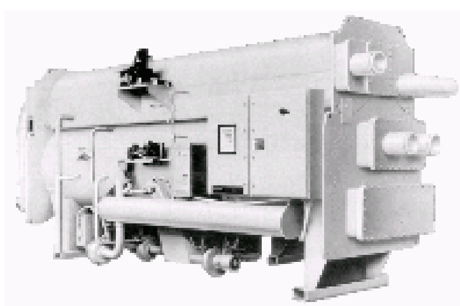
Evaporator LWT	40.00 F
Evaporator flow	2082.58 gpm
Evaporator EWT	56.00 F
Evaporator fouling factor	0.00010 hr-sq ft-deg F/Btu
Evaporator fluid type	Water
Evaporator fluid conc	0.00 %
Evaporator tube matl	.025w Cu I/E
Evaporator passes	2P 150 psi non-marine victaulic
Evaporator fluid velocity	3.55 ft/s
Evaporator pressure drop	8.99 ft H2O

Absorber / Condenser Information

Absorber EWT	83.00 F
Abs-Cond flow	6113.16 gpm
Condenser LWT	93.00 F
Abs-Cond fouling factor	0.00025 hr-sq ft-deg F/Btu
Abs-Cond fluid type	Water
Abs-Cond fluid conc	0.00 %
Absorber tube matl	.022w 95-5 CuNi smooth surface
Condenser tube matl	.028 Cu smooth
Absorber fluid velocity	7.04 ft/s
Condenser fluid velocity	8.36 ft/s
Abs-Cond pressure drop	26.72 ft H2O

Generator Information

Steam pressure to machine after	120.00 psig
Steam flow	13891.81 lb/hr
Steam rate	9.96 lb/ton-hr
High-temp generator tube matl	.028 439 sstl smooth
Low-temp generator tube matl	.028 95-5 CuNi smooth



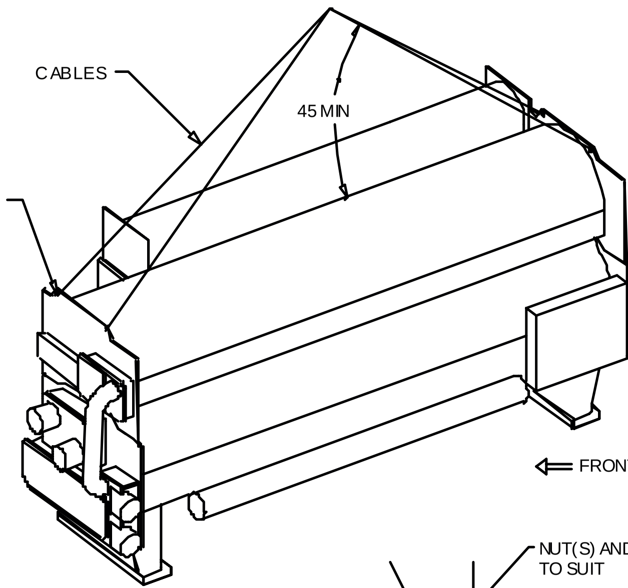
NOTES:

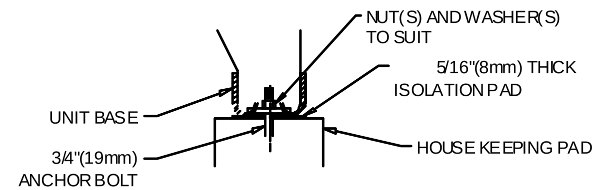
1. UNIT TO BE INSTALLED ON LEVEL SURFACE.
2. USE ANCHORING HOLES, AS REQUIRED, TO MEET LOCAL CODES. ANCHORING HARDWARE IS PROVIDED BY CUSTOMER.
3. ISOLATION PADS ARE SHIPPED IN LOOSE PARTS BOX FOR FIELD INSTALLATION.
4. RECOMMENDED SPACE ENVELOPE PROVIDES MINIMUM OF 36" (914mm) CLEARANCE AT RIGHT, LEFT, AND BACK ENDS OF UNIT WITH 48" (1219 mm) AT FRONT. ALLOW MINIMUM OF 18" (457mm) CLEARANCE ABOVE UNIT.

WARNINGS:

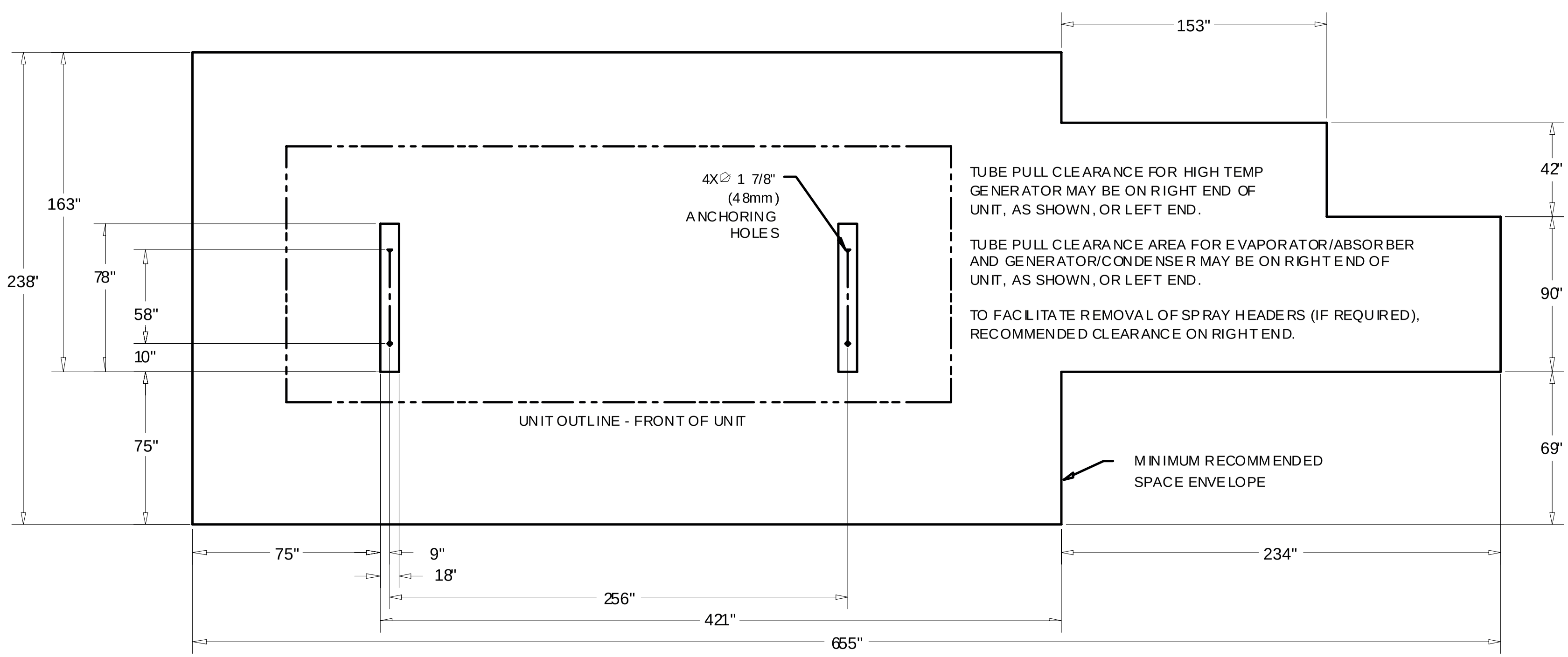
1. ATTACH CABLES ONLY AS SHOWN FOR 4 POINT LIFT OF UNIT. THE ANGLE FORMED BY THE CABLE RELATIVE TO THE TOP OF THE UNIT SHOULD NOT BE LESS THAN 45 °. OTHER ARRANGEMENTS MAY CAUSE EQUIPMENT DAMAGE OR SERIOUS PERSONAL INJURY.
2. EACH CABLE MUST BE CAPABLE OF SUPPORTING THE ENTIRE WEIGHT OF THE UNIT.
3. ATTACH SAFETY CABLES AS RECOMMENDED IN INSTALLATION MANUAL.

APPROXIMATE WEIGHT IN lb		MAXIMUM FLOOR LOAD IN psi
SHIPPING/ RIGGING	OPERATING	
82400.0 lb	115000.0 lb	63.00 psi



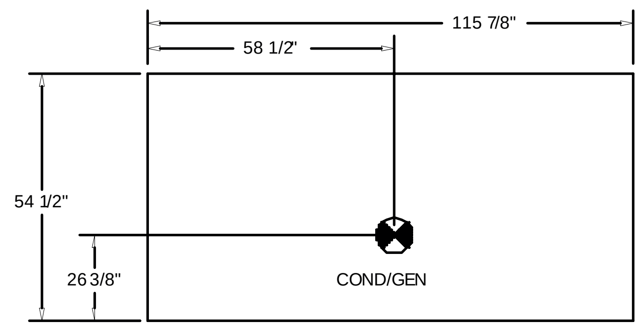


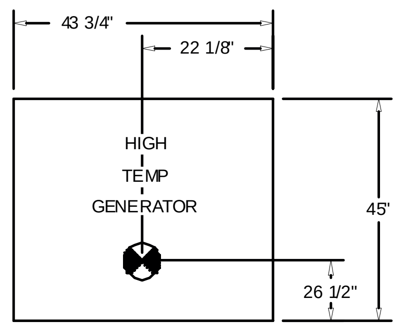
UNIT ANCHORING DETAIL

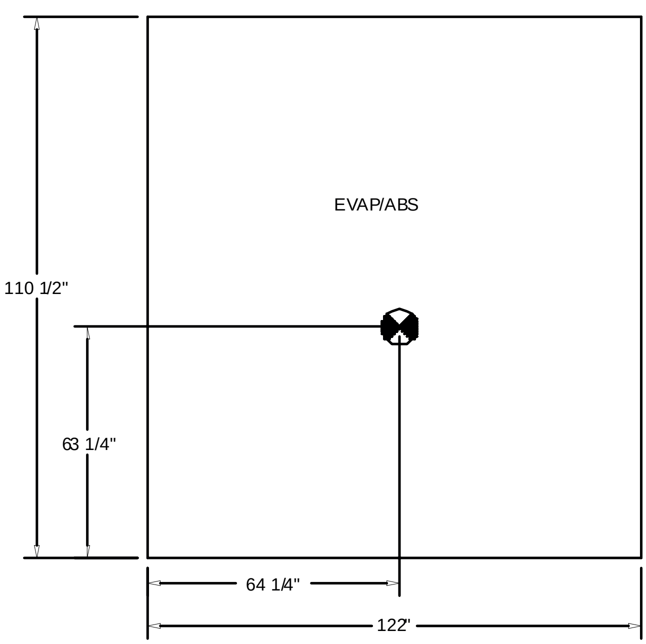


CUSTOMER NOTES:
1.) CENTER OF GRAVITY IS INDICATED BY ⊗
(APPROXIMATE MID-POINT OF COMPONENT LENGTH).
2.) DETAILED INFORMATION ON PIPING JOINT AND ELECTRICAL CONNECTION ASSEMBLY IS AVAILABLE UPON REQUEST.

MAJOR COMPONENT	LENGTH	WEIGHT lb
GEN/COND	349"	22512.0 lb
EVAP/ABS	347"	50928.0 lb
HIGH TEMP GENERATOR	255"	6714.0 lb







RIGHT SIDE VIEW

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TRANE

WARNING

HAZARDOUS VOLTAGE!

DISCONNECT ALL ELECTRIC POWER INCLUDING REMOTE DISCONNECTS AND FOLLOW LOCK OUT AND TAG PROCEDURES BEFORE SERVICING. INSURE THAT ALL MOTOR CAPACITORS HAVE DISCHARGED STORED VOLTAGE. UNITS WITH VARIABLE SPEED DRIVE, REFER TO DRIVE INSTRUCTIONS FOR CAPACITOR DISCHARGE. FAILURE TO DO THE ABOVE BEFORE SERVICING COULD RESULT IN DEATH OR SERIOUS INJURY.

AVERTISSEMENT

TENSION DANGEREUSE!

COUPER TOUTES LES TENSIONS ET OUVRIR LES SECTIONNEURS A DISTANCE, PUIS SUIVRE LES PROCÉDURES DE VERROUILLAGE ET DES ÉTIQUETTES AVANT TOUTE INTERVENTION. VÉRIFIER QUE TOUS LES CONDENSATEURS DES MOTEURS SONT DECHARGES. DANS LE CAS D'UNITÉS COMPORTANT DES ENTRAÎNEMENTS À VITESSE VARIABLE, SE REPORTER AUX INSTRUCTIONS DE L'ENTRAÎNEMENT POUR DÉCHARGER LES CONDENSATEURS.

NE PAS RESPECTER CES MESURES DE PRÉCAUTION PEUT ENTRAÎNER DES BLESSURES GRAVES POUVANT ÊTRE MORTELLES.

ADVERTENCIA

¡VOLTAJE PELIGROSO!

DESCONECTE TODA LA ENERGÍA ELÉCTRICA, INCLUSO LAS DESCONEXIONES REMOTAS Y SIGA LOS PROCEDIMIENTOS DE CIERRE Y ETIQUETADO ANTES DE PROCEDER AL SERVICIO. ASEGURESE DE QUE TODOS LOS CAPACITORES DEL MOTOR HAYAN DESCARGADO EL VOLTAJE ALMACENADO. PARA LAS UNIDADES CON EJE DE DIRECCIÓN DE VELOCIDAD VARIABLE, CONSULTE LAS INSTRUCCIONES PARA LA DESCARGA DEL CONDENSADOR

EL NO REALIZAR LO ANTERIORMENTE INDICADO, PODRÍA OCASIONAR LA MUERTE O SERIAS LESIONES PERSONALES.

CAUTION

USE COPPER CONDUCTORS ONLY!

UNIT TERMINALS ARE NOT DESIGNED TO ACCEPT OTHER TYPES OF CONDUCTORS.

FAILURE TO DO SO MAY CAUSE DAMAGE TO THE EQUIPMENT.

ATTENTION

N'UTILISER QUE DES CONDUCTEURS EN CUIVRE!

LES BORNES DE L'UNITÉ NE SONT PAS CONÇUES POUR RECEVOIR D'AUTRES TYPES DE CONDUCTEURS.

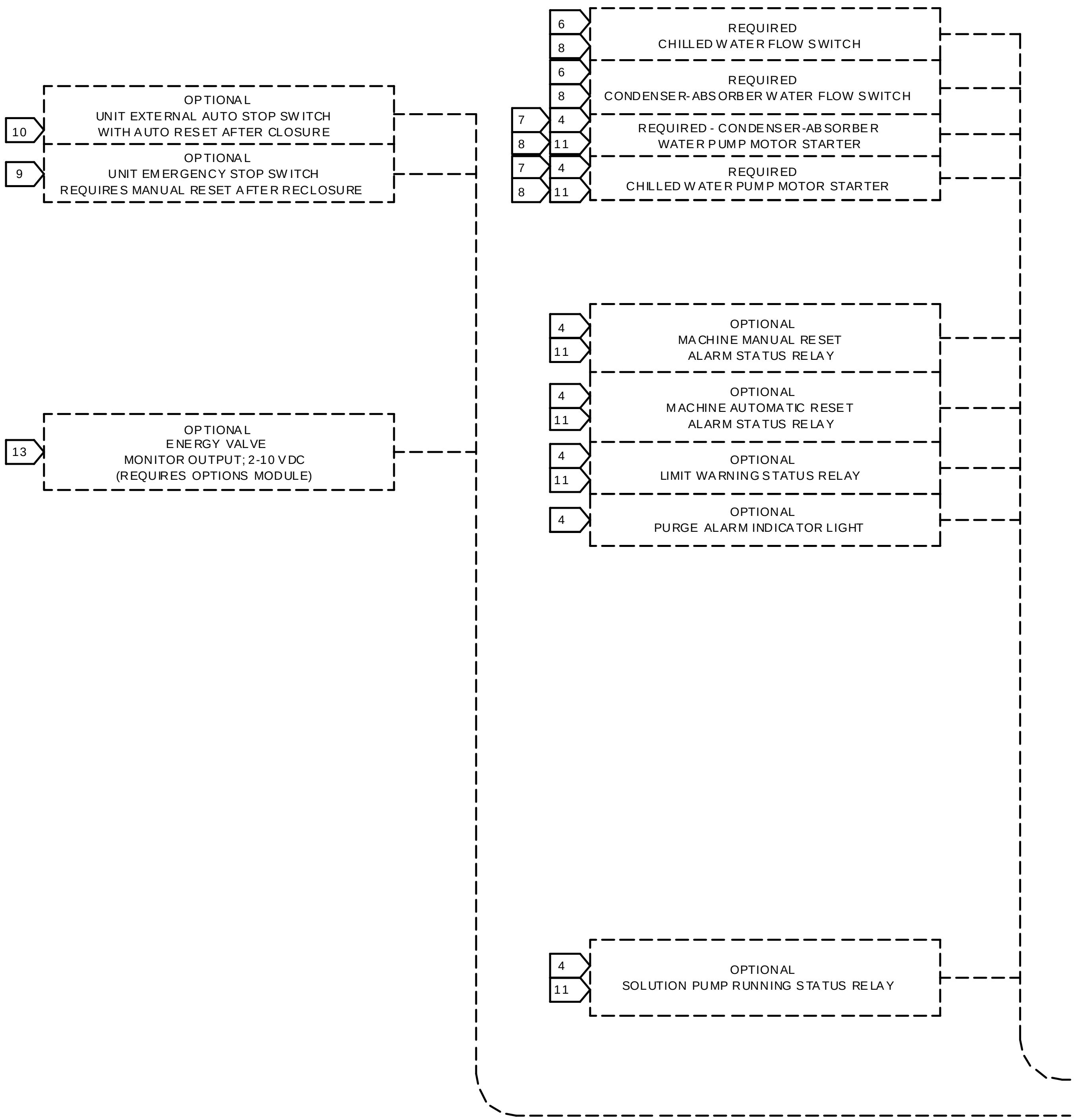
L'UTILISATION DE TOUT AUTRE CONDUCTEUR PEUT ENDOMMAGER L'ÉQUIPEMENT.

PRECAUCIÓN

¡UTILICE ÚNICAMENTE CONDUCTORES DE COBRE!

LAS TERMINALES DE LA UNIDAD NO ESTÁN DISEÑADAS PARA ACEPTAR OTROS TIPOS DE CONDUCTORES.

SI NO LO HACE, PUEDE OCASIONAR DAÑO AL EQUIPO.



REFER TO NOTES AND DRAWING ON NEXT PAGE

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GENERAL NOTES:

1. THIS DRAWING IS TO BE USED FOR THE PURPOSE OF ESTIMATING FIELD WIRING REQUIREMENTS. CHECK SALES ORDER TO DETERMINE WHICH OPTIONS ARE SPECIFIED AND REFER TO FIELD CONNECTION WIRING DIAGRAM FOR ACTUAL FIELD WIRING REQUIRED. DASHED LINES INDICATE DEVICES AND FIELD WIRING SUPPLIED BY CUSTOMER.

2. ALL FIELD WIRING MUST BE IN ACCORDANCE WITH THE NATIONAL ELECTRIC CODE OR STATE AND LOCAL REQUIREMENTS WHICH APPLY. ALL CUSTOMER CONTROL CIRCUIT WIRING MUST HAVE A MINIMUM RATING OF 150 VOLTS.

3 DO NOT ROUTE LOW VOLTAGE (30 VDC MAXIMUM) WIRING IN THE SAME CONDUIT AS CONTROL VOLTAGE (115 VAC) WIRING AND DO NOT POWER-UP UNIT UNTIL CHECK-OUT AND START-UP PROCEDURES HAVE BEEN COMPLETED.

4 THE MAIN UNIT CONTROL PANEL PROVIDES A CONTACT CLOSURE TO CONTROL THE INDICATED CUSTOMER CONNECTED DEVICE. CUSTOMER TO PROVIDE 115 VAC POWER TO EACH DEVICE. MAXIMUM FUSE SIZE IS 15 AMPS.

REQUIRED WIRING NOTES:

5 TRANE PROVIDES A TERMINAL BLOCK, FUSED OR NON-FUSED DISCONNECT SWITCH OR A CIRCUIT BREAKER IN THE MAIN UNIT CONTROL PANEL FOR LINE VOLTAGE CONNECTION WHICH REQUIRES THE USE OF COPPER CONDUCTORS ONLY. CHECK SALES ORDER TO DETERMINE WHICH OPTION IS SPECIFIED. WIRING SIZED PER NATIONAL ELECTRIC CODE BASED ON NAMEPLATE MINIMUM CIRCUIT AMPACITY RATING.

6 EVAPORATOR AND CONDENSER FLOW SWITCHES ARE TO BE INSTALLED AND WIRED TO THE MAIN UNIT CONTROL PANEL BY THE INSTALLING CONTRACTOR. THE PURCHASE OF FLOW SWITCHES FROM TRANE IS OPTIONAL. EACH FLOW SWITCH CIRCUIT REQUIRES TWO WIRES, 115 VAC. MINIMUM CONTACT RATING AT 115 VAC IS 4.8 MA.

7 CHILLED AND CONDENSER-ABSORBER WATER FLOW MUST BE PROVEN PRIOR TO CHILLER OPERATION. CONDENSER-ABSORBER WATER PUMP MUST BE CONTROLLED BY THE MAIN UNIT CONTROL PANEL FOR CHILLER SAFETY.

8 CIRCUIT REQUIRES TWO WIRES, 115 VAC. MAXIMUM MODULE CONTACT RATING AT 115 VAC OR 30 VDC IS 2.88 AMPS INDUCTIVE, 1/3 HP.

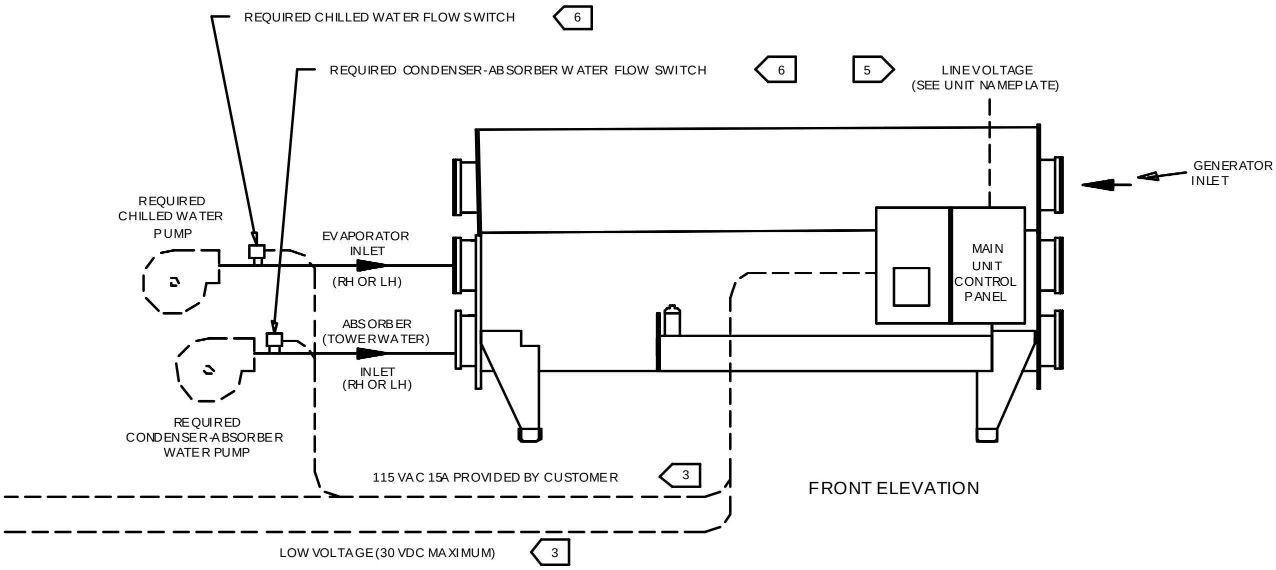
OPTIONAL WIRING NOTES:

9 OPTIONAL CONTROL FOR A CUSTOMER SPECIFIED OR INSTALLED LATCHING TRIPOUT. THE CHILLER WILL RUN NORMALLY WHEN THE CONTACT IS CLOSED AND TRIP THE CHILLER OFF WITH A MANUALLY RESETTABLE DIAGNOSTIC WHEN THE CONTACT OPENS. MANUAL RESET IS ACCOMPLISHED WITH THE DIAGNOSTIC KEY ON THE FRONT OF THE MAIN UNIT CONTROL PANEL. CUSTOMER SUPPLIED SILVER CONTACTS ARE REQUIRED FOR 24 VDC, 12 MA RESISTIVE LOAD. CIRCUIT REQUIRES TWO WIRES, 30 VDC MAXIMUM. DO NOT ROUTE IN CONDUIT WITH HIGHER VOLTAGE CIRCUITS.

10 OPTIONAL CONTROL FOR A CUSTOMER SPECIFIED OR INSTALLED REMOTE AUTO-STOP FUNCTION. THE CHILLER WILL RUN NORMALLY WHEN THE CONTACT IS CLOSED AND STOP THE CHILLER WHEN THE CONTACT OPENS. RECLOSURE OF THE CONTACT WILL PERMIT THE CHILLER TO AUTOMATICALLY RETURN TO NORMAL OPERATION. CUSTOMER SUPPLIED SILVER CONTACTS ARE REQUIRED FOR 24 VDC, 12 MA RESISTIVE LOAD. CIRCUIT REQUIRES TWO WIRES, 30 VDC MAXIMUM. DO NOT ROUTE IN CONDUIT WITH HIGHER VOLTAGE CIRCUITS.

11 CIRCUIT REQUIRES TWO WIRES, 115 VAC. NORMALLY OPEN MAXIMUM MODULE CONTACT RATING AT 115 VAC OR 30 VDC IS 2.88 AMPS INDUCTIVE, 1/3 HP.

12 CIRCUIT REQUIRES SHIELDED WIRE PAIR, 30 VDC MAXIMUM. BELDON TYPE 8760 RECOMMENDED. MAXIMUM LENGTH OF 5000 FEET.

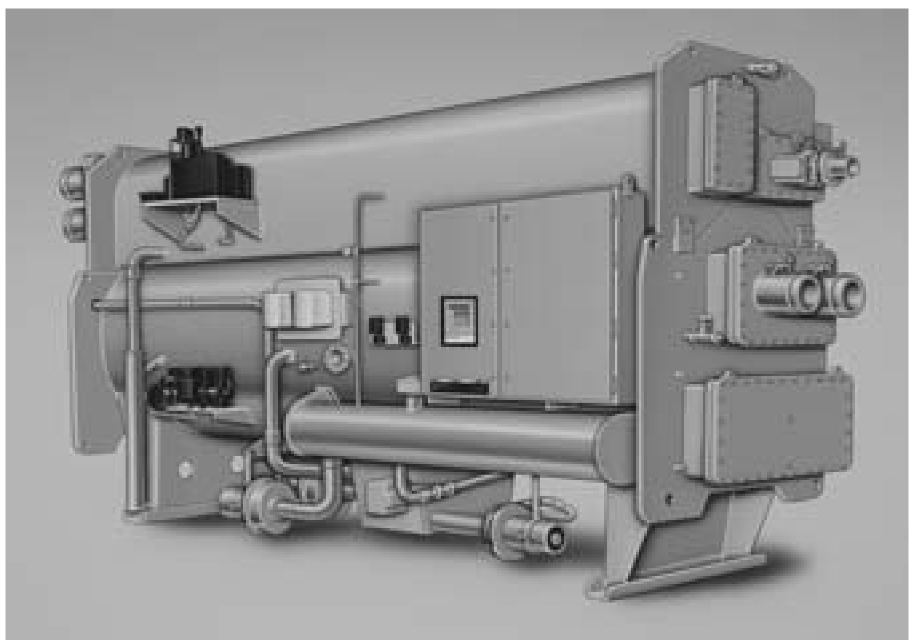


FRONT ELEVATION

Trane Horizon™ Absorption Series

Single-Stage Hot Water or Steam-Fired Absorption Water Chillers 500-1350 Tons

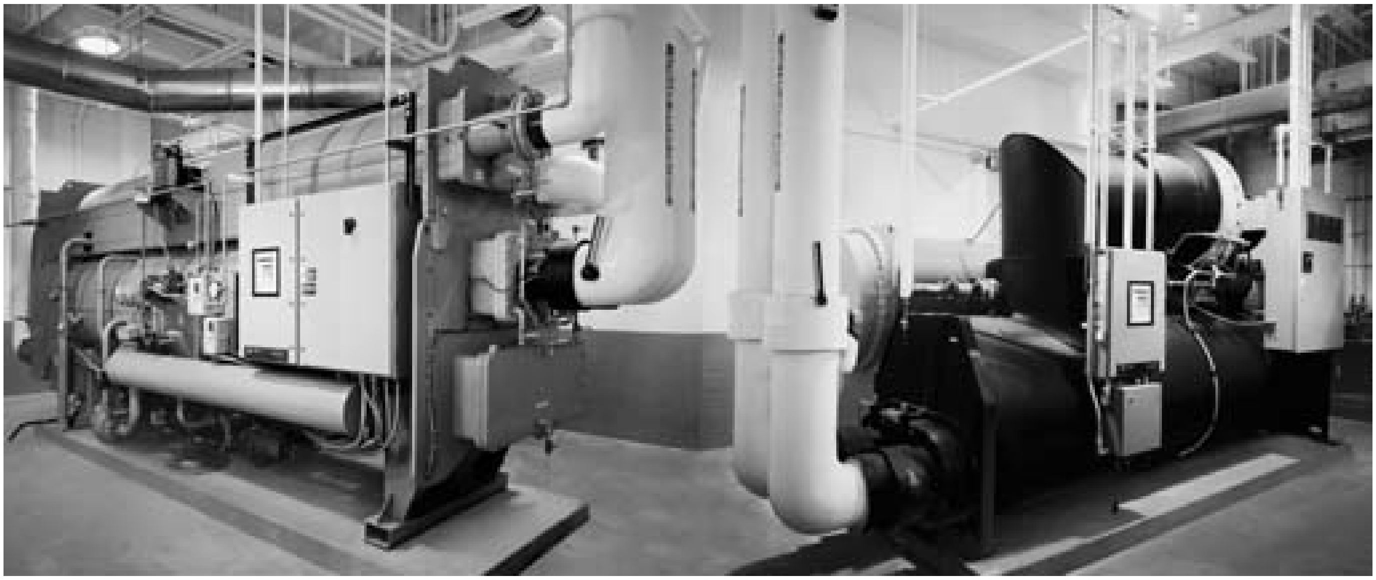
Built for Industrial and Commercial Applications



June 2004

ABS-PRC001-EN

Introduction



Hybrid Chiller Plant

A chiller plant design that allows the operator to choose between multiple energy sources is referred to as a hybrid design. Hybrid chiller plants are receiving increasing attention as valuable options for facility owners. There are various types of hybrid plant designs. They encompass different combinations of electric chillers and other chiller types, including gas or steam absorption chillers. The advantages of having a choice of energy sources will become even more viable as we move further into the new millennium.

Today we hear about utility deregulation. For the first time, building owners can negotiate power supply and natural gas contracts with their traditional supplier, as well as with new suppliers in the market. The fuel-switching flexibility of the hybrid plant puts the owner in a much stronger negotiating position. Similarly, many electric utilities offer attractive off-peak or dual fuel electric rates for applications which are not operating during peak electric system demand, most commonly in the summer months. This represents an opportunity for building owners who can switch to a gas or steam system.

Contents

Trane Horizon™ Absorption Series

Trane has led in absorption chiller design and manufacturing for four consecutive decades. In fact, Trane is the only North American chiller manufacturer to commercialize double-effect absorption, over 25 years ago. With over 10,000 absorption chillers manufactured and shipped, Trane serves the commercial, industrial and process worldwide markets. Microelectronic controls, adaptive frequency drives and smart purge systems have modernized the technology, making it more capable, more reliable and, in many applications, more economical.

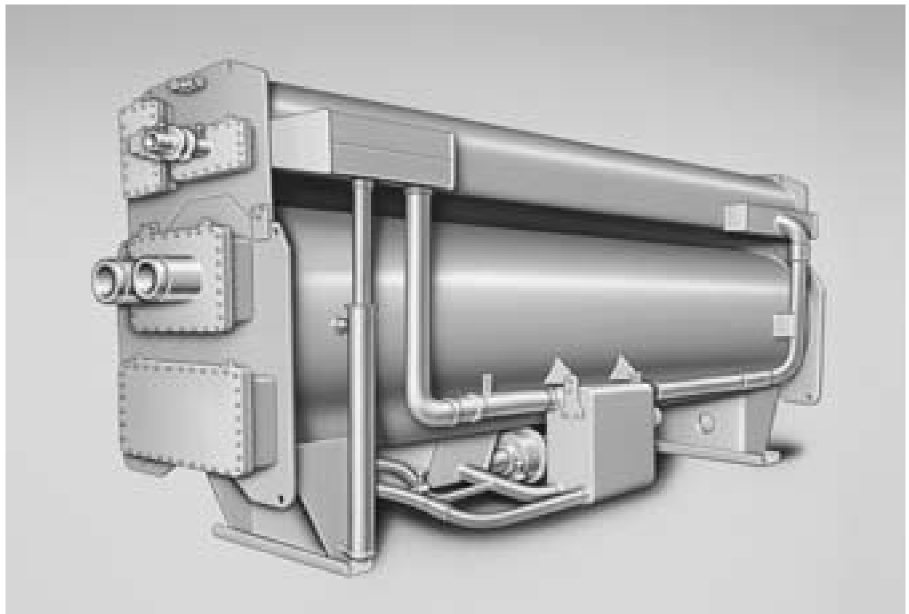
Performance
- Produces colder chilled water to 40°F [4.4°C].
- Starts with low 55°F [12.8°C] tower-water temperatures.
- Operates reliably with low 65°F [18.3°C] tower-water temperatures.

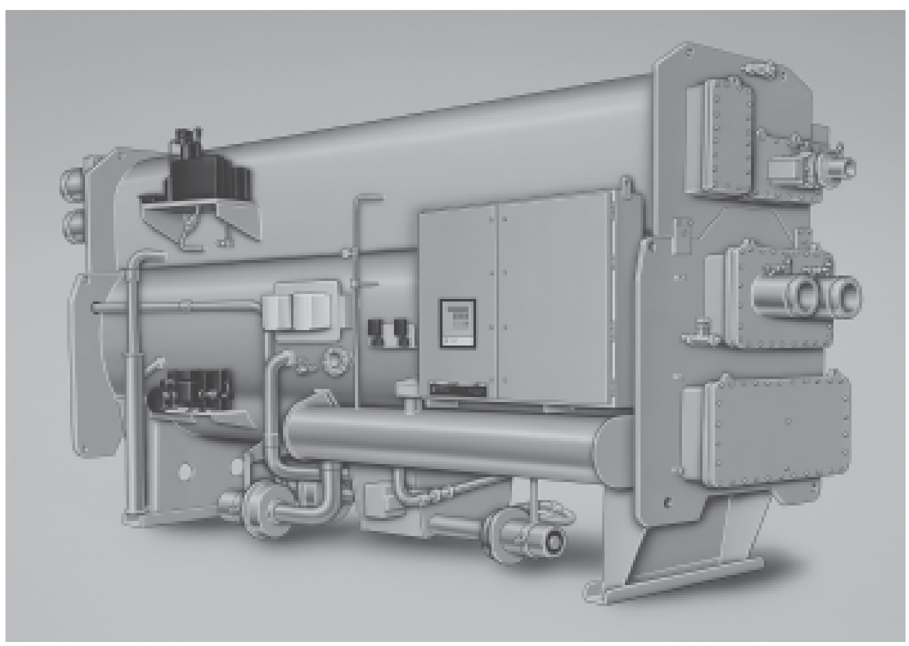
Easier Installation
- Rigging eyes built-in as standard.
- Shell disassembly option.
- Crossover pipe and steam valve available as an option.

Reliability
- Adaptive microprocessor controls.
- 50,000 hours life-extended pumps.
- Constructed of corrosion-resistant alloy materials.

Design Diversity
- Marine water boxes on cooling-water connections available as an option.
- Custom design options available.

Features and Benefits General





Trane Horizon™ Absorption Series, Single-Stage Hot Water- or Steam-Fired Absorption Water Chillers, 500-1350 Tons

Technology You Can Trust
In the early 1990's, with the assistance of the Gas Research Institute, Trane began developing an innovative series of absorption chillers. In 1995, Horizon chillers began shipping from the Trane manufacturing facility in La Crosse, Wisconsin. The Horizon chiller is so advanced, it redefined industry standards for absorption system integrity. Horizon chiller performance, efficiency and reliability far exceed that of past and present absorption chillers.

Dynamic By Design
Because uninterrupted chiller service is critical to your operation, Horizon chillers are designed to make chilled water reliably, even in the harshest industrial application. Water-tower systems and load requirements can challenge the long-term operation of many standard-grade chillers. The industrial-grade construction of the Horizon chiller accounts for varying load and water-temperature changes, as well as dirty tower water. They are built with corrosive-resistant alloy metals, and precision welded in an ISO 9001 quality-certified facility. Only extended-life pumps, valves and water boxes are manufactured into their design. For further dynamics, Horizon UCP2 adaptive microprocessor controls react precisely to system diversification. Quality construction, long-life components and adaptive controls are what make the Horizon dynamic by design.

Operates With Energy-Saving, Low-Pressure Steam or Hot Water
The Horizon family includes a single-stage, hot water- or steam-fired chiller line. Able to produce chilled water in the range of 40 to 60°F [4.4 to 15.6°C], these machines use 12 psig [0.83 bar] low-grade steam or 270°F [132°C] hot water. Making chilled water from these comparatively low-temperature inputs is particularly important for energy conserving applications, such as waste-heat recovery, co-generation equipment and solar-energy-powered cooling.

Using refrigerant water helps eliminate refrigerant management or availability concerns. Additionally, absorption technology reduces the use of electric energy.

Features and Benefits General

Sophisticated Reliability
Horizon controls meet specifications for stand alone or hybrid chiller control. UCP2 adaptive controls are critical to reliable operation. Trane controls are compatible with Integrated Comfort™ Systems (ICS), and are easily integrated into the Tracer® family of flexible chiller-plant system controllers with a single twisted-pair communications cable.

Ideal for Process and Commercial Applications
With Horizon chillers, the application possibilities for the absorption machine are expanded. Capabilities such as lower tower flow, variable evaporator flow, lower chilled-water temperatures and advanced control capabilities make the single-stage Horizon absorption chiller ideal for both process and comfort applications.

When Long-lived Reliability Is Important
Trane has been a long-time proponent of the use of high-quality materials in absorption chiller designs. The lithium bromide temperatures and water refrigerant, typical of all absorbers, can more quickly corrode lower-grade metals in the presence of air. Trane recommends and uses industrial-grade materials to provide long-lived, reliable cooling.

A Global Network of Absorption Expertise
When you specify a Trane Horizon chiller, you're getting the knowledge, expertise and assistance of a pool of experts that have decades of absorption expertise. Making The Trane Company part of your management team gives you access to refrigeration, air conditioning and facility control-system applications specialists, and a unique breadth of innovative solutions to satisfy your facilities needs for today and tomorrow.

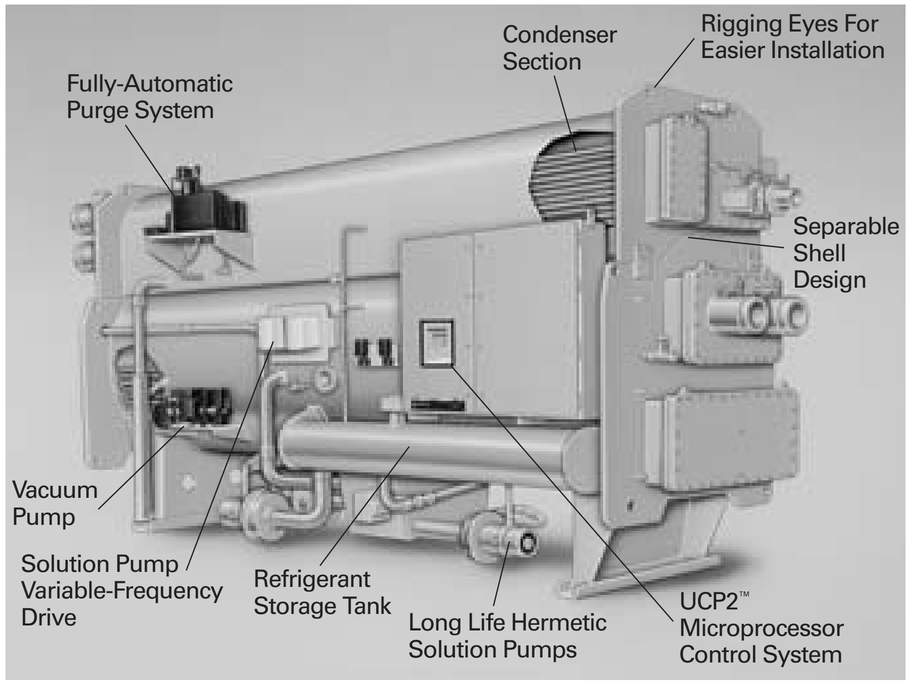
Standard Specification For Single-Stage Horizon Chillers
- C.O.P. 0.70
- Victaulic™ water connections
- Fully-automatic purge system
- Industrial-grade tubes
  - Generator .028" wall, 90/10 Cupro-nickel
  - Evaporator .025" wall copper (enhanced)
  - Absorber 500-800 tonnages .022" wall 95/5 Cupro-nickel 975-1350 tonnages .028" wall copper
  - Condenser .028" wall copper
- Advanced cycle-management system with Adaptive Frequency™ drive solution control
- 150 psig [10.3 bar] evaporator, absorber and condenser sections
- Industrial-grade energy valve
- Rigging eyes for easy installation
- Advanced microprocessor control system with adaptive control functions
- 2-line, 40-character clear-language interface to unit functions and diagnostic information
- Fixed and floating generator tube supports prevent thermal stress
- Efficient stainless steel brazed plate solution heat exchanger
- Long-life solution pumps
- Molybdate inhibitor system
- Factory-installed and-commissioned controls
- Individually replaceable tubes
- Removable absorber and evaporator spray trees

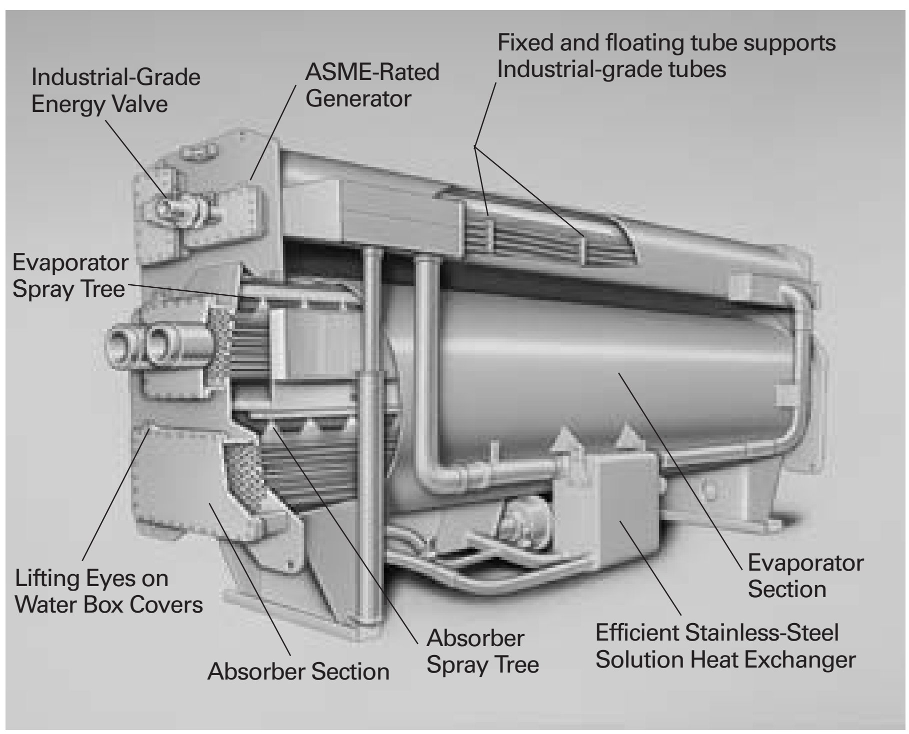
Optional Specification For Single-Stage Horizon Chillers
- Removable absorber and evaporator spray trees150 psig [10.3 bar] raised face flanges for the evaporator, condenser, and absorber water connections
- Disassembled unit — eases disassembly and reassembly of major components at the job site
- Lithium bromide filter
- Condenser and absorber marine style water boxes
- Factory installed cooling-water crossover pipe absorber to condenser
- Factory mounted energy valve
- Choice of tube materials and other chiller options
- Stainless steel evaporator pan

Absorption Cooling — A Sound Decision
Life-cycle costing has become a primary concern for chiller buyers who have long-term investment opportunity in mind. Changes in the distribution and pricing of electricity have made the absorption water chiller a popular choice when alternative energy use makes sense. Ask your local Trane representative for a comprehensive analysis of your facility, and the energy-saving opportunities Trane offers for the design of Heating, Ventilating and Air Conditioning systems and controls.

Features and Benefits

Component Identification





Horizon™ Single-Stage Absorption Refrigeration Cycle

Refrigeration Cycle
This is an example of typical machine operation at a standard rating point condition (i.e., 85°F [29.4°C] tower, 44°F [6.7°C] leaving chilled water) at full load. Dilute solution has a relatively high refrigerant content and low lithium bromide content. An intermediate solution is a mixture of dilute and concentrated solutions. A concentrated solution is one with a relatively low refrigerant content and high lithium bromide content.

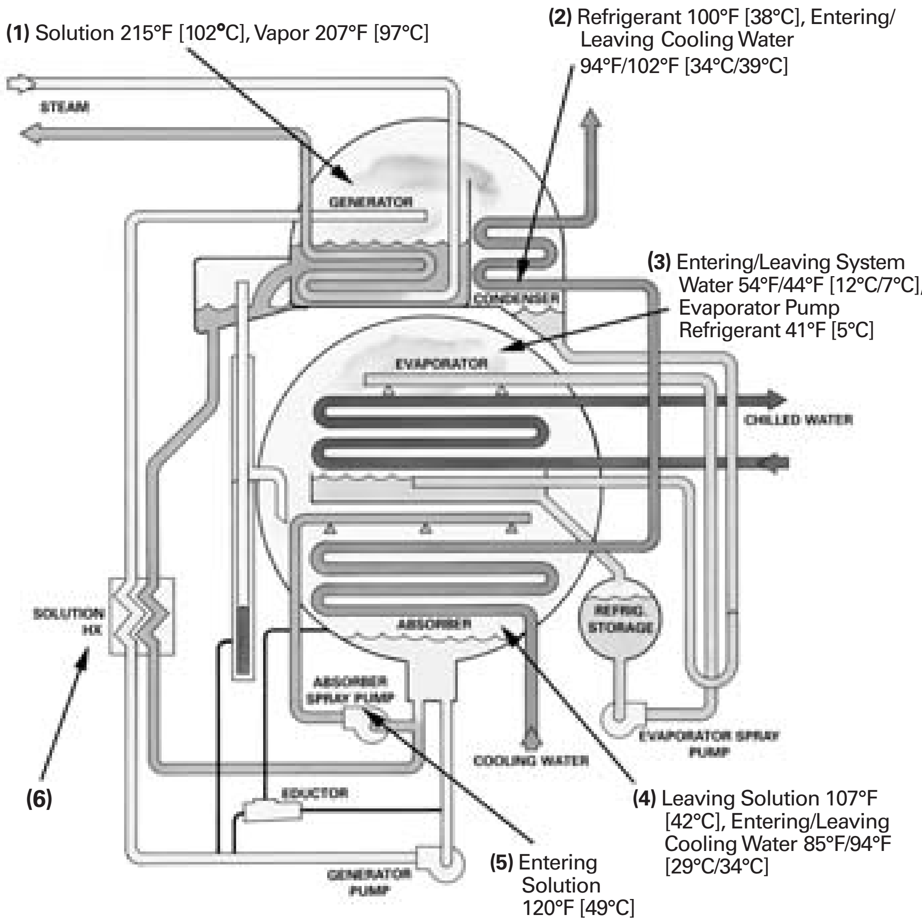
Generator (1)
Dilute solution is pumped into the generator, where it is boiled by the steam or hot water in the tube bundle, creating refrigerant vapor. The refrigerant vapor flows to the condenser (2). The now-concentrated solution flows by gravity, through the solution heat exchanger to the absorber spray system, where it is mixed with dilute solution from the absorber and sprayed on the absorber tube bundle.

Condenser (2)
Refrigerant vapor, produced by the generator, enters the condenser and changes to a liquid through condensation. The heat of condensation is rejected to the cooling water inside the tube bundle.

Evaporator (3)
The liquid refrigerant leaves the condenser through a J tube, where the pressure/temperature is reduced through expansion for delivery to the evaporator at 41°F [5°C]. System water runs through the tube bundle where its heat is transferred to the refrigerant, causing the refrigerant to vaporize/boil. The refrigerant vapor flows to the slightly lower pressure in the absorber.

Absorber (4)
Refrigerant vapor is absorbed by the lithium bromide solution. The now-dilute solution is pumped through the solution heat exchanger and on to the generator. The heat of vapor absorption is rejected via the cooling water inside the tube bundle.

Figure FB-1. Single-stage absorption refrigeration cycle



Absorption Process (5)
Solution (concentrated) enters the spray system from the generator and enters the spray system, wetting the tubes and providing a liquid surface for the refrigerant vapor (from the evaporator) to absorb into the lithium bromide solution. The solution temperature/concentration sprayed in the absorber controls the absorber pressure, thereby controlling the evaporator refrigerant temperature.

Solution Heat Exchanger (6)
Solution flows through the heat exchanger to be preheated, reducing the heat energy required to induce boiling within the generator, and to decrease the temperature of the solution being returned to the absorber, thus decreasing the load on the cooling tower.

Application Considerations General

General
The Horizon™ single-stage steam-fired or hot water absorption chiller is designed to provide 40°F to 60°F [4.4°C to 15.6°C] chilled water, for comfort or process cooling applications, within all three market segments – commercial, industrial and institutional. They are most-often used where an economic analysis of fuel costs versus electrical rates indicates an operating cost advantage.

In many process applications, they can be utilized to convert excess heat energy to provide chilled water for process or comfort applications.

Operating Limits
Trane single-stage absorption chillers operate with nominal 12 psig [0.83 bar] steam or nominal 270°F [132°C] hot water. In all applications, superheat should be limited so steam temperature does not exceed 340°F [171°C].

Waterflows that are within the limits indicated on the appropriate selection table will ensure tube water velocities not exceeding 10 feet per second [3.05 m/sec] in copper tubes and 11 feet per second [3.35 m/sec] in cupronickel tubes. Changes in condenser water temperature should not exceed 1°F per minute in the range from 75°F to 95°F [23.9°C to 35°C].

Sound and Vibration
Absorption units are well-suited for areas where low sound levels are required. The Trane Horizon single-stage steam absorption chiller will operate under normal load conditions at less than 85 dBA sound pressure level. During operation there is no vibration of any components that could be damaging to the chiller or that could transmit objectionable sound or vibration to the building.

Chiller Installation
The following should be considered when installing an absorption chiller:
- Rigging and service clearances
- Foundation support
- Chiller isolation for sound/vibration reduction
- Condensate handling
- Steam supply control
- Condenser-water temperature control
- Chilled-water flow control
- Chilled- and condenser-water flow limit
- Generator hot-water application

Cooling-Tower Water Flow
The ARI standard gpm/ton for single-stage absorption chillers is 3.6, however, lower flow through the condenser and absorber section will present an opportunity for a smaller tower, smaller piping, and smaller condenser pump. For more information on lower flows in the cooling tower water circuit, refer to the appropriate Trane engineering bulletin, available from your local Trane representative.

Water Treatment
The use of untreated or improperly treated water may result in scaling, erosion, and corrosion, algae or slime. It is recommended that the services of a qualified water-treatment specialist be used to determine what treatment, if any, is advisable. The Trane Company assumes no responsibility for the results of untreated or improperly treated water.

Combination Systems
Peak energy savings can be achieved when using a combination of electric chillers and absorption chillers for air conditioning loads. The absorption chiller is used to shave seasonal, billable peak-power demands during summer operation, and the electric chiller is run below the allowed demand limit, reducing costly demand charges. Trane offers both electric chillers and absorption chillers with the unit control panel (UCP2) as standard. Although the chillers have different features and modes of operation, the chiller control panel looks and acts the same when used with any chiller model. Each control panel is programmed to monitor the particular chiller for which it was designed, however, maintenance and service personnel only need to become familiar with one control panel. Combined with a Trane Tracer® system, a chiller plant has almost unlimited operational flexibility, and all equipment is supplied from a single source.

Multiple Machine Installations
The Trane absorption machine can be applied to series or parallel chilled-water flow, depending upon the design requirement. The arrangement that is best for an individual system should be based on an analysis of system water and temperature rise requirements, system and machine pressure-drop characteristics, and installation cost.

Parallel flow allows minimum chilled-water pressure drop through the machines. However, with one machine “off,” it is not usually possible to maintain the design chilled-water temperature unless one machine is isolated with shut off valves and the chilled-water flow decreased.

Series flow permits design chilled-water temperature at light loads with one machine “off.” However, at all operating conditions, the chilled-water pressure drop through the machine is high.

Accurate chilled-water temperatures can be maintained on individual machines between 100 percent and 10 percent of nominal chiller load, which allows for a wide range of control options. Each chiller has a stand-alone control system to manage the desired water temperature, and also the ability to receive remote commands to support various system demands from a control center. This versatility of control makes the management of more than one machine relatively easy.

Selection Procedure

Selection Procedure
Absorption refrigeration machines are usually selected to provide the required refrigeration capacity with the smallest practical machine of sufficient size. Machine size is based on chilled-water flow rates and temperatures specified for the air side of the system.

Total air-conditioning system first cost can be minimized by a careful analysis of system operating parameters. The effect of flow rates and temperatures, on both the building air side and the refrigeration machine selections, should be investigated to determine which system represents the best investment for the owner.

The information on the following pages provides performance data, at ARI standard conditions, for capacity in tons, efficiency, flow rates and water pressure drops. All capacities are in accordance with the expected ARI 560 Standard revision, and are based on fouling factors of .0001 for the evaporator waterside tubing and .00025 for the absorber and condenser tubing.

Standard Fouling
Unit performance at non-standard fouling factors may vary from standard performance. Fouling factors estimate the heat transfer penalty that coincides with the effect of typical fouling in evaporator and absorber/condenser (cooling) water circuits. All selections should use the standard fouling factor to more accurately estimate the chiller performance in an equipment room and to comply with ARI 560.

ARI Standard Fouling Factors

Evaporator	Condenser/Absorber
English Units – hr-ft²-F/Btu	
0.0001	0.00025
SI Units – m²-K/kW	
0.018	0.044

Additional Fouling
Any selection that uses a fouling factor greater than 0.0001 for the evaporator tubes, and 0.00025 for the condenser/absorber tubes, is a more conservative estimate that should only be used if there is an abnormal amount of fouling contaminants in the water systems. The ARI 560 Standard defines "additional fouling" as "Conditions such as water hardness, organic material, suspended solids and/or water velocity may necessitate the use of a greater field fouling allowance than that provided in the Standard Rating of equipment." The Trane single-stage Horizon Selection program should be used to determine the effect of nonstandard fouling factors. The following guidelines can be used for estimation prior to the selection:

ARI Standard Fouling Factors For Additional Fouling

Evaporator	Condenser/Absorber
English Units – hr-ft²-F/Btu	
0.0002	0.00026 – 0.00075
SI Units – m²-K/kW	
0.035	0.046

Part Load Performance
The Horizon single-stage absorption chiller exhibits excellent part-load performance characteristics. Air conditioning system loads are usually significantly less than full-load design conditions. Therefore, the absorption chiller operates at full load a small percentage of the time. Part-load absorption chiller operation is normally associated with reduced tower-water temperatures. At part-load operation, the heat rejected to the cooling tower is less than at full-load operation. Also, part-load operation is typically associated with reduced outside wet-bulb temperatures, resulting in improved cooling tower performance. The net result of less heat rejection and lower wet-bulb temperature is cooler tower water entering the chiller and improved unit performance.

Final Selection
A final selection must be done by the local Trane sales engineer using the Trane Horizon Single-Stage Absorption Selection Program. For applications higher than 1600 feet [500 meters] above sea level, final selection requires review by Absorption Product Marketing. Prior to accessing the computer selection program, the following data inputs should be tabulated:

- Temperature or pressure of the hot water or steam
- Two of the following three values must be provided[1]:
  - Evaporator Delta-T
  - Evaporator Flow
  - Cooling Capacity
- Leaving-Evaporator Water Temperature
- Entering-Absorber Water Temperature
- Cooling Water Flow
- Chilled water and tower water fouling factors

Other options that may also be selected are:

- Type and thickness of tube material
- Type of solution flowing through the evaporator and tower loop[2].

[1] Any limitations or restrictions should also be given (i.e., pressure drop, gpm etc.).

[2] Absorption chillers can be selected with a wide variety of media other than water (evaporator and absorber/condenser, or both). For media other than water, contact the local Trane sales office for chiller selections and information.

Selection Procedure

Product Coding Description

Selection

Product Coding Description
The coding block precisely identifies all characteristics of any Horizon™ Single-Stage Steam-Fired or Hot Water Absorption Chiller.

Table S-1. Product coding description

MODL	**Absorption Unit Model**
ABSD	Single Stage Absorption
NTON	**Unit Nominal Tonnage**
500	500 Nominal Tons
600	600 Nominal Tons
700	700 Nominal Tons
800	800 Nominal Tons
975	975 Nominal Tons
1100	1100 Nominal Tons
1225	1225 Nominal Tons
1350	1350 Nominal Tons
VOLT	**Unit Voltage**
190	190 Volt - 50 HZ
200	200 Volt - 60 HZ
220	220 Volt - 50 HZ
230	230 Volt - 60 HZ
380	380 Volt - 50 HZ
415	415 Volt - 50 HZ
460	460 Volt - 60 HZ
575	575 Volt - 60 HZ
ENSR	**Unit Energy Source**
STM	Steam Energy Source
HOTW	Hot Water Energy Source
ENPR	**Unit Energy Pressure**
50	Steam Energy Pressure - 50 PSIG ASME Required
150	Hot Water Energy Pressure - 150 PSIG - ASME Required
400	Hot Water Energy Pressure – 400 PSIG - ASME Required
PVCN	**Pressure Vessel Construction**
STD	Standard Construction
	Standard construction (includes ASME LTGN)
PURG	**Purge System**
AUTO	Automatic Purge System
LGTM	**Generator Tubes**
SB04	.028 Wall 90-10 CUNI Smooth Surface
SB05	.035 Wall 90-10 CUNI Smooth Surface
SB06	.049 Wall 90-10 CUNI Smooth Surface
SB16	.028 wall 409 SST smooth surface
CDTM	**Condenser Tubes**
SB09	.028 Wall Copper Smooth Surface
SB10	.035 Wall Copper Smooth Surface
SB04	.028 Wall 90-10 CUNI Smooth Surface
SB05	.035 Wall 90-10 CUNI Smooth Surface
SB06	.049 Wall 90-10 CUNI Smooth Surface
SB17	.028w 316L SST Smooth Surface
EVTM	**Evaporator Tubes**
ES12	.025 Wall Copper Enhanced Surface
ES11	.025 Wall 90-10 CUNI Enhanced Surface
ES05	.035 Wall 90-10 CUNI Enhanced Surface
ABTM	**Absorber Tubes**
SB00	.022 Wall 95-5 CUNI Smooth Surface
SB01	.028 Wall 95-5 CUNI Smooth Surface
SB02	.035 Wall 95-5 CUNI Smooth Surface
SB03	.049 Wall 95-5 CUNI Smooth Surface
SB04	.028 Wall 90-10 CUNI Smooth Surface
SB05	.035 Wall 90-10 CUNI Smooth Surface
SB06	.049 Wall 90-10 CUNI Smooth Surface
SB09	.028 Wall Copper Smooth Surface
SB17	.028 Wall 316L SST Smooth Surface
GNWA	**LTGN - Generator Water Box Arrangement**
GN02	1-Pass Non-Marine RF Flange
GN04	2-Pass Non-Marine RF Flange
CAWA	**Condenser and Absorber Water Box Arrangement**
CA17	150 PSI Marine Victaulic
CA18	150 PSI Marine RF Flange
CA19	150 PSI Non-Marine Victaulic
CA20	150 PSI Non-Marine RF Flange
EVWA	**Evaporator Water Box Arrangement**
EV31	1-Pass 150 PSI Non-Marine Victaulic
EV32	1-Pass 150 PSI Non-Marine RF Flange
EV01	2-Pass 150 PSI Non-Marine Victaulic
EV02	2-Pass 150 PSI Non-Marine RF Flange
CAWC	**Condenser and Absorber Water Connections**
RERE	In right-hand end – out right-hand end (700, 800, 1100, 1225, 1350 tons)
LELE	In left-hand end – out left-hand end (500 tons)
LERE	In left-hand end – out right-hand end (600 and 900 tons)
EVWC	**Evaporator Water Connections**
LEBK	Inlet Connection Left Back
LEFR	Inlet Connection Left Front
REBK	Inlet Connection Right Back
REFR	Inlet Connection Right Front
LEND	In left end, out the other end
REND	In right end, out the other end
CAFT	**Condenser and Absorber Water Box Fluid Type**
WTR	Water
EGLY	Ethylene Glycol Solution
PGLY	Propylene Glycol Solution
EVFT	**Evaporator Water Box Fluid Type**
WTR	Water
EGLY	Ethylene Glycol Solution
PGLY	Propylene Glycol Solution

Selection Procedure

Product Coding Description

EVLV **Unit Energy Valve**
BF02 2-Way 3" 150# Wafer Btrfly
BF03 2-Way 4" 150# Wafer Btrfly
BF04 2-Way 6" 150# Wafer Btrfly
BF05 2-Way 8" 150# Wafer Btrfly
BF22 3-Way 3" 150# Flanged tee Wafer Btrfly
BF23 3-Way 4" 150# Flanged tee Wafer Btrfly
BF24 3-Way 6" 150# Flanged tee Wafer Btrfly
BF32 3-Way 3" 300# Flanged tee Wafer Btrfly
BF33 3-Way 4" 300# Flanged tee Wafer Btrfly
BF34 3-Way 6" 300# Flanged tee Wafer Btrfly
BF42 2-Way 3" 150# Flanged Btrfly
BF43 2-Way 4" 150# Flanged Btrfly
BF44 2-Way 6" 150# Flanged Btrfly
BF45 2-Way 8" 150# Flanged Btrfly
VB01 2-Way 2" 150# Wafer V-Ball
VB02 2-Way 3" 150# Wafer V-Ball
VB03 2-Way 4" 150# Wafer V-Ball
VB11 2-Way 2" 300# Wafer V-Ball
VB12 2-Way 3" 300# Wafer V-Ball
VB13 2-Way 4" 300# Wafer V-Ball
VB41 2-Way 2" 150# Flanged V-Ball
VB42 2-Way 3" 150# Flanged V-Ball
VB43 2-Way 4" 150# Flanged V-Ball
EVIN **Unit Energy Valve Installation**
FLD Field-installed Energy Valve
FACT Factory-installed Energy Valve
EVPN **Evaporator Pan construction**
STD Evaporator Pan – Steel
SSTL Evaporator Pan – Stainless Steel
UPNT **Unit Paint**
SFPT Standard Factory Paint – Entire Unit
CSPT Customer Specified Paint – Entire Unit
WCNM **Water Chiller Nameplate**
SNMP Standard ABS Water Chiller Nameplate
BNMP Decorative Brass ABS Water Chiller Nameplate
SPKG **Unit Shipping Package**
DAU Domestic – Assembled Unit
DDG Domestic – 2-Piece Disassembled Unit
DAGF Domestic – Assembled - 2-Piece Field Disassembly
EAU Export – Assembled Unit
EDG Export – 2-Piece Disassembled Unit
EAGF Export – Assembled - 2-Piece Field Disassembly

ELPP **Electrical Protection Package**
SELP Standard Electrical Package
PPCO **Control Panel Power Connection**
CB Circuit Breaker
FDS Fused Disconnect Switch
NFDS Non-Fused Disconnect Switch
TB Terminal Block
LCLD **Local Clear Language Display**
CLDC Clear Language Display – Complex Character
CLDO Clear Language Display – Suitable for Outdoor Use
TRIM **Tracer Interface Control Module**
TRMI Tracer 100 Interface Module (com3)
TRMS Tracer Summit Interface Module (com4)
PRIM **Printer Interface Control Module**
YES Printer Interface Module
ACWR **Ambient Chilled Water Reset**
YES Ambient Chilled Water Reset
WVUO **Under/Over Phase Voltage Protection**
YES Under/over Voltage Protection
CTWF **Chiller/Tower Water Flow Display**
YES Differential Water Pressure Transducers
OPTM **Options Control Module**
YES Options Module
AFDS **Adjustable frequency drive**
YES Frequency drive
FLSW **Flow Switches**
1FS1 150 PSI NEMA 1 Flow Switch - QTY of 1
1FS2 300 PSI NEMA 1 Flow Switch - QTY of 1
1FS3 150 PSI NEMA 4 Flow Switch - QTY of 1
1FS4 300 PSI NEMA 4 Flow Switch - QTY of 1
2FS1 150 PSI NEMA 1 Flow Switch - QTY of 2
2FS2 300 PSI NEMA 1 Flow Switch - QTY of 2
2FS3 150 PSI NEMA 4 Flow Switch - QTY of 2
2FS4 300 PSI NEMA 4 Flow Switch - QTY of 2
LBMF **Lithium Bromide Filter**
Yes Lithium Bromide Filter
UINS **Unit Insulation**
CINS Cold Unit Insulation Only
CRPI **Condenser Cross-Over pipe**
Yes Condenser cross-over pipe, factory installed

Performance Data

Table PD-1. Performance data at ARI conditions

English Units*							
		Coefficient	Steam	Chilled Water		Cond/Abs Water	
	Capacity	of	Rate	Flow Rate	Press. Drop	Flow Rate	Press. Drop
Model	(Tons)	Performance	(lbm/ton/hr)	(gpm)	(ft Wtr)	(gpm)***	(ft Wtr)
ABSD500	571	0.71	17.71	1366	19.7	1800	27.4
ABSD600	670	0.72	17.45	1603	30.2	2160	26.6
ABSD700	738	0.71	17.68	1766	22.3	2520	12.2
ABSD800	859	0.72	17.62	2054	32.6	2880	16.6
ABSD975	998	0.71	17.91	2387	18.8	3510	33.5
ABSD1100	1105	0.70	17.98	2643	24.6	3960	20.1
ABSD1225	1238	0.70	17.95	2960	32.7	4410	25.7
ABSD1350	1371	0.71	17.90	3279	42.2	4860	32.2

* 3.6 gpm/nominal ton, Pstm = 12 psig, TctwS = 85°F, TcwS = 44°F, TcwR = 54°F, 0.0001 evap fouling, 0.00025 cond/abs fouling

SI Units**							
		Coefficient	Steam	Chilled Water		Cond/Abs Water	
	Capacity	of	Rate	Flow Rate	Press. Drop	Flow Rate	Press. Drop
Model	(kW)	Performance	(kg/kW-hr)	(m^3/hr)	(m wg)	(m^3/hr)	(m wg)
ABSD500	2008	0.71	2.28	310	6.0	409	8.3
ABSD600	2356	0.72	2.25	364	9.2	491	8.1
ABSD700	2595	0.71	2.28	401	6.8	572	3.7
ABSD800	3021	0.72	2.27	466	9.9	654	5.1
ABSD975	3510	0.71	2.31	542	5.7	797	10.2
ABSD1100	3886	0.70	2.32	600	7.5	899	6.1
ABSD1225	4354	0.70	2.31	672	10.0	1002	7.8
ABSD1350	4821	0.71	2.31	745	12.9	1104	9.8

** 0.23 m^3/nominal kWh, Pstm = 0.83 bar, TctwS = 29.4°C, TcwS = 6.67°C, TcwR = 12.2°C, 0.018 evap fouling, 0.044 cond/abs fouling

Performance Data

Figure PD-1. ABSD 500-800 capacity vs. chilled-water supply temperature at various cooling-water supply temperatures

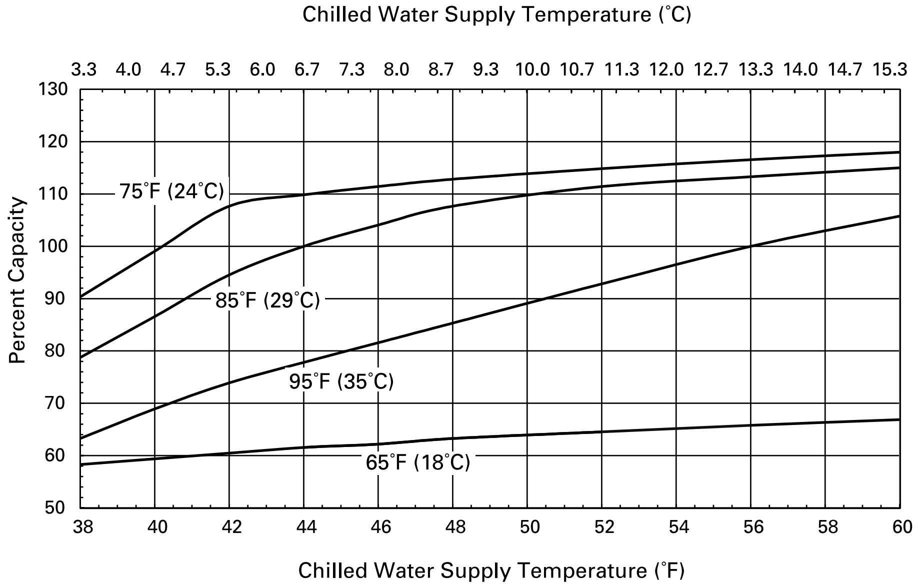
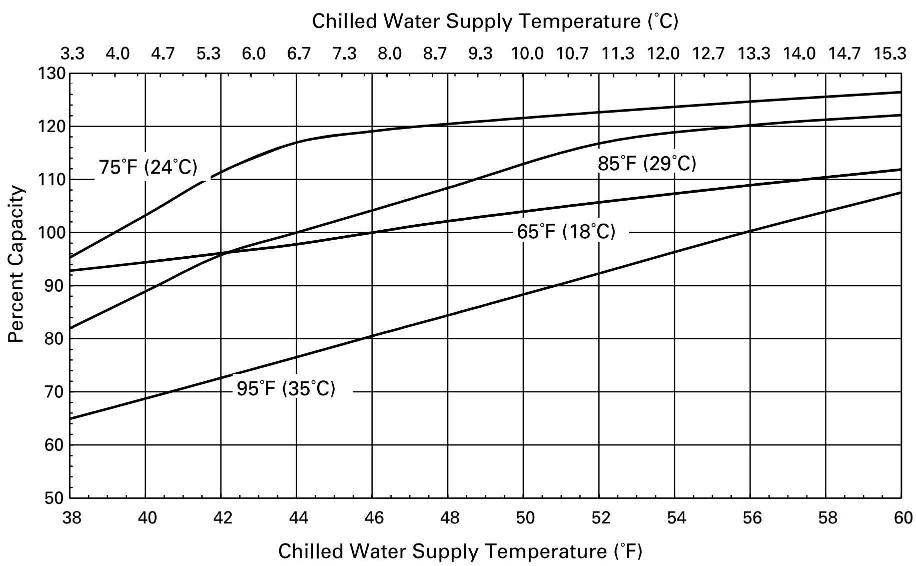


Figure PD-2. ABSD 975-1350 capacity vs. chilled water supply temperature at various cooling water supply temperatures



Performance Data

Figure PD-3. ABSD 500-800 part load performance - energy input vs. capacity at various cooling water supply temperatures: chilled water supply temperature = 44°F (7°C)

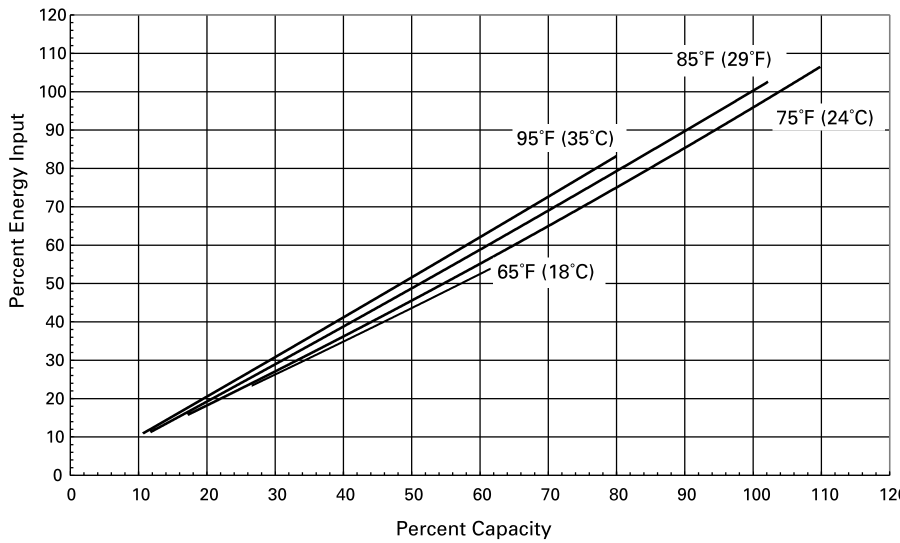
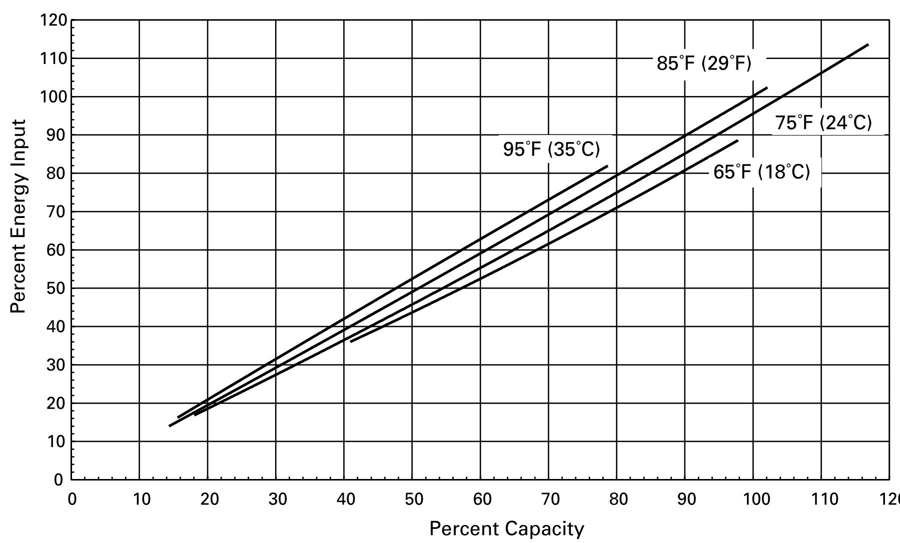


Figure PD-4. ABSD 975-1350 part load performance - energy input vs. capacity at various cooling water supply temperatures: chilled water supply temperature = 44°F (7°C)



Performance Data

Pressure Drop vs. Water Flow Rate

Figure PD-5. ABSD 500-800 pressure drop vs. chilled water flow rate – English and SI Units

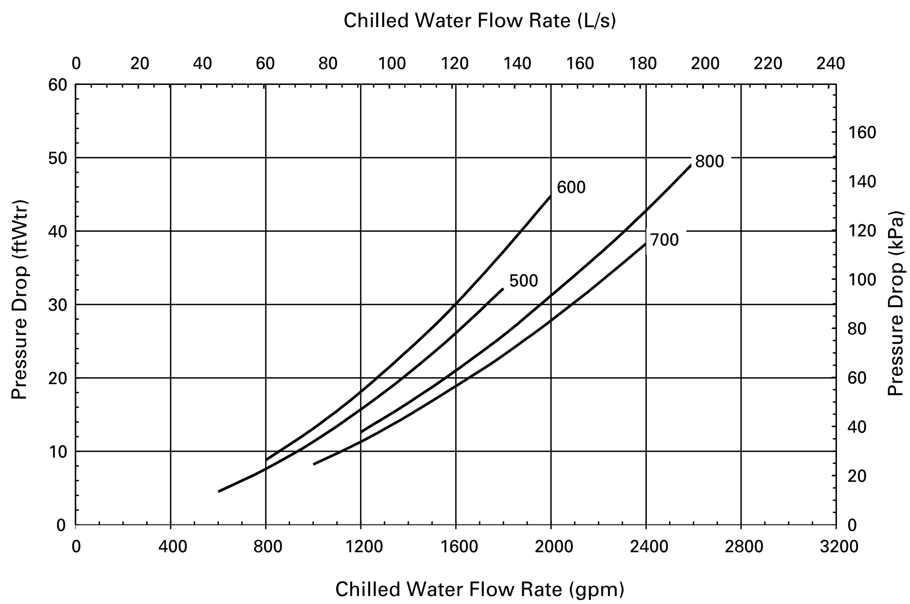
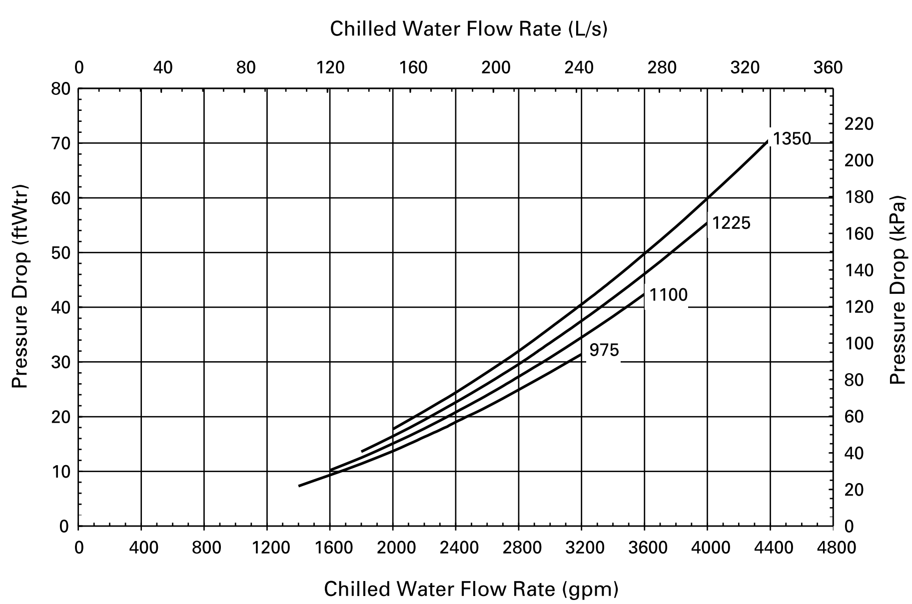


Figure PD-6. ABSD 975-1350 pressure drop vs. chilled water flow rate – English and SI Units



Performance Data

Pressure Drop vs. Water Flow Rate

Figure PD-7. ABSD 500-800 pressure drop vs. cooling water flow rate – English and SI Units

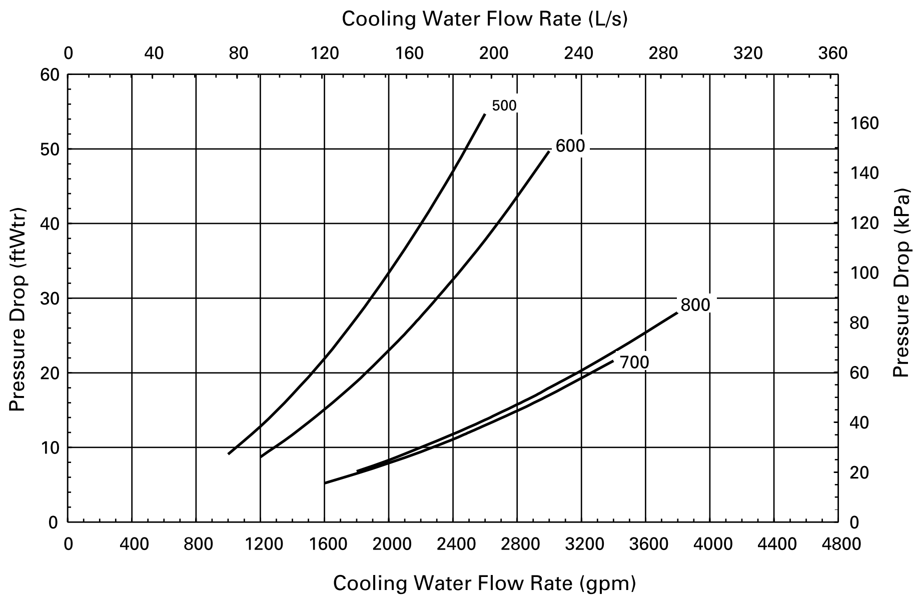
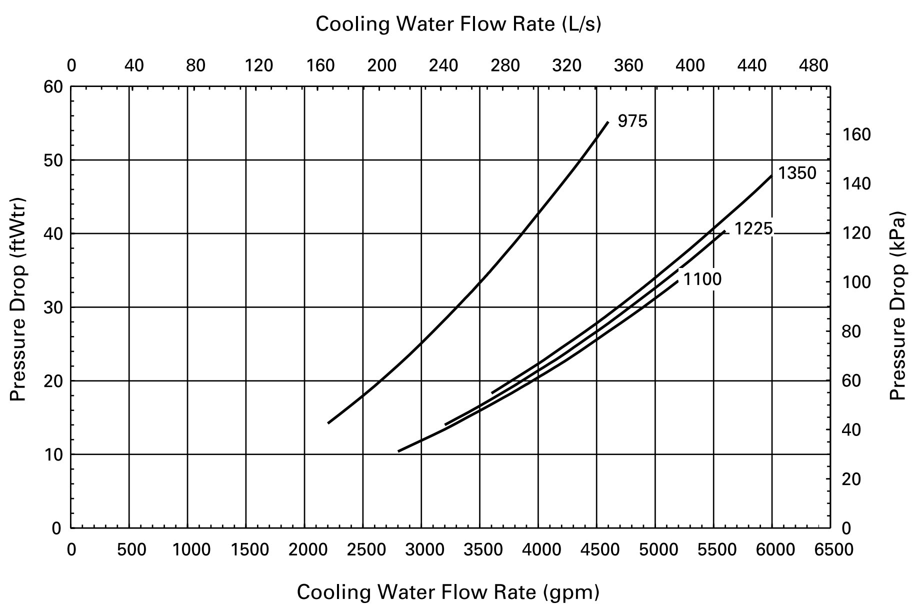


Figure PD-8. ABSD 975-1350 pressure drop vs. cooling water flow rate – English and SI Units



Electrical Data

Electrical Data

Factory-wired and-mounted power control includes main power connections. Total kW includes solution and refrigerant pump, motors, purge pump motor and control panel. Units may be supplied for operation on 230,460 or 575 volt, 3-phase, 60-hertz power, or 190, 220, 380 or 415 volt, 3-phase, 50-hertz power.

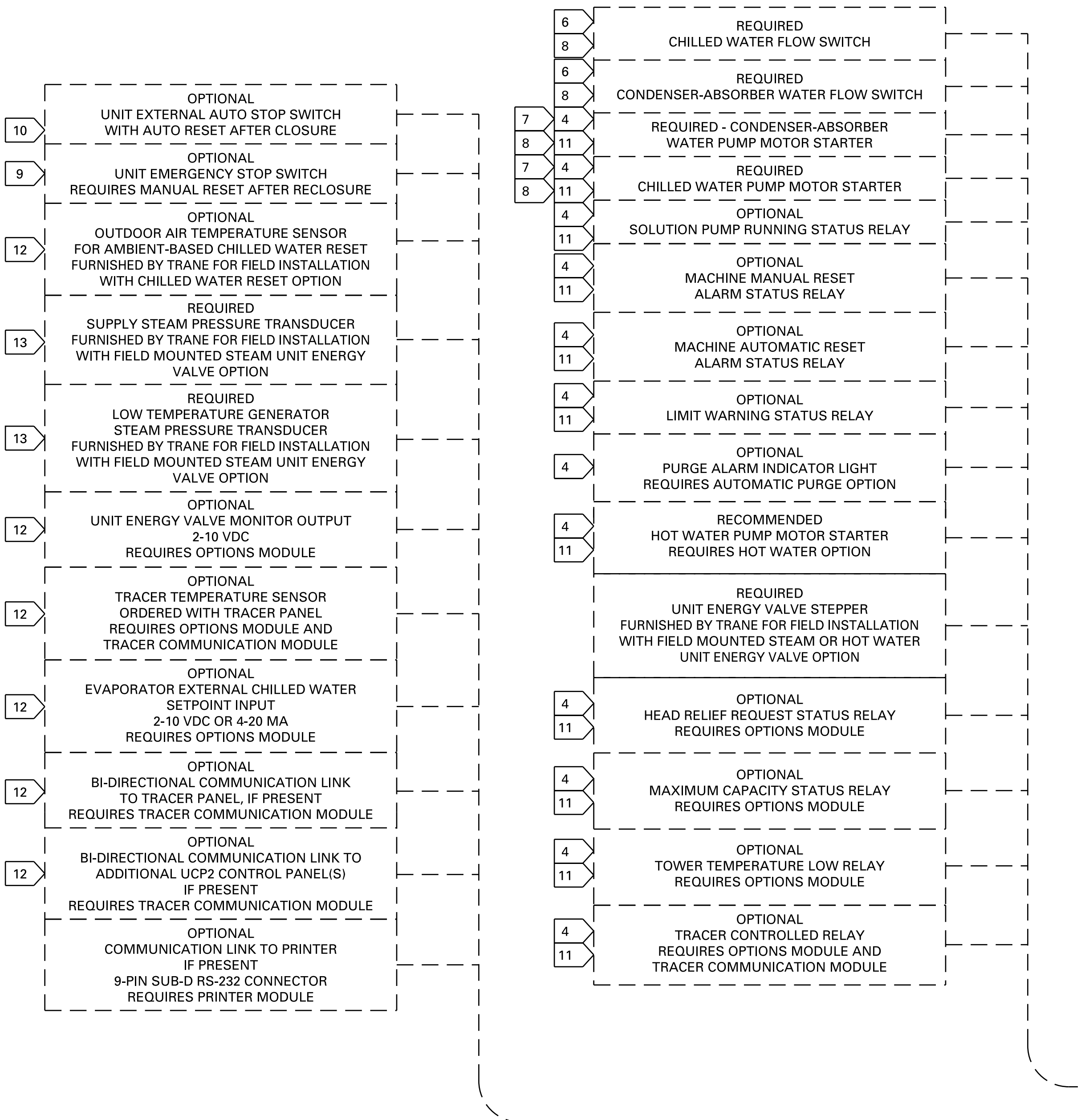
Table ED-1. Electrical data

Model	Supply Voltage	FLA	Total Motor HP	Total Motor kW	Control Circuit Amps	MCA	Max Fuse Size Amps
60 Hertz, 3-Phase							
500	200	69.0	13.0	9.7	10.0	86	90
thru	230	60.0	13.0	9.7	8.7	75	80
600	460	30.0	13.0	9.7	4.4	37	40
	575	25.0	13.0	9.7	3.5	31	35
700	200	90.0	17.5	13.0	10.0	109	110
thru	230	78.0	17.5	13.0	8.7	94	100
800	460	39.0	17.5	13.0	4.4	47	50
	575	32.0	17.5	13.0	3.5	39	40
	200	90.0	17.5	13.0	10.0	109	110
975	230	78.0	17.5	13.0	8.7	94	100
	460	39.0	17.5	13.0	4.4	47	50
	575	32.0	17.5	13.0	3.5	39	40
1100	200	96.0	20.0	14.9	10.0	115	125
thru	230	84.0	20.0	14.9	8.7	100	110
1350	460	42.0	20.0	14.9	4.4	50	60
	575	34.0	20.0	14.9	3.5	41	45
50 Hertz, 3-Phase							
Model	Supply Voltage	FLA	Total Motor HP	Total Motor kW	Control Circuit Amps	MCA	Max Fuse Size Amps
500	190	62.0	13.0	9.7	10.5	79	80
thru	220	52.4	13.0	9.7	9.1	67	70
600	380	30.0	13.0	9.7	5.3	38	40
	415	27.5	13.0	9.7	4.8	35	35
700	190	67.0	15.5	11.6	10.5	85	90
thru	220	57.4	15.5	11.6	9.1	73	80
800	380	33.0	15.5	11.6	5.3	42	45
	415	30.5	15.5	11.6	4.8	39	40
975	190	80.0	17.5	13.0	10.5	98	100
	220	68.0	17.5	13.0	9.1	84	90
	380	39.0	17.5	13.0	5.3	48	50
	415	36.0	17.5	13.0	4.8	44	45
1100	190	85.0	20.0	14.9	10.5	103	110
thru	220	73.0	20.0	14.9	9.1	89	90
1350	380	42.0	20.0	14.9	5.3	51	60
	415	39.0	20.0	14.9	4.8	47	50

Electrical Data

Wiring

⚠ WARNING	⚠ AVERTISSEMENT	⚠ CAUTION
HAZARDOUS VOLTAGE! DISCONNECT ALL ELECTRIC POWER INCLUDING REMOTE DISCONNECTS BEFORE SERVICING. FAILURE TO DISCONNECT POWER BEFORE SERVICING CAN CAUSE SEVERE PERSONAL INJURY OR DEATH.	VOLTAGE HASARDEUX! DECONNECTEZ TOUTES LES SOURCES ELECTRIQUES INCLUANT LES DISJONCTEURS SITUES A DISTANCE AVANT D'EFFECTUER L'ENTRETIEN. FAUTE DE DECONNECTER LA SOURCE ELECTRIQUE AVANT D'EFFECTUER L'ENTRETIEN PEUT ENTRAINER DES BLESSURES CORPORELLES SEVERES OU LA MORT.	USE COPPER CONDUCTORS ONLY! UNIT TERMINALS ARE NOT DESIGNED TO ACCEPT OTHER TYPES OF CONDUCTORS. FAILURE TO DO SO MAY CAUSE DAMAGE TO THE EQUIPMENT.



REFER TO NOTES AND DRAWING ON NEXT PAGE

Electrical Data

Wiring

GENERAL NOTES:

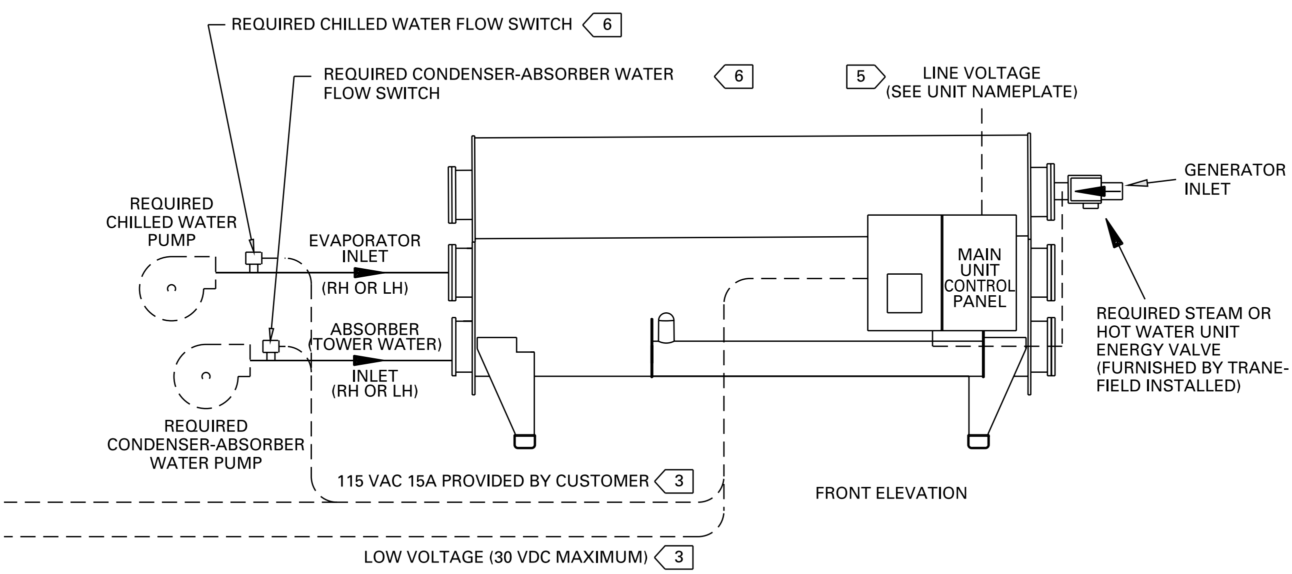
1. THIS DRAWING IS TO BE USED FOR THE PURPOSE OF ESTIMATING FIELD WIRING REQUIREMENTS. CHECK SALES ORDER TO DETERMINE WHICH OPTIONS ARE SPECIFIED AND REFER TO FIELD CONNECTION WIRING DIAGRAM FOR ACTUAL FIELD WIRING REQUIRED. DASHED LINES INDICATE DEVICES AND FIELD WIRING SUPPLIED BY CUSTOMER.
2. ALL FIELD WIRING MUST BE IN ACCORDANCE WITH THE NATIONAL ELECTRIC CODE OR STATE AND LOCAL REQUIREMENTS WHICH APPLY. ALL CUSTOMER CONTROL CIRCUIT WIRING MUST HAVE A MINIMUM RATING OF 150 VOLTS.
3. DO NOT ROUTE LOW VOLTAGE (30 VDC MAXIMUM) WIRING IN THE SAME CONDUIT AS CONTROL VOLTAGE (115 VAC) WIRING AND DO NOT POWER-UP UNIT UNTIL CHECK-OUT AND START-UP PROCEDURES HAVE BEEN COMPLETED.
4. THE MAIN UNIT CONTROL PANEL PROVIDES A CONTACT CLOSURE TO CONTROL THE INDICATED CUSTOMER CONNECTED DEVICE. CUSTOMER TO PROVIDE 115 VAC POWER TO EACH DEVICE. MAXIMUM FUSE SIZE IS 15 AMPS.

REQUIRED WIRING NOTES:

5. TRANE PROVIDES A TERMINAL BLOCK, FUSED OR NON-FUSED DISCONNECT SWITCH OR A CIRCUIT BREAKER IN THE MAIN UNIT CONTROL PANEL FOR LINE VOLTAGE CONNECTION WHICH REQUIRES THE USE OF COPPER CONDUCTORS ONLY. CHECK SALES ORDER TO DETERMINE WHICH OPTION IS SPECIFIED. WIRING SIZED PER NATIONAL ELECTRIC CODE BASED ON NAMEPLATE MINIMUM CIRCUIT AMPACITY RATING.
6. EVAPORATOR AND CONDENSER FLOW SWITCHES ARE TO BE INSTALLED AND WIRED TO THE MAIN UNIT CONTROL PANEL BY THE INSTALLING CONTRACTOR. THE PURCHASE OF FLOW SWITCHES FROM TRANE IS OPTIONAL. EACH FLOW SWITCH CIRCUIT REQUIRES TWO WIRES, 115 VAC. MINIMUM CONTACT RATING AT 115 VAC IS 4.8 MA.
7. CHILLED AND CONDENSER-ABSORBER WATER FLOW MUST BE PROVEN PRIOR TO CHILLER OPERATION. CONDENSER-ABSORBER WATER PUMP MUST BE CONTROLLED BY THE MAIN UNIT CONTROL PANEL FOR CHILLER SAFETY.
8. CIRCUIT REQUIRES TWO WIRES, 115 VAC. MAXIMUM MODULE CONTACT RATING AT 115 VAC OR 30 VDC IS 2.88 AMPS INDUCTIVE, 1/3 HP.

OPTIONAL WIRING NOTES:

9. OPTIONAL CONTROL FOR A CUSTOMER SPECIFIED OR INSTALLED LATCHING TRIPOUT. THE CHILLER WILL RUN NORMALLY WHEN THE CONTACT IS CLOSED AND TRIP THE CHILLER OFF WITH A MANUALLY RESETTABLE DIAGNOSTIC WHEN THE CONTACT OPENS. MANUAL RESET IS ACCOMPLISHED WITH THE DIAGNOSTIC KEY ON THE FRONT OF THE MAIN UNIT CONTROL PANEL. CUSTOMER SUPPLIED SILVER CONTACTS ARE REQUIRED FOR 24 VDC, 12 MA RESISTIVE LOAD. CIRCUIT REQUIRES TWO WIRES, 30 VDC MAXIMUM. DO NOT ROUTE IN CONDUIT WITH HIGHER VOLTAGE CIRCUITS.
10. OPTIONAL CONTROL FOR A CUSTOMER SPECIFIED OR INSTALLED REMOTE AUTO-STOP FUNCTION. THE CHILLER WILL RUN NORMALLY WHEN THE CONTACT IS CLOSED AND STOP THE CHILLER WHEN THE CONTACT OPENS. RECLOSURE OF THE CONTACT WILL PERMIT THE CHILLER TO AUTOMATICALLY RETURN TO NORMAL OPERATION. CUSTOMER SUPPLIED SILVER CONTACTS ARE REQUIRED FOR 24 VDC, 12 MA RESISTIVE LOAD. CIRCUIT REQUIRES TWO WIRES, 30 VDC MAXIMUM. DO NOT ROUTE IN CONDUIT WITH HIGHER VOLTAGE CIRCUITS.
11. CIRCUIT REQUIRES TWO WIRES, 115 VAC. NORMALLY OPEN MAXIMUM MODULE CONTACT RATING AT 115 VAC OR 30 VDC IS 2.88 AMPS INDUCTIVE, 1/3 HP.
12. CIRCUIT REQUIRES SHIELDED WIRE PAIR, 30 VDC MAXIMUM. BELDON TYPE 8760 RECOMMENDED. MAXIMUM LENGTH OF 5000 FEET.
13. TRANE PROVIDES STEAM PRESSURE TRANSDUCER SHIELDED CABLE ASSEMBLIES FOR FIELD INSTALLATION BY CUSTOMER.



Controls Data

Setting The Standards
Trane set the standard for unit microprocessor controls in 1985 with the first generation of Unit Control Panel. Associated with this standard have been:

- Proportional Integral Derivative (PID) control strategies, which provide stable operation and high accuracy for better performance, along with feed forward plus;
- Adaptive Control™ to keep the chiller "on line" and at the same time keep the chiller away from a major failure;
- Software based safeties that do not depend on electromechanical hardware – hardware that means questionable reliability and added cost;
- Operator interface that accesses chiller information and control adjustments at the front of the panel.

UCP2™
UCP2 adds more flexibility, more reliability and better system performance than even our most demanding customers expect.

Flexibility
Trane offers the ability to adapt to changes easily and effectively without adding prohibitive cost. To provide flexibility, the controller responds to a wide variety of needs for:

- **System Designs,** including equipment, operating conditions and controls variations that are either existing or being considered for new installations.

  Key to designing non-traditional systems is the ability to evaluate the cost and reliability issues of these systems in comparison to the more traditional systems. Trane recommends the use of C.D.S. Network Equipment Economics, the Trane Applications Manuals and consultation with a Trane sales engineer for help in this analysis.

- **System Upgrades,** including the ability to accommodate changes in the chilled-water system design or equipment room requirements, or to accommodate new technologies that become available.
- Modular structure of the UCP2 makes it possible for the designer to select the system controls and associated interfaces to Tracer® (or other building automation systems) that are required for the chiller plant design. With this modular concept, capability can be added or upgraded at any time, with only temporary interruption of chilled-water production.
- The operator can quickly program a Custom Report — so that only what are considered to be the most frequently accessed/important reports are available — at any time, right at the front of the panel.
- With easy front panel programmability of Daily, Service Start-up and Machine Configuration settings and setpoints, the operator, serviceman and system designer can customize the use of the micro controller to unique conditions of the chiller plant — whether the purpose of chilled water is for comfort cooling or for process cooling.
- All data that is necessary for the safe operation and easy serviceability of the chiller is provided as standard on all Horizon® absorption chillers. Options are available that provide additional controls/data that are required for: an industrial/process system design, applications outside of the typical chilled water system design, the need for redundant machine protection or the desire for more system information.

Controls Data

Reliability

To most people, reliability means "dependability — giving the same result on successive trials." To our customers, however, it has come to mean "keep chilled water flowing." In other words, "when I turn the switch on, cold water comes out." In order to do this, the micro controller must be aware of what is happening in the system. But more importantly, it must be able to make decisions and adjustments to keep the chiller running as long as possible, even when non-standard conditions exist — conditions such as bad power, bad water (flow, temperature, fouling) or system component failure. Also, the Trane UCP2 panel continuously monitors for noncondensables and purges automatically.

- With Enhanced Adaptive Control™ the controller does everything it can to avoid taking the chiller offline.
  - — Senses evaporator temperature limit and high temperature limit
  - — Displays a warning message about the potential condition/safety trip
  - — Takes the following corrective action sequentially as the condition worsens:
    - limits loading
    - prevents further loading
    - unloads until condition improves
    - takes chiller offline
- With more diagnostics and diagnostic history that are time/date stamped and with help messages, the operator or serviceman can take faster and more effective corrective action.

System Performance

"Chilled Water System" encompasses many levels of control: Standalone Chiller, Chiller Plant, Applied System, Central Building Automation System. However, regardless of the system level being designed, the unit controls become critical, not just in making every level operate reliably but also in facilitating optimal performance. UCP2 provides more capability and more intelligence to make this operation/ optimization possible.

Panel Features:

The absorption chiller Unit Control Panel (UCP2) incorporates the following features and components:

Control Functions

- Smart dilution-cycle duration based on system requirements
- Adaptive evaporator leaving-fluid temperature control
- Low evaporator-temperature limit
- High solution-temperature limit
- Solution flow control via AFD
- Soft loading
- Nuisance trip prevention via Adaptive Control
- Chilled-water reset
- Optimum concentration control
- Crystallization recovery via SDR

Controls Data

Safeties

- Smart shutdown sequence: condenser/ absorber loss of flow
- Low condenser/absorber water temperature
- High-pressure cutout
- Evaporator leaving-fluid temperature cutout
- Motor current overload
- High motor-winding temperature
- Over/under voltage (optional)
- Purge limit
- Sensor failure detection

Monitored Points

Chiller information is available at the operator interface via a clear language display. Access to the information is through four dedicated report keys: Customer, Chiller, Cycle and Pump/ Purge.

Customer Report

User-defined custom report (operator may choose up to 20 points from a list of over 100 choices).

Chiller Report

Status, fluid temperatures, and setpoints:

- Operating mode (i.e. run status)
- Chilled-water setpoint
- Evaporator entering/leaving water temperatures
- Absorber entering/leaving water temperatures
- Condenser leaving-water temperature outdoor air temperature
- Evaporator leaving-water temperature
- Chilled-water reset

Cycle Report

Refrigerant temperatures and pressures:

- Solution temperature leaving generator
- Solution temperature entering generator
- Generator-leaving concentration
- Generator cutout and monitor temperature
- Crystallization detection temperature
- Crystallization trip temperature
- Saturated condenser refrigerant temperature
- Absorber-entering concentration
- LiBr crystallization margin
- Solution temperature entering absorber
- Absorber spray temperature
- Solution temperature leaving absorber
- Saturated evaporator refrigerant temperature
- Evaporator leaving-water temperature
- Evaporator entering-water temperature
- Absorber entering-water temperature
- Absorber leaving-water temperature
- Condenser leaving-water temperature
- Solution pump auto/manual speed command
- Energy input auto/manual/slaved reported command
- Steam Supply Pressure
- Generator Steam Pressure

Pump/Purge Report

- Solution pump
  - — Counters for starts and hours
  - — Motor phase currents
  - — Motor phase voltages (optional)
- Purge Pump
  - — Operating mode and status
  - — Refrigerant suction temperature
  - — Pumpout rate
  - — Total pumpout time
  - — Service log

Controls Data

Diagnostics
The absorption chiller Unit Control Panel (UCP2) provides over 70 different diagnostics such as:

- Water and refrigerant/solution temperatures out of range
- Loss of system waterflows
- Sensor and switch faults
- Overload trips
- Over/under voltage (optional)
- Crystallization recovery
- Emergency stop
- Loss of communication to other modules
- Motor abnormal

Operator Interface
The Trane Horizon® steam-fired absorption chiller control panel, UCP2, is easy to use, understand, access information, read, change setpoints, diagnose problems, maintain, and to reset after shutdown.

Convenience
Enunciation of all information is at the front panel display (including power, voltage, amps, purge pressures, and number of starts data). Messages are displayed using clear language.

Readability

- Two-line, 40-character display that is easy to read from within a 60-degree angle
- LCD backlight so that the display can be read in a variety of equipment-room lighting
- Seven languages available
- Metric (SI) units available
- Complete character human interface available

Ease of Use

- Keypad programmability — no manual switches or setpoint potentiometers
- Logically arranged report groups with report header and setpoint groups
- Selectable security
- Variable points updated every two seconds
- Messages that direct user to problem source via a menu item

Trane ICS Compatibility
The Trane absorption chiller control panel, UCP2, is 100 percent compatible with the Trane Integrated Comfort™ systems, ICS, UCP2 easily integrates into the Tracer® family of flexible chiller-plant system controllers with a single twisted-wire pair communications cable.

For more information on the Trane absorption chiller unit control panel, please contact your local Trane sales engineer.

Dimensions and Weights

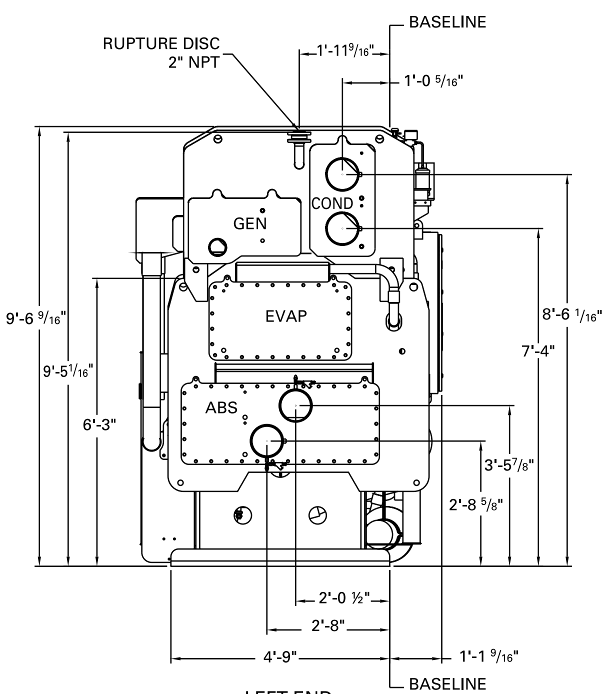
Physical Dimensions

ABSD 500, 600, 700, 800 Physical Dimensions English and SI Units

This section provides the overall dimensions of the Horizon absorption chiller. See unit submittal drawings for configured water nozzle connection dimensions. A 500 Ton 2 pass absorber and condenser is illustrated. All catalog dimensional drawings are subject to change. Current submittal drawings should be referred to for detailed dimensional information. Contact the local Trane sales office for submittal and template information.

Table DW-1. Dimensional data

			English Units			
Unit	A	B	C	D	E	F
500	13′-9½″	14′-5½″	1′-7⅜″	17′-9¾″	14′-2⅛″	8′-0⅞″
600	16′-5½″	17′-1½″	1′-8⅞″	20′-7¼″	16′-10⅛″	10′-8⅞″
700	19′-1⅜″	19′-9½″	1′-8⅞″	23′-3¼″	19′-6⅛″	13′-11⅛″
800	21′-9⅜″	22′-5½″	1′-8⅞″	25′-11¼″	22′-2⅛″	16′-10⅞″
			SI Units			
Unit	A	B	C	D	E	F
500	4204	4407	492	5429	4321	2461
600	5017	5220	530	6280	5134	3273
700	5826	6033	530	7093	5947	4245
800	6639	6845	530	7906	6760	5153



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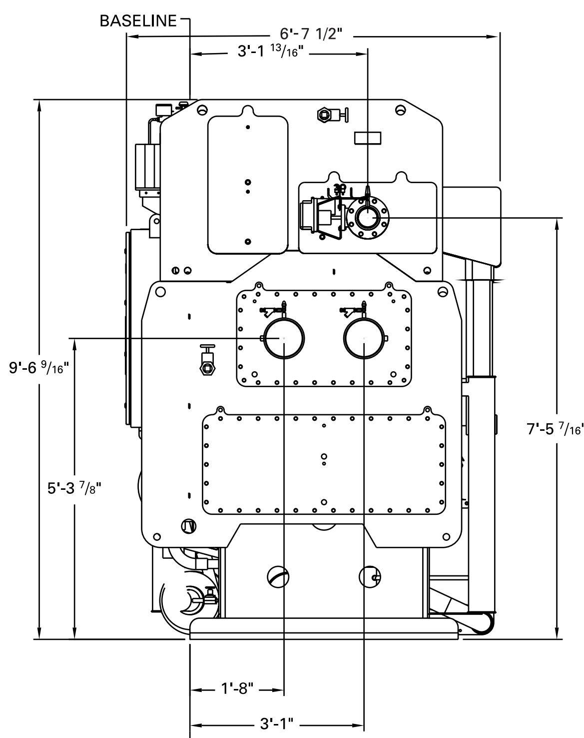
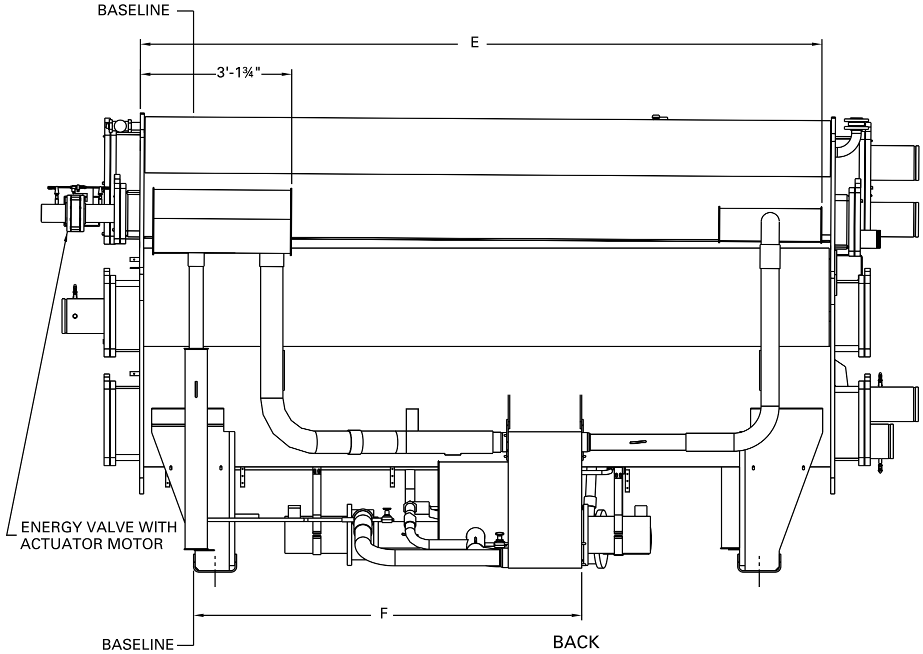


RIGHT END

Table DW-2. English to SI Units Cross Reference

Conversion Chart (Ft. to mm)	
English Units	SI Units
1 7/8"	48
2"	51
1' 0 5/16"	313
1' 1 1/2"	343
1' 1 9/16"	344
1' 3 1/2"	394
1' 8"	508
1' 8 7/8"	530
1' 11 9/16"	598
2' 0 1/2"	622
2' 8"	813
2' 8 5/8"	829
3' 1"	940
3' 1 3/4"	959
3' 1 13/16"	960
3' 5 7/8"	1064
3' 6"	1067
3' 9"	1143
4' 0 1/8"	1222
4' 6"	1372
4' 9"	1448
5' 3 7/8"	1622
6' 3"	1905
6' 7 1/2"	2019
7' 4"	2235
7' 5 7/16"	2272
8' 6 1/16"	2593
9' 5 1/16"	2886
9' 6 9/16"	2910



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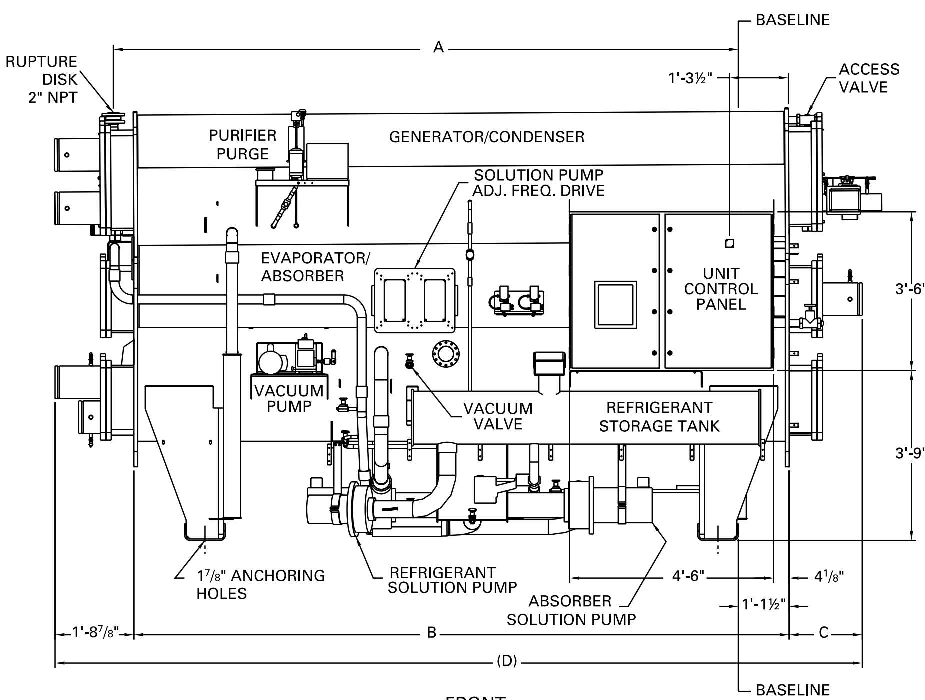


FRONT

Dimensions and Weights

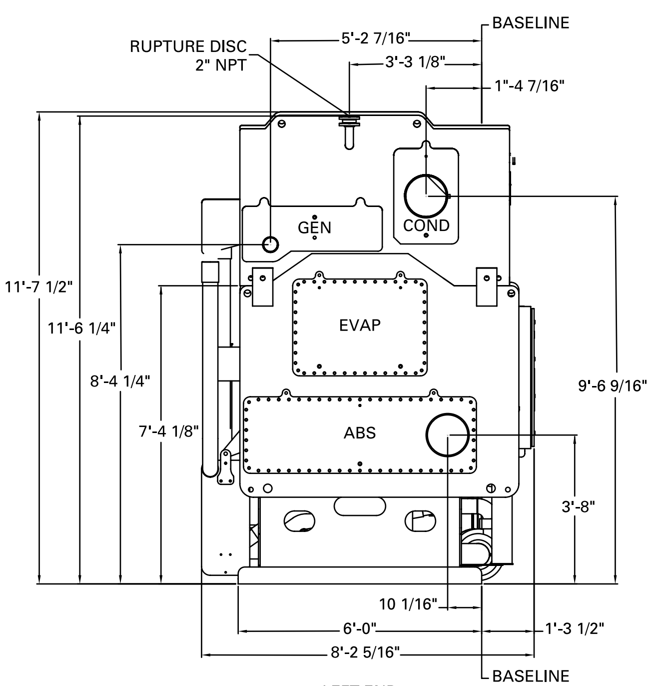
Physical Dimensions

ABSD 975, 1100, 1225, 1350 Physical Dimensions English and SI Units

This section provides the overall dimensions of the Horizon absorption chiller. See unit submittal drawings for configured water nozzle connection dimensions. All catalog dimensional drawings are subject to change. Current submittal drawings should be referred to for detailed dimensional information. Contact the local Trane sales office for submittal and template information.

Table DW-3. Dimensional data

		English Units			
Unit	A	B	D	E	F
975	17' - 7 1/2"	18' - 0"	21' - 8"	17' - 3"	N/A
1100	19' - 7 1/2"	20' - 0"	23' - 8"	19' - 3"	N/A
1225	21' - 7 1/2"	22' - 0"	25' - 8"	21' - 3"	N/A
1350	23' - 7 1/2"	24' - 0"	27' - 8"	23' - 3"	N/A
		SI Units			
Unit	A	B	D	E	F
975	5372	5486	6604	5258	N/A
1100	5982	6096	7214	5868	N/A
1225	6591	6705	7823	6477	N/A
1350	7201	7315	8433	7087	N/A



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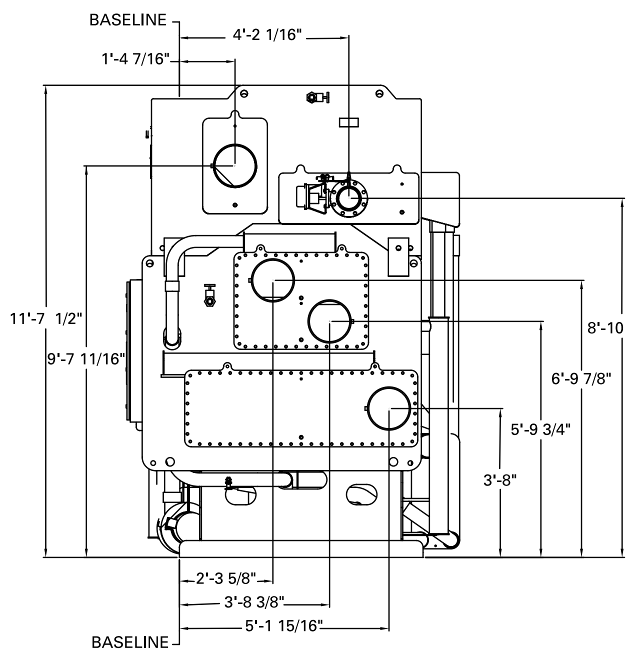


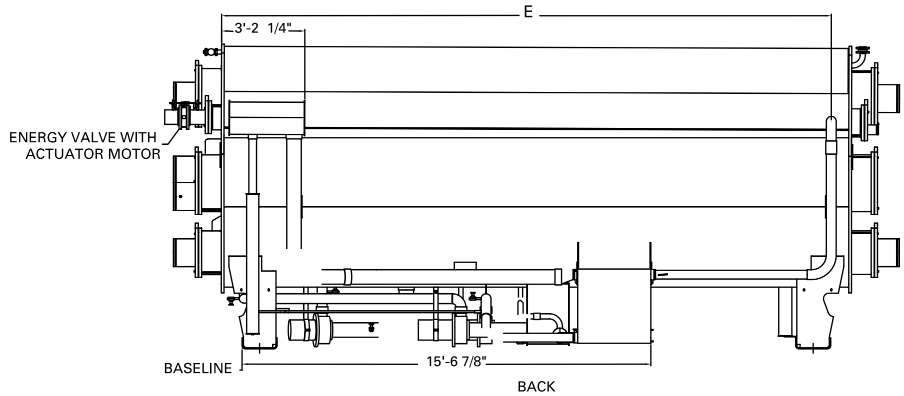
RIGHT END

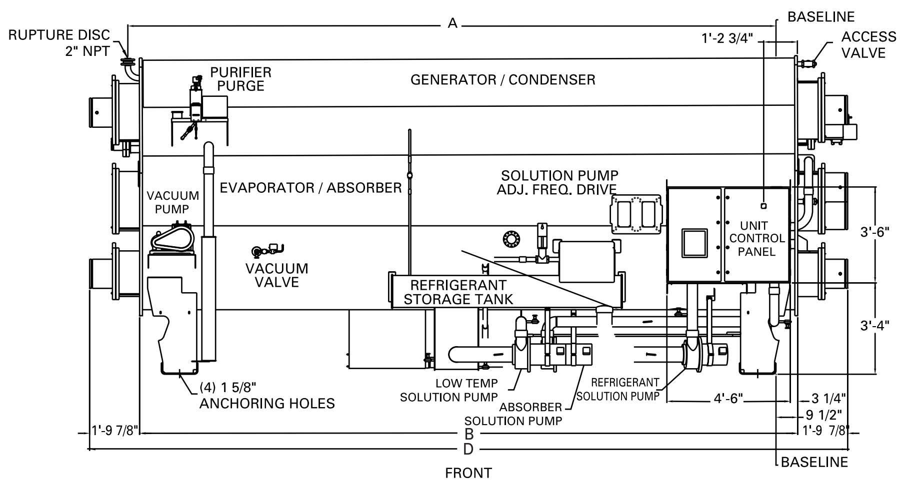
Dimensions and Weights

Physical Dimensions

Table DW-4. English to SI Units Cross Reference

Conversion Chart (Ft. to mm)	
English Units	**SI Units**
4' - 2 1/16"	50
2"	51
3 1/4"	83
9 1/2"	241
10 1/16"	256
1' - 2 3/4"	375
1' - 3 1/2"	394
1' - 4 7/16"	418
1' - 9 7/8"	556
2' - 3 5/8"	702
3' - 3 1/8"	994
3' - 4"	1016
3' - 6"	1067
3' - 8"	1118
4' - 6"	1372
5' - 1 15/16"	1573
5' - 2 7/16"	1586
5' - 9 3/4"	1772
6' - 0"	1829
6' - 9 7/8"	2080
7' - 4 1/8"	2238
8' - 2 5/16"	2497
8' - 4 1/4"	2546
8' - 10 5/8"	2708
9' - 6 9/16"	2910
9' - 7 11/16"	2938
11' - 6 1/4"	3512
11' - 7 1/2"	3543





Dimensions and Weights

Disassembly Options

Separated Machine Sections

Disassembled machines can ship to the job site in two main sections, the evaporator/ absorber as a section and the low temperature generator/ condenser as a separate section. Contact the local Trane sales office for current submittal information.

Figure DW-1. Disassembly options – right end view

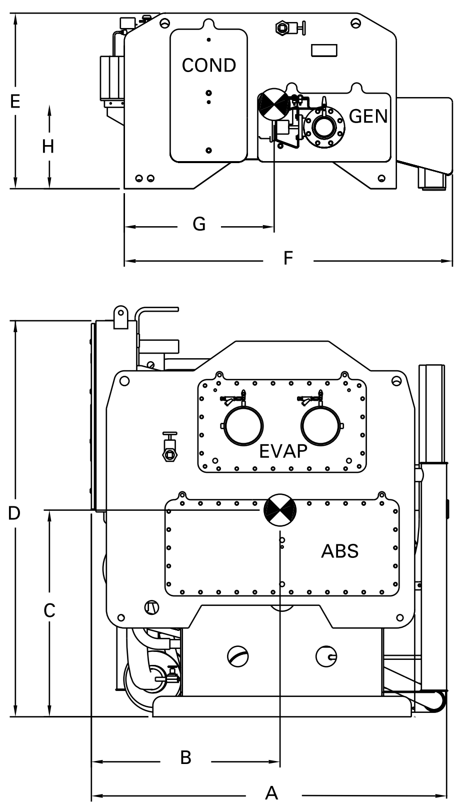


Table DW-5. Disassembly and center of gravity dimensions

Unit Size	500	600	700	800	975	1100	1225	1350
				English Units				
A	5′ 11¼″	5′ 11¼″	5′ 11¼″	5′ 11¼″	8'-2 3/8″	8'-2 3/8″	8'-2 3/8″	8'-2 3/8″
B	3′ 5 5/8″	3′ 5 5/8″	3′ 5 5/8″	3′ 5 5/8″	3'-11¼″	3'-11¼″	3'-11¼″	3'-11¼″
C	3′ 9 3/8″	3′ 10″	3′ 10 1/8″	3′ 10 3/8″	4'-8 ¾"	4'-8 ¾"	4'-8 ¾"	4'-8 ¾"
D*	7′ 3″	7′ 3″	7′ 3″	7′ 3″	8'-2 5/8"	8'-2 5/8"	8'-2 5/8"	8'-2 5/8"
E	3′ 2 5/8″	3′ 2 5/8″	3′ 2 5/8″	3′ 2 5/8″	4'-2 3/8"	4'-2 3/8"	4'-2 3/8"	4'-2 3/8"
F	6′ 0 3/8″	6′ 0 3/8″	6′ 0 3/8″	6′ 0 3/8″	7'-7"	7'-7"	7'-7"	7'-7"
G	2′ 9″	2′ 9″	2′ 9″	2′ 9″	3'-8 1/2"	3'-8 1/2"	3'-8 1/2"	3'-8 1/2"
H	1′ 6½″	1′ 6½″	1′ 6½″	1′ 6 ½″	2'-0 3/8"	2'-0 3/8"	2'-0 3/8"	2'-0 3/8"
				SI Units (mm)				
A	1810	1810	1810	1810	2499	2499	2499	2499
B	1057	1057	1057	1057	1200	1200	1200	1200
C	1153	1168	1172	1178	1441	1441	1441	1441
D	2210	2210	2210	2210	2505	2505	2505	2505
E	981	981	981	981	1280	1280	1280	1280
F	1838	1838	1838	1838	2311	2311	2311	2311
G	838	838	838	838	1130	1130	1130	1130
H	470	470	470	470	619	619	619	619

*Indicates overall height of chiller. The top of the evaporator shell is the highest point on chiller sizes 975-1350 tons. The top of the control panel is the highest point on chillers 800 tons and below.

Foundation Support

The foundation must be level, smooth, and capable of supporting the machine weight. The machine legs should be positioned over isolation pads. A housekeeping pad or support rail is recommended to elevate the machine for maintenance. Any foundation pad should provide adequate structural support and keep the installed machine level within 1/16-inch [1.6 mm] by length and width for reliable operation. Leveling marks on the evaporator and absorber tube sheet can be used to check the machine after it is positioned on the pad.

Chiller Isolation

Isolation pads are provided with each unit. The purpose of the isolation pad is to distribute the machine weight and minimize sound and vibration transmission through the building structure.

Figure DW-2. Typical machine rigging points

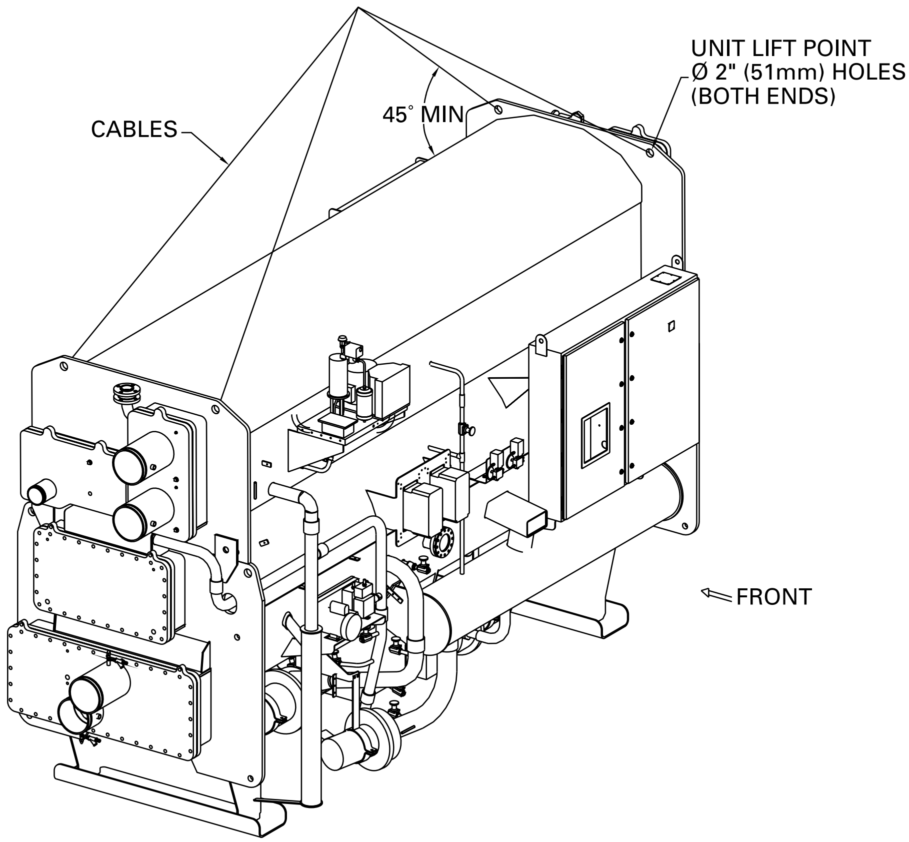
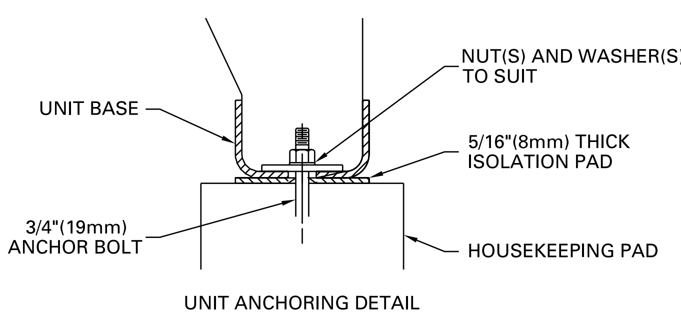


Figure DW-3. Unit anchoring detail – all sizes



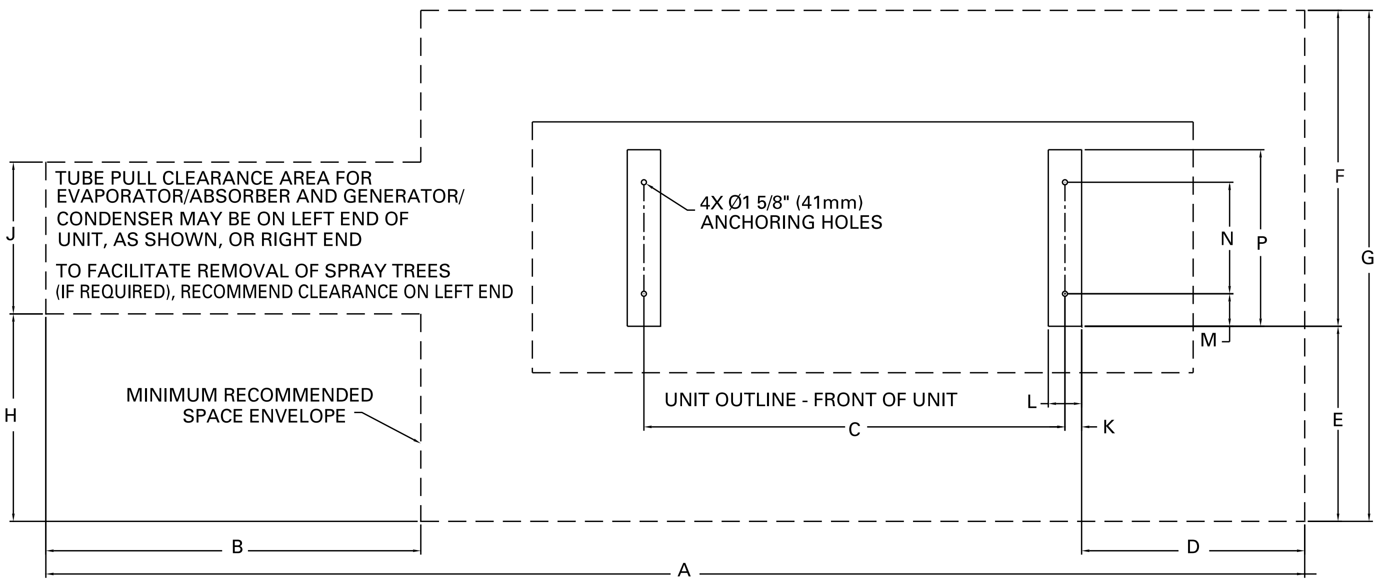


Figure DW-4. Service clearances

Table DW-6. Service clearances

English Units								
Unit Size	500	600	700	800	975	1100	1225	1350
A	33' - 10 1/4"	39' - 2 1/4"	44' - 6 1/4"	49' - 10 1/4"	40' - 11 7/8"	44' - 11 7/8"	48' - 11 7/8"	52' - 11 7/8"
B	10' - 1"	12' - 9"	15' - 5"	18' - 1"	13' - 4 1/8"	15' - 4 1/8"	17' - 4 1/8"	19' - 4 1/8"
C	11' - 3 7/8"	13' - 11 7/8"	16' - 7 7/8"	19' - 3 7/8"	15' - 1"	17' - 1"	19' - 1"	21' - 1"
D	6' - 0"	6' - 0"	6' - 0"	6' - 0"	5' - 7 3/8"	5' - 7 3/8"	5' - 7 3/8"	5' - 7 3/8"
E	5' - 3"	5' - 3"	5' - 3"	5' - 3"	5' - 3 1/2"	5' - 3 1/2"	5' - 3 1/2"	5' - 3 1/2"
F	8' - 6"	8' - 6"	8' - 6"	8' - 6"	9' - 10 7/8"	9' - 10 7/8"	9' - 10 7/8"	9' - 10 7/8"
G	13' - 9"	13' - 9"	13' - 9"	13' - 9"	15' - 2 3/8"	15' - 2 3/8"	15' - 2 3/8"	15' - 2 3/8"
H	5' - 7"	5' - 7"	5' - 7"	5' - 7"	5' - 7 3/8"	5' - 7 3/8"	5' - 7 3/8"	5' - 7 3/8"
J	4' - 1"	4' - 1"	4' - 1"	4' - 1"	5' - 4 1/4"	5' - 4 1/4"	5' - 4 1/4"	5' - 4 1/4"
K	5 3/8"	5 3/8"	5 3/8"	5 3/8"	8"	8"	8"	8"
L	10 3/4"	10 3/4"	10 3/4"	10 3/4"	16"	16"	16"	16"
M	10 1/2"	10 1/2"	10 1/2"	10 1/2"	10"	10"	10"	10"
N	3' - 0"	3' - 0"	3' - 0"	3' - 0"	4' - 4"	4' - 4"	4' - 4"	4' - 4"
P	4' - 9"	4' - 9"	4' - 9"	4' - 9"	6' - 0"	6' - 0"	6' - 0"	6' - 0"
SI Units (mm)								
Unit Size	500	600	700	800	975	1100	1225	1350
A	10319	11944	13570	15196	12494	13713	14932	16151
B	3073	3886	4699	5512	4067	4677	5286	5896
C	3451	4264	5077	5890	4597	5207	5817	6426
D	1829	1829	1829	1829	1711	1711	1711	1711
E	1600	1600	1600	1600	1613	1613	1613	1613
F	2591	2591	2591	2591	3019	3019	3019	3019
G	4191	4191	4191	4191	4632	4632	4632	4632
H	1702	1702	1702	1702	1711	1711	1711	1711
J	1245	1245	1245	1245	1632	1632	1632	1632
K	137	137	137	137	203	203	203	203
L	273	273	273	273	406	406	406	406
M	267	267	267	267	254	254	254	254
N	914	914	914	914	1321	1321	1321	1321
P	1448	1448	1448	1448	1829	1829	1829	1829

Rigging and Service Clearances

Service clearance is required on all sides of the machine. Pay particular attention to the control panel door clearance and the clearance at one end for tube service.

Figure DW-4 and Table DW-6 illustrate the recommended clearances for normal service and tube replacement. When sufficient overhead clearance exists, we recommend placing a 6-8 inch (150-200 mm) extension underneath the machine legs for additional access under the chiller.

Overhead lift is the recommended method when moving a machine. Before lifting the machine, determine the approximate location of the center of gravity.

Low Temperature Insulation (Cold Insulation Type)

Cold insulation can be ordered as a factory-installed option. The quantity and the areas to be covered are illustrated in Table DW-7 and Figure DW-5.

Figure DW-5. Cold insulation

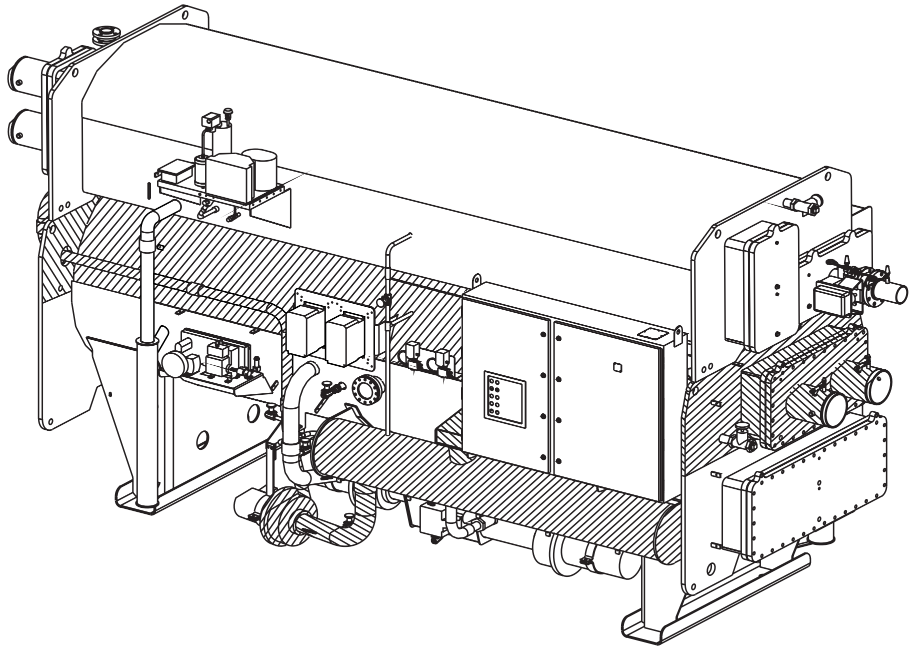


Table DW-7. Cold insulation area and length

English Units											
Refrigerant Storage Tank Circuit		Evaporator Shell		Tubesheets & Water Boxs		2" Pipe		4.50" Pipe			
500T	45.01 sq. ft	500T	97.65 sq. ft	500T-800T	99.74 sq. ft	500T-800T	11.19 LN FT	500T-800T	2.625 LN FT		
600T	55.53 sq. ft	600T	115.87 sq. ft								
700T	66.04 sq. ft	700T	134.12 sq. ft								
800T	76.55 sq. ft	800T	152.32 sq. ft								
Refrigerant Storage Tank Circuit		Evaporator Shell		Tubesheets & Water Boxs		3.50" Pipe		4.00" Pipe		4.50" Pipe	
975T-1350T	64.876 sq. ft	975T	154.24 sq. ft	975T-1350T	164.32 sq. ft	975T-1350T	5.97 LN FT	975T-1350T	2.92 LN FT	975T-1350T	2.24 LN FT
		1100T	171.58 sq. ft								
		1225T	188.91 sq. ft								
		1350T	206.26 sq. ft								
SI Units											
Refrigerant Storage Tank Circuit		Evaporator Shell		Tubesheets & Water Boxs		2" Pipe		4.50" Pipe			
500T	4.18 sq. m	500T	9.07 sq. m	500T-800T	9.27 sq. m	500T-800T	3411 mm	500T-800T	800 mm		
600T	5.16 sq. m.	600T	10.76 sq. m.								
700T	6.14 sq. m.	700T	12.46 sq. m.								
800T	7.11 sq. m.	800T	14.15 sq. m.								
Refrigerant Storage Tank Circuit		Evaporator Shell		Tubesheets & Water Boxs		3.50" Pipe		4.00" Pipe		4.50" Pipe	
975T-1350T	6.03 sq. m	975T	14.33 sq. m	975T-1350T	15.27 sq. m	975T-1350T	1820 mm	975T-1350T	890 mm	975T-1350T	683 mm
		1100T	15.94 sq. m.								
		1225T	17.55 sq. m.								
		1350T	19.16 sq. m.								

Table DW-8. Weights and connection sizes

English Units						
	Weights		Connection Sizes		Unit Charging	
Model	Shipping [lbm]	Operating [lbm]	Evap [in]	Cond/Abs [in]	54.7% Brine [lbm]	Refrigerant [gal]
ABSD 500	25606	35420	8	8	4471	150
ABSD 600	28639	39792	8	8	4878	190
ABSD 700	31683	44939	10	10	5691	230
ABSD 800	34843	49458	10	10	6098	270
ABSD 975	42255	56967	12	12	6100	162
ABSD 1100	45389	61183	12	12	6500	179
ABSD 1225	48740	65664	12	12	6910	197
ABSD 1350	51901	69916	12	12	7310	213
SI Units						
	Weights		Connection Sizes		Unit Charging	
Model	Shipping [kg]	Operating [kg]	Evap [mm]	Cond/Abs [mm]	54.7% Brine [kg]	Refrigerant [l]
ABSD 500	11614	16066	203	203	2028	568
ABSD 600	12990	18049	203	203	2213	719
ABSD 700	14371	20384	254	254	2581	871
ABSD 800	15804	22434	254	254	2766	1022
ABSD 975	19166	25840	305	305	2767	613
ABSD 1100	20588	27752	305	305	2948	679
ABSD 1225	22108	29785	305	305	3134	745
ABSD 1350	23542	31713	305	305	3316	805

Note: Weight information are estimates based on standard units. Weight and unit charging information can vary based on unit options and operating conditions.

Job Site Connections

Steam Supply and Condensate Piping

Steam Supply

Figure JC-1 illustrates a typical steam-supply piping illustration that includes the appropriate hardware.

The steam supply piping should be designed in accordance with good design practice, providing strainers, unions and gate valves for ease of operation and maintenance. A properly sized steam-modulating valve, based on design flow and pressure drop requirements, is provided by The Trane Company. Steam inlet connection is always right end of unit.

A hand valve in the steam supply piping is recommended when the machine will be out of operation for an extended period. The modulating steam valve may experience a small amount of leakage during shutdown. This leakage may result in heating of the equipment room unless the machine is properly isolated with a hand valve.

In all applications, it is recommended that the steam supply pressure to the control valve inlet not exceed design to ensure that the valve closes properly. If steam supply pressures exceed design, a pressure reducing station should be used to control the steam pressure to the valve.

The unit control has adjustable features that minimize steam draw on start-up. The adjustable steam-control feature allows the user to adapt the machine to the available steam source capability.

Figure JC-1. Typical steam supply piping

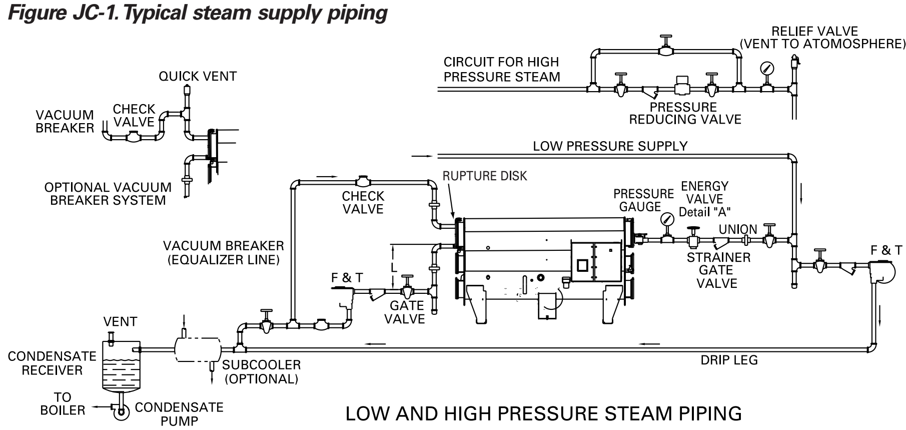


Table JC-1. Steam supply and condensate return piping responsibilities

Item	Material Provided By		Installed By	
	Trane	Other	Trane	Other
Energy Valve	X		X	
T-Type Strainer, Flanged connections, gate valve, drip leg w/dirt pocket, float and thermostatic trap, pressure gauge vent and valve, pressure reducing valve, pressure gauge, relief valve check valve, connecting piping.		X		X
Rupture Disk Assembly	X		X	
Rupture Disk Piping		X		X

Job Site Connections

Steam Supply and Condensate Piping

Condensate Handling
Figure JC-1 illustrates a typical condensate system consisting of steam traps, condensate receivers and condensate pumps. Such systems provide the most economical method for returning condensate to a boiler. Properly-sized float and thermostatic traps are required for proper operation. The use of bucket traps is not recommended.

Trane absorption machines use steam-throttling control. A maximum of three percent of the condensate may flash to a vented receiver at full load. This flashing decreases as the load decreases, and is virtually nonexistent below 70 percent load. When the machine is operating at less than 70 percent load, the pressure in the generator tube bundle may be below atmospheric pressure. The temperature of the condensate leaving the machine under these conditions is less than 212°F [100°C], so flashing does not occur.

A subcooler may be installed ahead of the receiver to cool the condensate to a temperature below the saturation temperature at atmospheric pressure, thus eliminating flashing entirely. It is recommended that a cooling medium, such as boiler feed water, be used to keep this energy within the system. The pressure drop through the subcooler should be minimized.

Figure JC-1 indicates an equalizer line installed to avoid condensate backup in the machine. The swing check opens if a vacuum develops within the tube bundle under part-load operation.

This prevents development of a lower pressure in the concentrator than at the outlet of the trap.

Packaged Condensate Systems
Several manufacturers have available packaged condensate-pump systems, designed for various condensate temperatures. A decision regarding the use of these systems with a Trane absorption machine should be based on a thorough economic analysis of the particular installation. The following factors should be considered:

1. Condensate may flash in the receiver less than 20 percent of the total operating time in a typical installation. The amount of condensate that may flash varies from a maximum of three percent at full load, to none at less than 70 percent load. A subcooler can be used to eliminate the small amount of flashing that may occur when the machine is operating under heavy load.
2. The condensate system must prevent condensate from backing up into the machine at part load when the pressure in the generator tube bundle is below atmospheric pressure.
3. The condensate system must not draw supply steam through the machine. This reduces the machine efficiency and may offset any potential energy savings that might otherwise be realized by the use of the condensate return system. Also, reduced tube life would result due to erosion.

If the decision is made to use a packaged condensate-pump system, follow the manufacturer's recommendations regarding its application.

Hot Water Piping
The hot water system must be designed such that it will avoid fluctuations in the pressure differences across the control valve. Trane absorption chillers for use with hot water may be used at an entering hot-water temperature of 270°F [132°C] or below. Piping for a typical hot water installation using a temperature of 270°F [132°C] or less is shown in Figure JC-2. In this arrangement, a three-way energy valve is used to control capacity by varying the quantity of hot water flowing through the chiller, while maintaining a constant supply and return flow rate. As shown in Figure JC-3, a two-way energy valve can also be used where the return and supply flow rates can vary. The generator design is rated to 150 psig [10.3 bars] with a 400 psig [27.6 bars] optional design available.

When the supply-water temperature exceeds 270°F [132°C], a separate circulating pump is recommended in a run-around loop as shown in Figure JC-4. The hot water for the absorption machine should be taken from a header installed between the hot-water supply and return mains. The flow of hot water through the machine is held constant, but the temperature of the circulating water is varied to meet load requirements by modulating the amount of high-temperature supply water added to the loop. This is done by installing a two-way modulating valve at the loop outlet. The valve responds to the chilled-water temperatures, but limits the water temperature entering the machine to a maximum of 270°F [132°C].

Hot Water Valves
Trane provides hot-water temperature-control valves with the machine for installation by the contractor at the job site. These valves are selected by The Trane company based on data provided by the contractor (*i.e. water flow to be used and the design pressure-drop across the valve.)

It is desirable to use the smallest valve, with the highest pressure drop, appropriate to the design water flow and allowable pressure drop in the system. The smaller the valve, the better the control. Hot water inlet connection is right end of unit.

Figure JC-2. Hot water supply piping – 270°F and below with 3-way energy valve

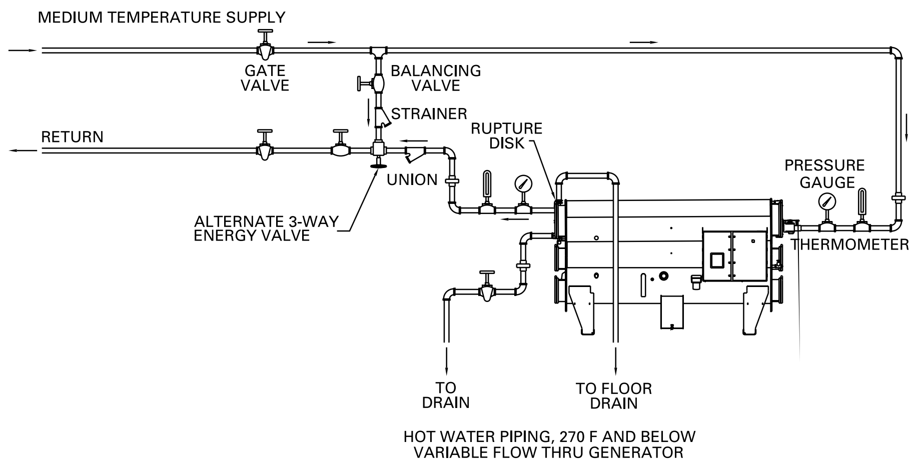


Figure JC-3. Hot water supply piping – 270°F and below with 2-way energy valve

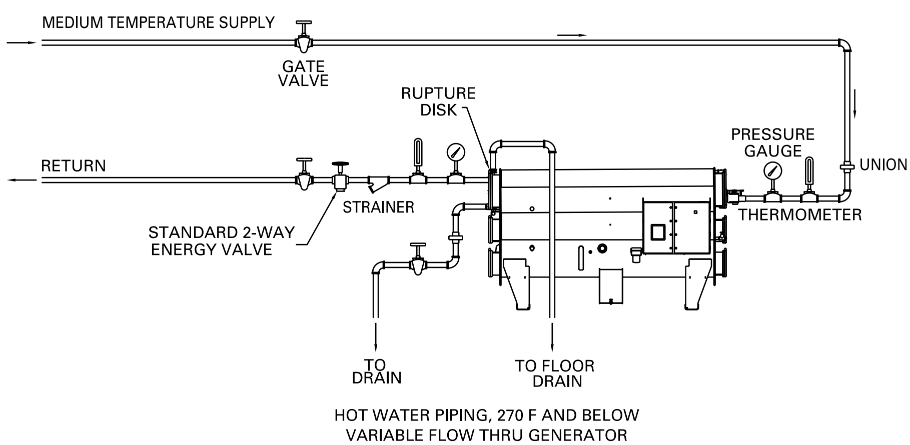


Figure JC-4. Hot water supply temperature piping above 270°F

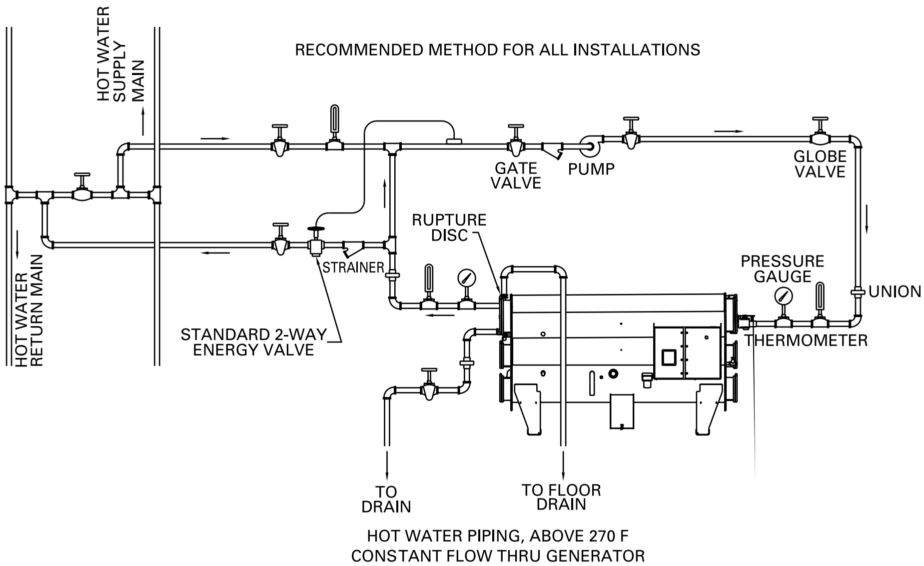


Table JC-2. Hot water supply piping responsibilities

Item	Material Provided By		Installed By	
	Trane	Other	Trane	Other
Energy Valve (2-Way/3-Way)	X			X
Gate valve, balance valve, Y-type strainer w/valve, bypass circuit, check valve, thermometer, pressure gauge, vent shutoff valve, union or flanged connection circulating pump		X		X
Rupture Disk Assembly	X		X	
Rupture Disk Piping		X		X

Cooling Water Piping

The cooling water piping design for the Horizon™ series of absorption chillers differs from conventional reciprocating or centrifugal systems, in that cooling water passes through the absorber section of the machine prior to entering the condenser. The absorption chiller must control the start and stop of cooling water flow.

The Horizon Single Stage absorption chiller is designed to start and operate with cooling-water temperatures as low as 55°F [12.8°C]. In typical applications, the machine is selected on the basis of the cooling-water temperature that will be available at full-load and at the design outside conditions. In air conditioning applications utilizing a cooling tower, this is usually 85°F [29.4°C].

With a cooling tower sized at design conditions, the temperature of the cooling-water supply to the unit will decrease with any decrease in cooling load or outside wet-bulb temperature. The lower cooling-water temperature would normally tend to increase the capacity potential of the unit. In the Trane design, the UCP2 adaptive controls will limit the energy input of the machine based on the entering cooling water temperature, thereby preventing overfiring of the machine.

In typical air-conditioning applications, precise cooling-water temperature control is not required. In process applications, however, where extremely close control of leaving chilled-water is required, it is recommended that a tower valve be used to maintain cooling-water temperature at a specified temperature. Constant cooling-water temperature allows the unit control valve to more precisely control leaving chilled-water temperature. Also, in applications where well water or other cooling water will be available at a temperature below 65°F [18.3°C], a control valve is recommended to maintain the temperature at 65°F [18.3°C] or above. Changes in condenser water temperature should not exceed 1°F per minute in the range of 75°F to 95°F [23.9 to 35°C].

Figure JC-5. Cooling-water piping with cooling tower

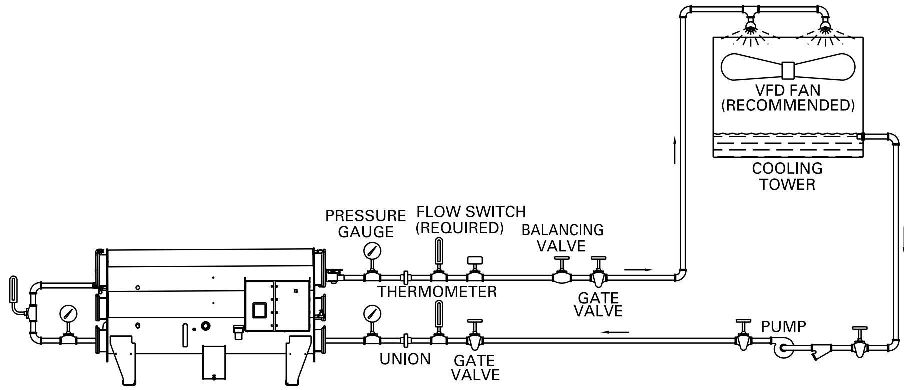


Figure JC-6. Cooling-water piping, three-way mixing valve

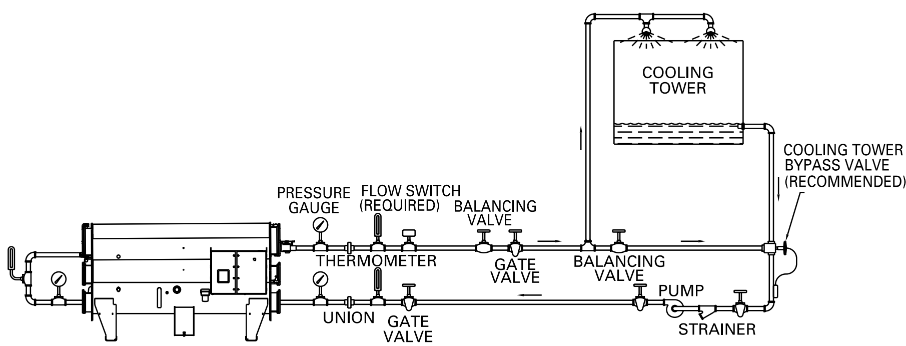


Figure JC-5 illustrates a typical air-conditioning installation without a cooling-tower control valve. Figure JC-6 illustrates typical cooling-water piping in applications where a three-way valve may be required. Figure JC-7 illustrates typical cooling-water piping utilizing well or river water.

Job Site Connections

Cooling Water Piping

Figure JC-7. Cooling-water piping with well or river water

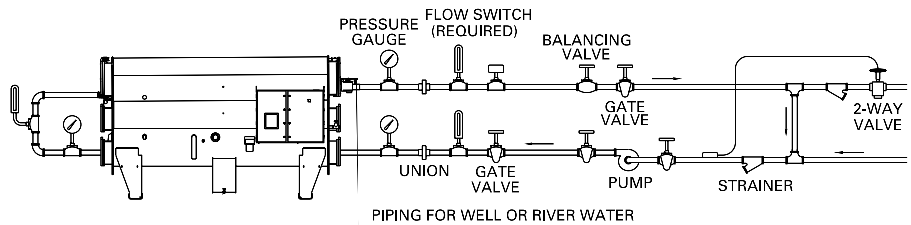


Table JC-3. Condenser/absorber piping responsibility

	Material Provided By		Installed By	
Item	Trane	Other	Trane	Other
Crossover Pipe	(factory installed option) X or	X	(factory installed (option) X or	
Flow Switch	(optional) X or	X		X
Balancing valve, gate valve, thermometer (optional), pressure gauge vent and shutoff valve, Victaulic or flange connection, pipe stub, strainer, pump.		X		X

Mechanical Specifications

General

The unit is a complete, single-effect steam- or hot-water-fired absorption chiller package, built in an ISO 9001 environment. The chiller consists of generator/condenser section, evaporator/absorber section, controls, pumps, heat exchanger, and energy control valve. All units are of hermetic design, factory-assembled and-leak-tested prior to shipment. Units can be separated and shipped disassembled for rigging purposes. Unit controls are factory mounted and wired, including microelectronic control panel, sensors and purge system. An energy valve can be factory mounted and wired as an option on steam-fired units. The unit is painted prior to shipping with two coats of a water-base air-dry primer. Standard method of shipment is by truck.

Generator/Condenser-Evaporator/Absorber

The shell material is carbon steel. The standard generator tube material is cupro-nickel, the evaporator is copper, absorber is cupro-nickel or copper and the condenser is copper. Tubes are mechanically rolled into the tube sheets and are replaceable from either end. The condenser, evaporator and absorber tube supports are fixed. The generator consists of fixed and floating tube supports to allow for even tube expansion. Solution spray systems are replaceable from one end of the unit without sacrificing the hermetic integrity of the unit.

Design working pressure for the water boxes is 150 psig [10.3 bars]. All tube bundles are tested at 150 percent of design working pressure. All water boxes have gasketed, removable covers for access. Optional marine-type water boxes can be provided on the condenser and absorber. Water connections are provided with either victaulic or raised-face flanged connections.

Heat Exchangers

A brazed-plate solution heat exchanger is provided to reduce energy use and improve unit performance. Heat exchanger surfaces are 300 series stainless steel.

Pumps

Solution and refrigerant are circulated by means of three hermetic, single-stage centrifugal pumps. The pump impellers are cast iron, with a steel shaft supported by two tapered carbon bearings. The bearings are lubricated and the motor is cooled via the pumped fluid. Adjustable-frequency drives are provided on the generator pump and absorber pump to provide solution flow control.

Automatic Purge System

The purge system utilizes an eductor for moving noncondensables to the condenser, Purifier™ Purge to collect the noncondensables in an external storage tank, and a vacuum pump for removal of the noncondensables. The purge operates automatically to remove noncondensables from the unit during periods of chiller operation and shutdown. Logging of purge information is provided via the unit control panel.

Generator

The shell is carbon steel. Tube sheets are steel and standard generator tubes are constructed of copper nickel. The generator has fixed and floating tube supports to allow for even tube expansion. The steam side of the generator is designed and stamped for 50 psi ASME construction. For hot water as the energy source, the generator is ASME designed and stamped for 150 or 400 psi [10.3 or 27.6 bars]. The generator/condenser includes a rupture disk, which is sized to meet ANSI/ASHRAE B 15.

Optional Lithium Bromide Filter

The filter system consists of the filter assembly and the associated piping and filter-isolation valves needed for operation and maintenance. The main filter body is stainless steel with a removable, cleanable, stainless steel internal 150-micron element. The filter isolation valves allow service of the filter assembly without disturbing the operation of the rest of the machine.

Control Panel

The UCP2™ is a microprocessor-based chiller control system that provides complete stand-alone operation. It is a factory-mounted package, including a full complement of controls to safely and efficiently operate the absorption liquid chiller. The UCP2™ provides:

- Chilled-water temperature control
- Concentration control

System Features and Functions

- User interface with a 40-character, 2-line display capable of displaying 7 languages and SI or English units, and a 16 key keypad
- Passwords for protection of unit setup and configuration
- Chilled-water pump control
- Absorber/condenser pump control
- Automatic and manual control of solution and refrigerant pumps
- Economical solution-flow control of the low-temperature solution pump and absorber pump via an adjustable-frequency drive
- Anti-crystallization through dilution control
- Automatic and manual purge system
- Chilled-water reset
- Two-way valve assembly for hot-water flow control or steam flow control
- Concentration control
- Steam adaptive flow control

Mechanical Specifications

Adaptive Limits
- Evaporator-water temperature limit
- Low absorber/condenser limit
- Soft-loading control

System Protection
- Evaporator freeze protection
- Chilled-water flow confirmation
- Cooling-water flow confirmation
- Emergency stop/shutdown
- Under/over voltage detection

Monitor and Displays
- Chilled-water temperature entering and leaving
- Absorber/condenser water temperature entering and leaving
- Solution concentrations
- Solution temperatures
- Total pump current
- Unit voltage
- Chiller run-time and starts
- Purge operation and run time
- Alarm light
- Diagnostic messages
- Help screens
- Evaporator-water flow (option)
- Cooling-water flow (option)

Interfaces To UCP2™
- External machine manual-reset alarm indication output
- External machine auto-reset warning indication output
- External limit warning-indication output
- Maximum capacity indication output
- External auto-stop/emergency shutdown
- Interface to Tracer Summit™
- External chilled-water setpoint
- Tracer™ controlled relay
- Printer interface

Contractor Responsibilities

1. Install the unit on a level surface. Neoprene isolation pads supplied by the manufacturer shall be placed under the unit.
2. Connect the unit control panel to all operating external safety and auxiliary control devices. Cooling water flow interlock is required.
3. Insure that piping adjacent to the machine does not restrict removal of headers for inspection, cleaning and removing tubes.
4. Provide gauge cocks and optional thermometer wells for temperature and pressure readings at the inlet and outlet of the evaporator, at the inlet and outlet of the absorber, and at the outlet of the condenser.
5. Provide balancing valves in all external water circuits to allow balance and trim of the system.
6. Provide and install strainers ahead of all pumps and automatic modulating valves to insure proper pump and valve operation.
7. Insulate the chilled-water headers and other portions of the unit, as pointed out in the manufacturer's installation literature, to prevent condensation on cold surfaces.
8. Provide and install a flow switch in the chilled-water circuit, and interlock it with the starting control circuit of the unit. Proof of flow is required prior to permitting unit operation. Provide and install a flow switch in the tower-water circuit, which shall be interlocked with the starting control circuit of the unit such that proof of flow is required to prevent machine damage
9. Provide necessary distilled or demineralized water for refrigerant charge and trim charge.
10. Provide labor to charge the machine with lithium bromide solution and refrigerant water, and assist in machine starting and calibration under supervision of the manufacturer's representative.
11. Provide an appropriately-sized vacuum pump and personnel to evacuate the unit prior to charging (if required).
12. Field assemble machines (if required) and leak test in accordance with instructions in the manufacturer's installation bulletin.
13. Connect the rupture disc to an appropriate floor drain or retention chamber. The vent piping shall be supported and connected by a flexible connector to prevent stress at the connection.
14. Install any control components provided by the manufacturer for installation external to the machine.
15. Furnish and install, external to the unit control panel, a separately-fused disconnect switch, if not provided.
16. Install required power supply wiring to the control panel. Use copper wire only.

Insulation Required

Insulation is required on cold areas to prevent sweating. Insulation is available as a factory provided, factory installed option.

Insulation for cold insulation area should be ¾-inch [19 mm] Armaflex or equivalent, and should be applied to evaporator waterboxes, refrigerant storage tank, refrigerant pump and refrigerant piping.

Cold insulation area on ABSD requires __________ per unit.

Cold insulation area for pipes on requires __________ linear ft. of pipe insulation.

Standard/Non-Standard/Design Special Options

Standard Features

- Victaulic water connections
- Variable-speed drives on solution pumps
- 50,000 hours design life solution pumps
- Corrosion resistant alloy tubes
  Generator – .028 wall, 90/10 cupro-nickel
  Evaporator – .025 copper
  Absorber 500-800 tonnages – .022” wall 95/5 cupro-nickel
  975-1350 tonnages .028” wall copper
  Condenser – .028” wall copper
- Factory-mounted and-tested microprocessor controls
- 150 psig [10.3 bar] water boxes
- Environmentally friendly inhibitor
- Fixed and floating tube supports which allow for expansion of tubes without problems of high stress
- Designed, manufactured and tested for superior hermetic integrity
- Fully automatic purge

Options

- Marine water boxes on the condenser and absorber sections
- Factory installed cooling-water crossover pipe
- Industrial duty factory mounted energy valve
- 150 psig [10.3 bar] raised face flanges for the evaporator, condenser and absorber water connections
- Major component disassembly in two pieces for installations that can benefit from the handling of smaller components.
- Lithium bromide filter
- Stainless steel evaporator pan

Design Special Options

In addition to the options already available, Trane’s design department is able to supply custom features for many special requirements.

Examples are:

- Factory provided, factory installed cold insulation
- Heavy wall tubes
- 90/10 CuNi, stainless steel and titanium tubes
- 300 psig [20.7 bar] water boxes
- NEMA 4 and 4X for additional chiller protection against outdoor elements or water impingement from various directions
- Alternate pass arrangements
- Marine-style evaporator water boxes
- Epoxy paint system for added protection against outdoor elements or corrosive environments such as chemical plants or salt water locations
- Custom color paints
- Sacrificial anodes for use where corrosive water is present
- Gantries for “swing out” water box covers for easy tube-cleaning capability
- Custom control configurations
- Specials for international code compliance
- Special packaging requirements
- Options for using non-standard heat sources
- Hinged water box covers

Standard Conversion Table

To Convert From:	To:	Multiply By:
Length		
Feet (ft)	meters (m)	0.30481
Inches (In)	millimeters (mm)	25.4
Area		
Square Feet (ft^2)	square meters (m^2)	0.093
Square Inches (In^2)	square millimeters (mm^2)	645.2
Volume		
Cubic Feet (ft^3)	Cubic meters (m^3)	0.0283
Cubic Inches (In^3)	Cubic mm (mm3)	16387
Gallons (gal)	litres (l)	3.785
Gallons (gal)	cubic meters (m^3)	0.003785
Flow		
Cubic feet/min (cfm)	cubic meters/second (m^3/s)	0.000472
Cubic Feet/min (cfm)	cubic meters/hr (m^3/hr)	1.69884
Gallons/minute (GPM)	cubic meters/hr (m^3/hr)	0.2271
Gallons/minute (GPM)	litres/second (l/s)	0.06308
Velocity		
Feet per minute (ft/m)	meters per second (m/s)	0.00508
Feet per second (ft/s)	meters per second (m/s)	0.3048

To Convert From:	To:	Multiply By:
Energy and Power and Capacity		
British Thermal Units (BTUH)	Kilowatt (kW)	0.000293
British Thermal Units (BTU)	KCalorie (Kcal)	0.252
Tons (refrig. effect)	Kilowatt (refrig. effect)	3.516
Tons (refrig. effect)	Kilocalories per hour (Kcal/hr)	3024
Horsepower	Kilowatt (kW)	0.7457
Pressure		
Feet of water (ftH$_2$0)	Pascals (PA)	2990
Inches of water (inH$_2$0)	Pascals (PA)	249
Pounds per square inch (PSI)	Pascals (PA)	6895
PSI	Bar or KG/CM^2	6.895 x 10^{-2}
Weight		
Ounches (oz)	Kilograms (kg)	0.02835
Pounds (lbs)	Kilograms (Kg)	0.4536
Fouling factors for heat exchangers		
0.00075 ft^2 °F hr/BTU	= 0.132 m^2 ° K/kW	
0.00025 ft^2 °F hr/BTU	= 0.044 m^2 ° K/kW	

Temperature – Centigrade (°C) Versus Fahrenheit (°F)

Note: The center columns of numbers, referred to as BASE TEMP., is the temperature in either degrees Fahrenheit (°F) or Centigrade (°C), whichever is desired to convert into the other. If degrees Centrigrade is given, read degrees Fahrenheit to the right. If degrees Fahrenheit is given, read degrees Centigrade to the left.

Temperature			Temperature			Temperature			Temperature			Temperature		
°C	C or F	°F	°C	C or F	°F	°C	C or F	°F	°C	C or F	°F	°C	C or F	°F
– 40.0	**– 40**	– 40.0	– 15.0	**+ 5**	+ 41.0	+ 10.0	**+ 50**	+ 122.0	+ 35.0	**+ 95**	+ 203.0	+ 60.0	**+ 140**	+ 284.0
– 39.4	**– 39**	– 38.2	– 14.4	**+ 6**	+ 42.8	+ 10.6	**+ 51**	+ 123.8	+ 35.6	**+ 96**	+ 204.8	+ 60.6	**+ 141**	+ 285.8
– 38.9	**– 38**	– 36.4	– 13.9	**+ 7**	+ 44.6	+ 11.1	**+ 52**	+ 125.6	+ 36.1	**+ 97**	+ 206.6	+ 61.1	**+ 142**	+ 287.6
– 38.3	**– 37**	– 34.6	– 13.3	**+ 8**	+ 46.4	+ 11.7	**+ 53**	+ 127.4	+ 36.7	**+ 98**	+ 208.4	+ 61.7	**+ 143**	+ 289.4
– 37.8	**– 36**	– 32.8	– 12.8	**+ 9**	+ 48.2	+ 12.2	**+ 54**	+ 129.2	+ 37.2	**+ 99**	+ 210.2	+ 62.2	**+ 144**	+ 291.2
– 37.2	**– 35**	– 31.0	– 12.2	**+ 10**	+ 50.0	+ 12.8	**+ 55**	+ 131.0	+ 37.8	**+ 100**	+ 212.0	+ 62.8	**+ 145**	+ 293.0
– 36.7	**– 34**	– 29.2	– 11.7	**+ 11**	+ 51.8	+ 13.3	**+ 56**	+ 132.8	+ 38.3	**+ 101**	+ 213.8	+ 63.3	**+ 146**	+ 294.8
– 36.1	**– 33**	– 27.4	– 11.1	**+ 12**	+ 53.6	+ 13.9	**+ 57**	+ 134.6	+ 38.9	**+ 102**	+ 215.6	+ 63.9	**+ 147**	+ 296.6
– 35.6	**– 32**	– 25.6	– 10.6	**+ 13**	+ 55.4	+ 14.4	**+ 58**	+ 136.4	+ 39.4	**+ 103**	+ 217.4	+ 64.4	**+ 148**	+ 298.4
– 35.0	**– 31**	– 23.8	– 10.0	**+ 14**	+ 57.2	+ 15.0	**+ 59**	+ 138.2	+ 40.0	**+ 104**	+ 219.2	+ 65.0	**+ 149**	+ 300.2
– 34.4	**– 30**	– 22.0	– 9.4	**+ 15**	+ 59.0	+ 15.6	**+ 60**	+ 140.0	+ 40.6	**+ 105**	+ 221.0	+ 65.6	**+ 150**	+ 302.0
– 33.9	**– 29**	– 20.2	– 8.9	**+ 16**	+ 60.8	+ 16.1	**+ 61**	+ 141.8	+ 41.1	**+ 106**	+ 222.8	+ 66.1	**+ 151**	+ 303.8
– 33.3	**– 28**	– 18.4	– 8.3	**+ 17**	+ 62.6	+ 16.7	**+ 62**	+ 143.6	+ 41.7	**+ 107**	+ 224.6	+ 66.7	**+ 152**	+ 305.6
– 32.8	**– 27**	– 16.6	– 7.8	**+ 18**	+ 64.4	+ 17.2	**+ 63**	+ 145.4	+ 42.2	**+ 108**	+ 226.4	+ 67.2	**+ 153**	+ 307.4
– 32.2	**– 26**	– 14.8	– 7.2	**+ 19**	+ 66.2	+ 17.8	**+ 64**	+ 147.2	+ 42.8	**+ 109**	+ 228.2	+ 67.8	**+ 154**	+ 309.2
– 31.7	**– 25**	– 13.0	– 6.7	**+ 20**	+ 68.0	+ 18.3	**+ 65**	+ 149.0	+ 43.3	**+ 110**	+ 230.0	+ 68.3	**+ 155**	+ 311.0
– 31.1	**– 24**	– 11.2	– 6.1	**+ 21**	+ 69.8	+ 18.9	**+ 66**	+ 150.8	+ 43.9	**+ 111**	+ 231.8	+ 68.9	**+ 156**	+ 312.8
– 30.6	**– 23**	– 9.4	– 5.5	**+ 22**	+ 71.6	+ 19.4	**+ 67**	+ 152.6	+ 44.4	**+ 112**	+ 233.6	+ 69.4	**+ 157**	+ 314.6
– 30.0	**– 22**	– 7.6	– 5.0	**+ 23**	+ 73.4	+ 20.0	**+ 68**	+ 154.4	+ 45.0	**+ 113**	+ 235.4	+ 70.0	**+ 158**	+ 316.4
– 29.4	**– 21**	– 5.8	– 4.4	**+ 24**	+ 75.2	+ 20.6	**+ 69**	+ 156.2	+ 45.6	**+ 114**	+ 237.2	+ 70.6	**+ 159**	+ 318.2
– 28.9	**– 20**	– 4.0	– 3.9	**+ 25**	+ 77.0	+ 21.1	**+ 70**	+ 158.0	+ 46.1	**+ 115**	+ 239.0	+ 71.1	**+ 160**	+ 320.0
– 28.3	**– 19**	– 2.2	– 3.3	**+ 26**	+ 78.8	+ 21.7	**+ 71**	+ 159.8	+ 46.7	**+ 116**	+ 240.8	+ 71.7	**+ 161**	+ 321.8
– 27.8	**– 18**	– 0.4	– 2.8	**+ 27**	+ 80.6	+ 22.2	**+ 72**	+ 161.6	+ 47.2	**+ 117**	+ 242.6	+ 72.2	**+ 162**	+ 323.6
– 27.2	**– 17**	+ 1.4	– 2.2	**+ 28**	+ 82.4	+ 22.8	**+ 73**	+ 163.4	+ 47.8	**+ 118**	+ 244.4	+ 72.8	**+ 163**	+ 325.4
– 26.7	**– 16**	+ 3.2	– 1.7	**+ 29**	+ 84.2	+ 23.3	**+ 74**	+ 165.2	+ 48.3	**+ 119**	+ 246.2	+ 73.3	**+ 164**	+ 327.2
– 26.1	**– 15**	+ 5.0	– 1.1	**+ 30**	+ 86.0	+ 23.9	**+ 75**	+ 167.0	+ 48.9	**+ 120**	+ 248.0	+ 73.9	**+ 165**	+ 329.0
– 25.6	**– 14**	+ 6.8	– 0.6	**+ 31**	+ 87.8	+ 24.4	**+ 76**	+ 168.8	+ 49.4	**+ 121**	+ 249.8	+ 74.4	**+ 166**	+ 330.8
– 25.0	**– 13**	+ 8.6	0.0	**+ 32**	+ 89.6	+ 25.0	**+ 77**	+ 170.6	+ 50.0	**+ 122**	+ 251.6	+ 75.0	**+ 167**	+ 332.6
– 24.4	**– 12**	+ 10.4	+ 0.6	**+ 33**	+ 91.4	+ 25.6	**+ 78**	+ 172.4	+ 50.6	**+ 123**	+ 253.4	+ 75.6	**+ 168**	+ 334.4
– 23.9	**– 11**	+ 12.2	+ 1.1	**+ 34**	+ 93.2	+ 26.1	**+ 79**	+ 174.2	+ 51.1	**+ 124**	+ 255.2	+ 76.1	**+ 169**	+ 336.2
– 23.3	**– 10**	+ 14.0	+ 1.7	**+ 35**	+ 95.0	+ 26.7	**+ 80**	+ 176.0	+ 51.7	**+ 125**	+ 257.0	+ 76.7	**+ 170**	+ 338.0
– 22.8	**– 9**	+ 15.8	+ 2.2	**+ 36**	+ 96.8	+ 27.2	**+ 81**	+ 177.8	+ 52.2	**+ 126**	+ 258.8	+ 77.2	**+ 171**	+ 339.8
– 22.2	**– 8**	+ 17.6	+ 2.8	**+ 37**	+ 98.6	+ 27.8	**+ 82**	+ 179.6	+ 52.8	**+ 127**	+ 260.6	+ 77.8	**+ 172**	+ 341.6
– 21.7	**– 7**	+ 19.4	+ 3.3	**+ 38**	+ 100.4	+ 28.3	**+ 83**	+ 181.4	+ 53.3	**+ 128**	+ 262.4	+ 78.3	**+ 173**	+ 343.4
– 21.1	**– 6**	+ 21.2	+ 3.9	**+ 39**	+ 102.2	+ 28.9	**+ 84**	+ 183.2	+ 53.9	**+ 129**	+ 264.2	+ 78.9	**+ 174**	+ 345.2
– 20.6	**– 5**	+ 23.0	+ 4.4	**+ 40**	+ 104.0	+ 29.4	**+ 85**	+ 185.0	+ 54.4	**+ 130**	+ 266.0	+ 79.4	**+ 175**	+ 347.0
– 20.0	**– 4**	+ 24.8	+ 5.0	**+ 41**	+ 105.8	+ 30.0	**+ 86**	+ 186.8	+ 55.0	**+ 131**	+ 267.8	+ 80.0	**+ 176**	+ 348.8
– 19.4	**– 3**	+ 26.6	+ 5.5	**+ 42**	+ 107.6	+ 30.6	**+ 87**	+ 188.6	+ 55.6	**+ 132**	+ 269.6	+ 80.6	**+ 177**	+ 350.6
– 18.9	**– 2**	+ 28.4	+ 6.1	**+ 43**	+ 109.4	+ 31.1	**+ 88**	+ 199.4	+ 56.1	**+ 133**	+ 271.4	+ 81.1	**+ 178**	+ 352.4
– 18.3	**– 1**	+ 30.2	+ 6.7	**+ 44**	+ 111.2	+ 31.7	**+ 89**	+ 192.2	+ 56.7	**+ 134**	+ 273.2	+ 81.7	**+ 179**	+ 354.2
– 17.8	**0**	+ 32.0	+ 7.2	**+ 45**	+ 113.0	+ 32.2	**+ 90**	+ 194.0	+ 57.2	**+ 135**	+ 275.0	+ 82.2	**+ 180**	+ 356.0
– 17.2	**+ 1**	+ 33.8	+ 7.8	**+ 46**	+ 114.8	+ 32.8	**+ 91**	+ 195.8	+ 57.8	**+ 136**	+ 276.8	+ 82.8	**+ 181**	+ 357.8
– 16.7	**+ 2**	+ 35.6	+ 8.3	**+ 47**	+ 116.6	+ 33.3	**+ 92**	+ 197.6	+ 58.3	**+ 137**	+ 278.6	+ 83.3	**+ 182**	+ 359.8
– 16.1	**+ 3**	+ 37.4	+ 8.9	**+ 48**	+ 118.4	+ 33.9	**+ 93**	+ 199.4	+ 58.9	**+ 138**	+ 280.4	+ 83.9	**+ 183**	+ 361.4
– 15.6	**+ 4**	+ 39.2	+ 9.4	**+ 49**	+ 120.2	+ 34.4	**+ 94**	+ 201.2	+ 59.4	**+ 139**	+ 282.2	+ 84.4	**+ 184**	+ 363.2

FOR INTERPOLATION IN THE ABOVE TABLE USE:

BASE TEMPERATURE (°F or °C)	1	2	3	4	5	6	7	8	9	10
DEGREES CENTIGRADE:	0.56	1.11	1.67	2.22	2.78	3.33	3.89	4.44	5.00	5.56
DEGREES FAHRENHEIT:	1.8	3.6	5.4	7.2	9.0	10.8	12.6	14.4	16.2	18.0

Literature Order Number	ABS-PRC001-EN
File Number	PL-RF-ABS-000-PRC001-EN-0604
Supersedes	ABS-PRC001-EN 0603
Stocking Location	Inland

Trane
A business of American Standard Companies
www.trane.com

For more information contact your local sales office or e-mail us at comfort@trane.com

APPENDIX D: COOLING TOWER

Cooling Towers
Baltimore Aircoil Company, 31132A
1132 Nominal Tonnage, 1-75 HP Fan
480 volt / 3 Phase / 60 Hz
Cost: $5,400

Dennis Scouler & Assoc., Inc.
Metro Area:
Harrisburg, Pennsylvania
4621 North Front Street
Harrisburg, PA 17110

Series 3000
Open Cooling Towers

Product Detail

Series 3000 Open Cooling Towers

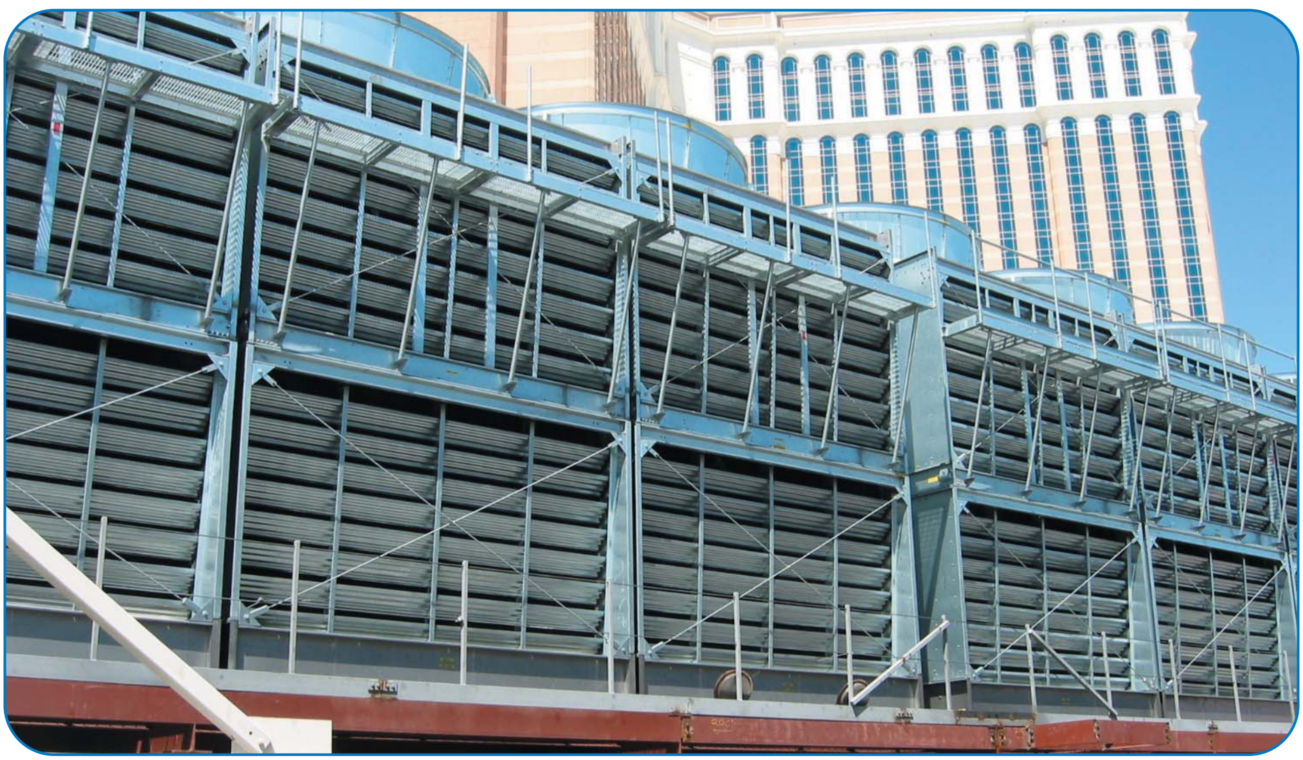
Single Cell Capacity:
219 – 1,350 Nominal Tons
660 – 4,050 gpm at 95°F/85°F/78°F

Series 3000 Cooling Towers deliver independently verified, fully rated thermal performance over a wide range of flow and temperature requirements. Standard design features satisfy today's environmental concerns, minimize installation costs, maximize year-round operating reliability, and simplify maintenance requirements.

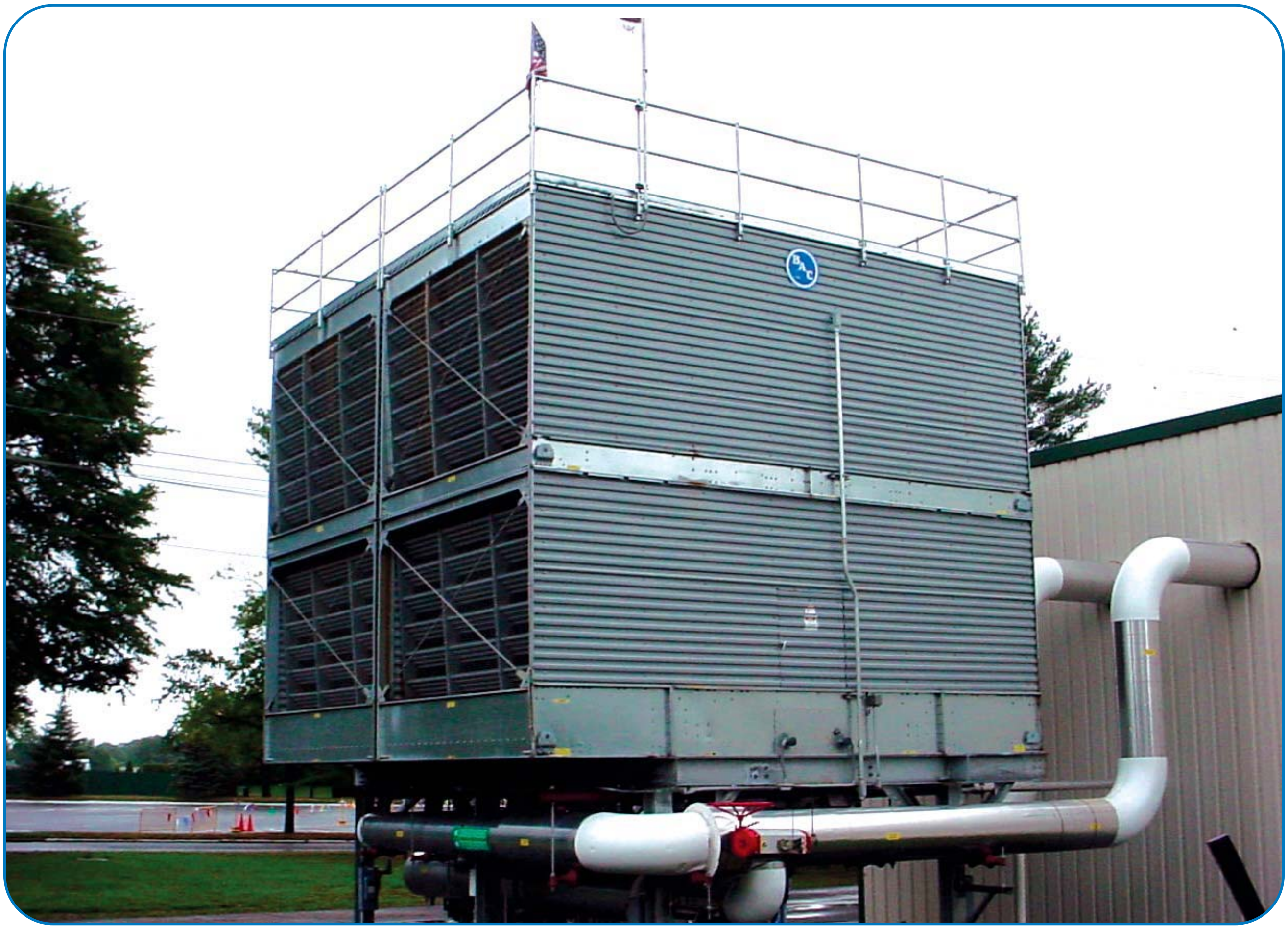
Series 3000 Cooling Towers

- **Low energy consumption**
- **Low installed cost**
- **Easy maintenance**
- **Reliable year-round operation**
- **Long service life**
- **ASHRAE Standard 90.1 compliant**
- **Five-year warranty on mechanical equipment**

CTI CERTIFIED



Open Cooling Towers



Benefits

Low Energy Consumption

- Evaporative cooling equipment minimizes the energy consumption of the entire system because it provides lower operating temperatures. The owner saves money while conserving natural resources and reducing environmental impact.
- The Series 3000 provides the heat rejection required at the lowest possible energy input via:
    - High efficiency, low horsepower axial fans
    - High efficiency BACross® Wet Deck, which provides maximum air/water contact time at low air pressure drops
    - Variable Frequency Drives
    - ENERGY-MISER® Fan System available (see page D16 for details)
- All units meet or exceed ASHRAE Standard 90.1 energy efficiency requirements.

Low Installed Cost

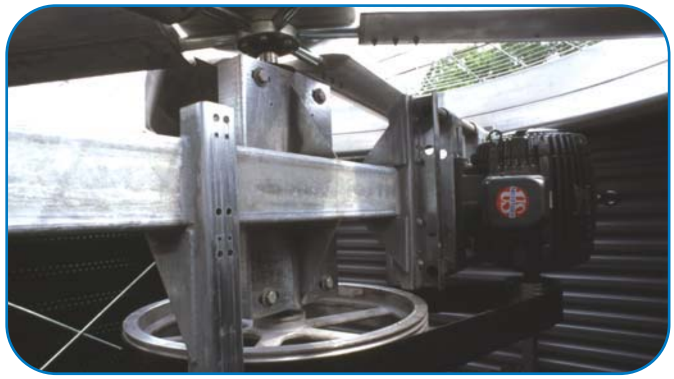
- **Support –** All models mount directly on two parallel I-beams and ship complete with motors and drives factory-installed and aligned.
- **Modular Design –** Models 3728A through 31056A and 31132A through 31301A ship in two sections to minimize the size and weight of the heaviest lift, allowing for the use of smaller, less costly cranes.
- **Piping -** The optional EASY CONNECT® Piping Arrangement with BALANCE CLEAN® Chamber further reduces installation costs by eliminating overhead piping and piping support requirements (see page D17 for details).

Easy Maintenance

- **Easy Cleaning –** The wet deck surface is elevated above the sloped cold water basin floor to facilitate flushing of dirt and debris from this critical area.
- **Hinged Access Doors –** Provide easy access to the unit interior to adjust the make-up float valve, clean the cold water basin and strainer, and service the fan drive system.
- **Easy Maintenance -**The optional EASY CONNECT® Piping Arrangement with BALANCE CLEAN® Chamber simplifies maintenance by allowing all routine maintenance of the water distribution system to be performed from the unit interior. This option includes an integral strainer that collects dirt and debris before reaching the hot water basins, keeping nozzles clean (see page D17 for details).

Reliable Year-Round Operation

- **Drive System –** Backed by a five-year fan drive and motor warranty, the BALTIDRIVE® Power Train utilizes special corrosion-resistant materials of construction and state-of-the-art technology to ensure ease of maintenance and reliable year-round performance.



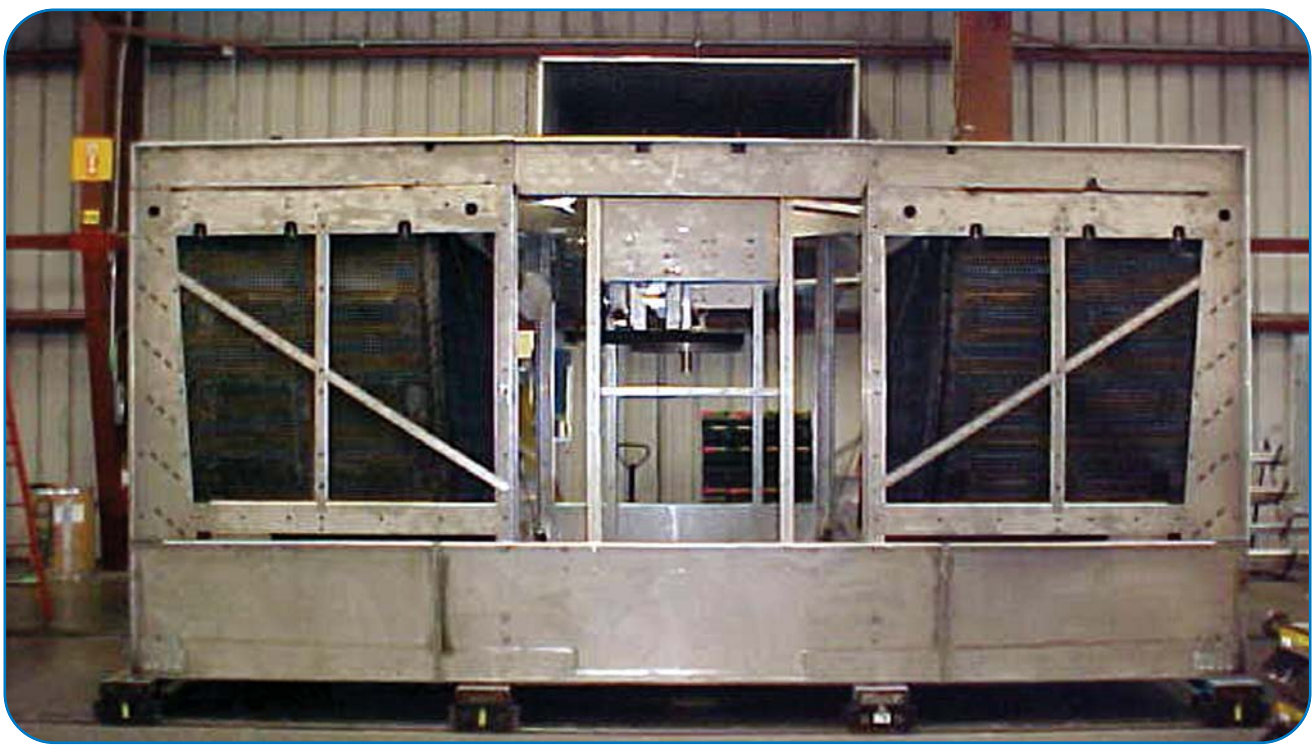
BALTIDRIVE® Power Train

- **Separate Air Inlet Louvers –** Reduce the potential for scale build-up and damaging ice formations at the air/water interface by providing a line of sight from the outside of the unit into the wet deck.

Long Service Life

- **Frame Construction –** Enables casing panels, critical links for long service life, to be constructed of corrosion-resistant, fiberglass reinforced polyester (FRP).

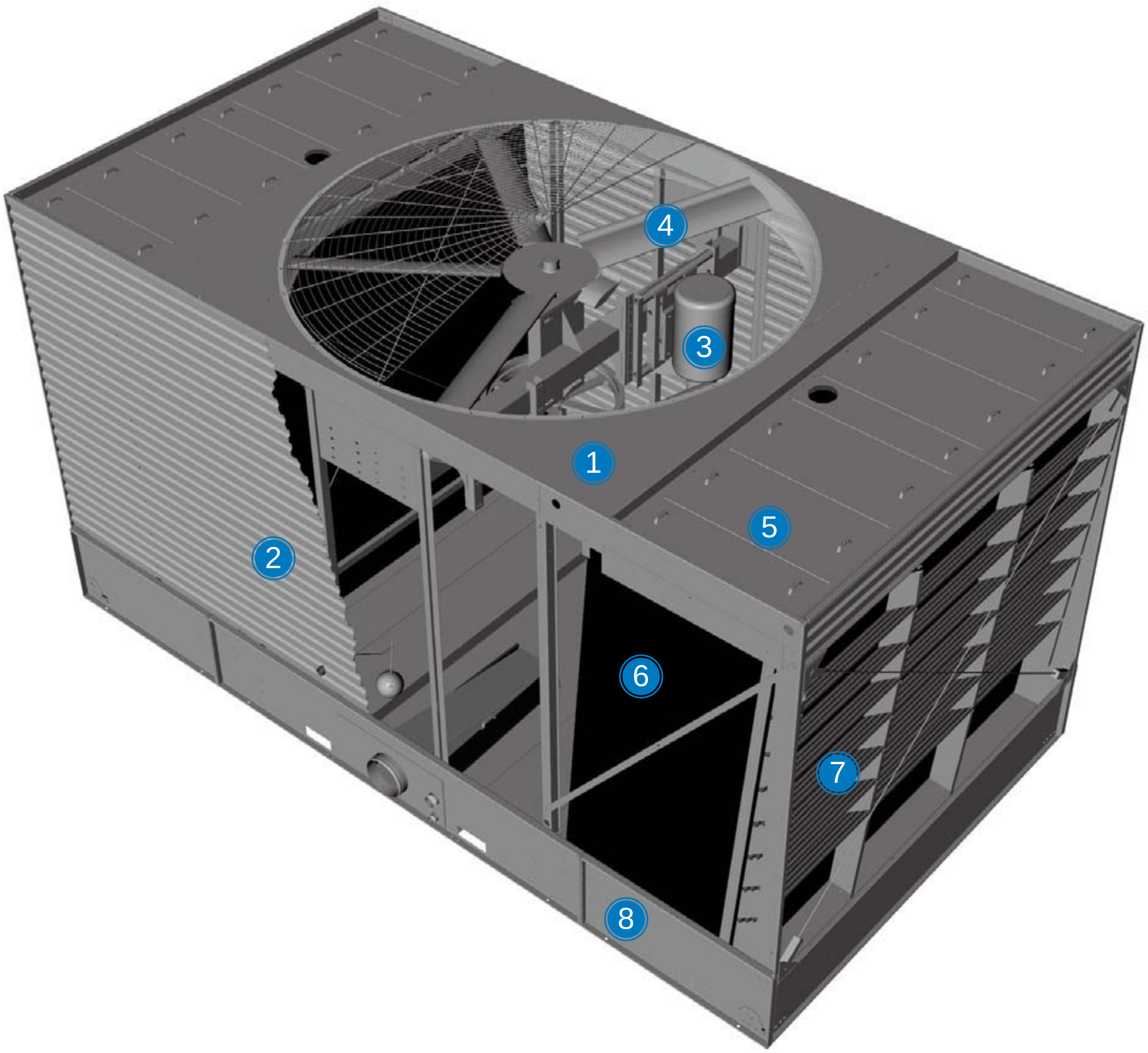
- **Materials of Construction –** Various materials are available to meet the corrosion resistance, unit operating life, and budgetary requirements of any project (see page D15 for construction options).



Series 3000 Cooling Tower (frame construction shown without FRP casing panels)

Construction Details

Series 3000



1 Heavy-Duty Construction

- Heavy-gauge steel frame
- Designed to meet anchorage requirements of UBC 1997, Importance Factor 1.0, Seismic Zone 2B conditions and 30 psf wind loads

2 FRP Casing Panels

- Corrosion resistant
- Maintenance free
- UV resistant finish

3 BALTIDRIVE® Power Train

- Premium quality, solid backed, multi-groove belt
- Corrosion resistant cast aluminum sheaves
- Heavy-duty bearings (280,000 hour average life)
- Cooling tower duty fan motor
- Five-year motor and drive warranty

B.A.C. FAN DRIVE 5 YEAR WARRANTY

4 Low HP Axial Fan

- Quiet operation
- Corrosion resistant aluminum

5 Water Distribution System

- Steel covers in easy to remove sections
- Low pump head gravity distribution basins
- Large orifice, non-clog nozzles

6 BACross® Wet Deck Surface with Integral Drift Eliminators

- Polyvinyl chloride (PVC)
- Impervious to rot, decay and biological attack
- Flame spread rating of 5 per ASTM E84-77a

7 FRP Air Inlet Louvers

- Corrosion resistant
- UV resistant finish
- Maintenance free

8 Cold Water Basin

- Sloped cold water basin for easy cleaning
- Suction strainer with anti-vortex hood
- Adjustable water make-up assembly

9 Hinged Access Doors (Not Shown)

- Inward swinging door on each end wall

Custom Features and Options

Construction Options

- **Standard Construction:**
  Steel panels and structural elements are constructed of heavy-gauge G-235 hot-dip galvanized steel. Casing panels and air inlet louvers are constructed of UV-resistant, fiberglass reinforced polyester (FRP).
- **Optional BALTIBOND® Corrosion Protection System:**
  The BALTIBOND® Corrosion Protection System, a hybrid polymer coating used to extend equipment life, is applied to all hot-dip galvanized steel components of the cooling tower.
- **Optional Stainless Steel Cold Water Basin:**
  A Type 304 stainless steel cold water basin is provided. Seams between panels inside the cold water basin are welded. The basin is leak tested at the factory and welded seams are provided with a Five-Year leak-proof warranty.
- **Optional Stainless Steel Hot and Cold Water Basins:**
  Type 304 stainless steel hot water basins are provided in addition to the cold water basin described above.
- **Optional JE PREMIER SERIES® Construction:**
  Steel panels and structural elements are constructed of Type 304 stainless steel. Seams between panels inside the cold water basin are welded. The basin is leak tested at the factory and welded seams are provided with a Five-Year leak-proof warranty. Casing panels and air inlet louvers are constructed of corrosion and UV resistant fiberglass reinforced polyester (FRP). Each cooling tower provided with the JE PREMIER SERIES® Construction is backed by a comprehensive Louver-to-Louver℠ Five-Year Warranty, which covers ALL components from the fan to the cold water basin, from louver to louver, including the motor.

See page J4 for more details on the materials described above.

Fan Drive System

The fan drive system provides the cooling air necessary to reject unwanted heat from the system to the atmosphere. The standard fan drive system on the Series 3000 is the exclusive BALTIDRIVE® Power Train*. This BAC engineered drive system consists of a specially designed powerband and two cast aluminum sheaves located on minimum shaft centerline distances to maximize belt life. A cooling tower duty fan motor, custom engineered for BAC to provide maximum performance for cooling tower service, is provided and backed by BAC's comprehensive Five-Year motor and fan drive warranty.

(*) Note: Model 31301A is provided with a gear fan drive system.

ENERGY-MISER® Fan System

The ENERGY-MISER® Fan System consists of two standard single-speed fan motors and drive assemblies. One drive assembly is sized for full speed and load, and the other is sized for approximately 2/3 speed and consumes only 1/3 the design horsepower. This configuration allows the system to be operated like a two-speed motor, but with the reserve capacity of a standby motor in the event of failure. As a minimum, approximately 70% capacity will be available from the low horsepower motor, even on a design wet-bulb day. Controls and wiring are the same as those required for a two-speed, two-winding motor. Significant energy savings are achieved when operating at low speed during periods of reduced load and/or low wet-bulb temperatures.

ENERGY-MISER® Fan System

Gear Drive System, Close-Coupled Motor

A gear drive system is available as a fan drive option on Series 3000 Cooling Towers. Both the gear drive and couplings are selected with a 2.0 service factor. Gear construction includes a nickel-alloy steel shaft, casehardened gears, self lubrication, and a single piece, gray iron housing. This drive system ships completely installed and aligned.

Gear Drive System, Close-Coupled Motor

Gear Drive System, Externally Mounted Motor

A gear drive system with a TEFC motor mounted outside the airstream is also available on Series 3000 Cooling Towers. A non-corrosive carbon-fiber composite drive shaft with stainless steel hubs is selected with a 2.0 service factor. The motor and drive shaft ship separately for easy field installation.

Gear Drive System, Externally Mounted Motor

Series 3000

Custom Features and Options

Low Sound Operation


Unit with intake and discharge sound attenuation

The low sound levels generated by Series 3000 Cooling Towers make them suitable for installation in most environments. For very sound sensitive installations, the Series 3000 is available with a low sound fan option that significantly reduces the sound levels generated from the tower with minimal impact on thermal performance. The cooling tower thermal performance with the low sound fan has been certified in accordance with CTI Standard STD-201.

For extremely sound sensitive installations, factory designed, tested and rated sound attenuation is available for both the air inlet and discharge of Series 3000 Cooling Towers.


Basinless Series 3000 Cooling Tower on a concrete basin

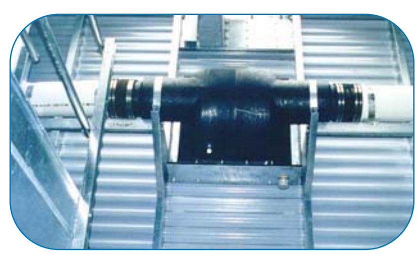
Basinless Unit Construction

The basinless unit construction option enables Series 3000 Cooling Towers to be directly applied to new or existing concrete cold water basins. This custom feature, available exclusively on BAC Series 3000 Cooling Towers, reduces maintenance costs by eliminating the integral basin from traditional units. It simplifies piping and pumping requirements of multi-cell installations and provides a cost-effective solution for many field-erected cooling tower replacement projects.

EASY CONNECT® Piping Arrangement with BALANCE CLEAN® Chamber

This exclusive BAC option reduces routine maintenance and simplifies water inlet piping on the Series 3000. The BALANCE CLEAN® Chamber features an integral strainer which prevents large debris from reaching the hot water distribution basins. The BALANCE CLEAN® Chamber automatically balances flow within each cell, eliminating the need for flow balancing valves. The unique design of the water distribution system enables all routine maintenance to be performed from the unit interior, thereby eliminating the need to use the cooling tower fan deck as a working surface to perform routine maintenance of the water distribution system. A single water inlet connection, located on the side or bottom of each unit, eliminates the need for overhead piping and piping supports.


Integral strainer, BALANCE CLEAN® Chamber option


Optional EASY CONNECT® Piping Arrangement with BALANCE CLEAN® Chamber

Accessories

Ladder, Safety Cage, Gate and Handrails

In the event the owner requires easy access to the cooling tower fan deck, the Series 3000 can be furnished with ladders extending from the top of the unit to the base, as well as safety cages, safety gates, and handrail packages. All components are designed to meet OSHA requirements. All access to the top of the equipment must be made in accordance with applicable governmental occupational safety standards.

External platform at louver face

External Service Platforms

For external service, louver face platforms, access door platforms and fan deck extensions can be added to the cooling tower when the unit is purchased or as an aftermarket item. Safety cages and safety gates are also available. All components are designed to meet OSHA requirements.

Internal walkway

Internal Walkway and Service Platform

A galvanized steel internal walkway is available to provide a permanent working surface for easy access to the strainer, outlet, and make-up water assembly. For access to the motor and drive assemblies on two-piece units, an internal ladder and upper service platform with handrails is available. Safety gates are available for all handrail openings. All components are designed to meet OSHA requirements.

Internal ladder and service platform

Vibration Cutout Switch

A factory mounted vibration cutout switch is available to effectively protect against equipment failure due to excessive vibration of the mechanical equipment system. BAC can provide either a mechanical or solid-state electronic vibration cutout switch in a NEMA 4 enclosure to ensure reliable protection. Additional contacts can be provided to either switch type to activate an alarm.

Accessories

Basin Heaters

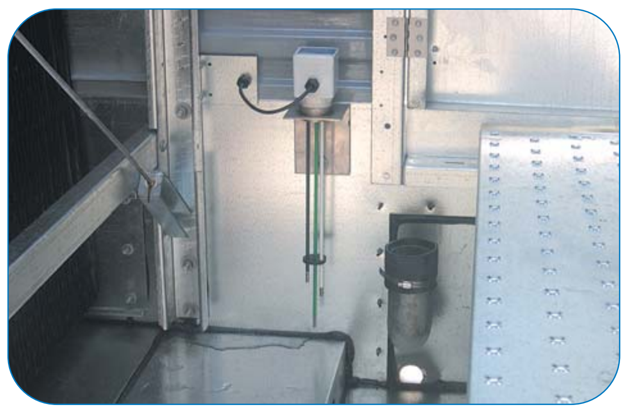
Cooling towers exposed to below freezing ambient temperatures require protection to prevent freezing of the water in the cold water basin when the unit is idle. Factory-installed heaters, which maintain +40°F (4.4°C) water temperature, are a simple and inexpensive way of providing such protection.

Heater Sizing Data

MODELNUMBERS	0ºF (-17.8°C) Ambient Heaters		-20ºF (-28.9°C) Ambient Heaters	
	No. of Heaters	kW per Heater	No. of Heaters	kW per Heater
3240A thru 3379A	2	6	2	9
3412A thru 3527A	2	8	2	12
3473A thru 3672A	2	10	2	14
3728A thru 31056A	2	12	2	15
3583A thru 3725A	2	14	2	18
31132A thru 31301A	2	14	2	20

Electric Water Level Control Package

The electric water level control replaces the standard mechanical makeup valve when a more precise water level control is required. This package consists of a conductance-actuated level control mounted in the basin and a solenoid activated valve in the make-up water line. The valve is slow closing to minimize water hammer.



Electric Water Level Control Package

Extended Lubrication Lines

Extended lubrication lines with grease fittings are available for lubrication of the fan shaft bearings. Fittings are located inside the plenum area next to the access door.

High Temperature Wet Deck

If operation above 130°F (54.4°C) is anticipated, an optional high temperature wet deck material is available which increases the maximum allowable entering water temperature to 135°F (57.2°C).

Factory Mutual Approval

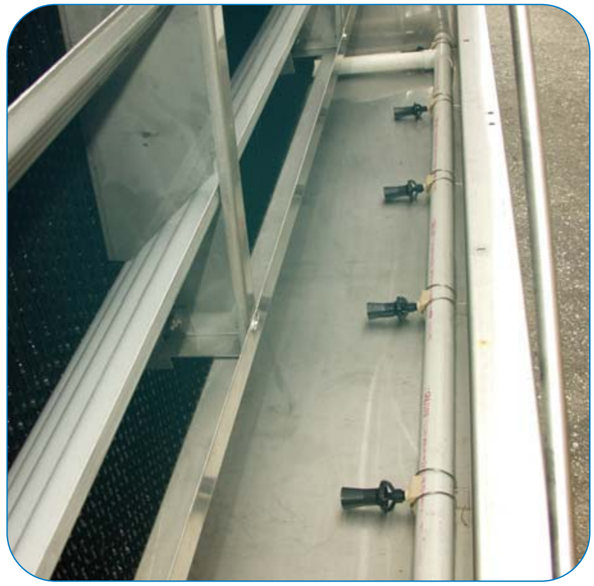
All multi-cell Series 3000 Cooling Towers are available with Factory Mutual (FM) Approved construction as an option.

Air Inlet Screens

Wire mesh screens can be factory-installed over the inlet louvers to prevent debris from entering the tower.

Basin Sweeper Piping

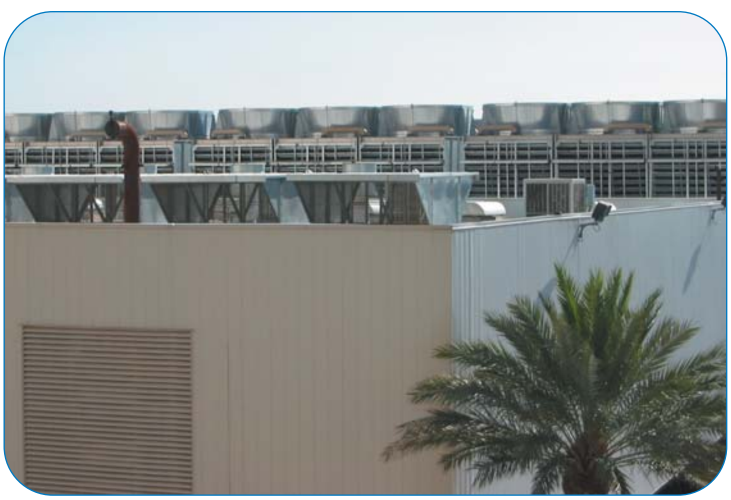
Basin sweeper piping provides an effective method of preventing sediment from collecting in the cold water basin of the tower. A complete piping system, including nozzles, is provided in the tower basin for connection to side stream filtration equipment (by others).



Basin Sweeper Piping

Side Outlet Depressed Sump

A side outlet depressed sump box is available for field installation below the base of the tower to facilitate jobsite piping. The outlet connection is designed to mate with an ASME Class 150 flat face flange. See the Connection Guide (page J2) for more information on standard and optional unit connection types.



Velocity Recovery Stacks

Velocity Recovery Stacks

Velocity recovery stacks are available on the Series 3000 for incremental thermal performance increases. This accessory can be used to gain extra capacity in tight layouts, while maintaining the same footprint and unit horsepower, as well as maintaining CTI certification. Field assembly is required.

Series 3000

Engineering Data

Do not use for construction. Refer to factory certified dimensions. This brochure includes data current at time of publication, which should be reconfirmed at the time of purchase. Up-to-date engineering data, free product selection software, and more can be found at **www.BaltimoreAircoil.com**.

Single Cell Unit

MODEL NUMBER	NOMINAL TONNAGE[5]	MOTOR HP	FAN (CFM)	WEIGHTS (lbs)			DIMENSIONS[4]			
				OPERATING[1]	SHIPPING	HEAVIEST SECTION	L	W	H[3]	A
3240A	240	10	62,790	14,770	6,790	6,790	8'-5 3/4"	18'-0 1/2"	9'-3 5/8"	8'-7 3/4"
3272A	272	15	71,340	14,900	6,920	6,920				
3299A	299	20	78,110	14,960	6,980	6,980				
3333A	333	20	85,720	15,750	7,260	7,260	8'-5 3/4"	18'-0 1/2"	10'-7 5/8"	9'-11 3/4"
3358A	358	25	91,960	15,780	7,290	7,290				
3379A	379	30	97,400	15,830	7,340	7,340				
3412A	412	25	103,700	18,580	8,420	8,420	9'-9 1/4"	20'-0 1/2"	10'-9 1/8"	9'-11 3/4"
3436A	436	30	109,830	18,630	8,470	8,470				
3455A	455	25	112,250	19,480	8,740	8,740	9'-9 1/4"	20'-0 1/2"	12'-1 1/8"	11'-3 3/4"
3482A	482	30	118,880	19,530	8,790	8,790				
3527A	527	40	130,160	19,690	8,950	8,950				
3473A	473	25	118,870	23,090	10,190	10,190	11'-9 3/4"	21'-6 1/2"	10'-10 1/8"	9'-11 3/4"
3501A	501	30	125,900	23,140	10,240	10,240				
3552A	552	30	136,170	25,690	10,800	10,800	11'-9 3/4"	21'-6 1/2"	12'-2 1/8"	11'-3 3/4"
3604A	604	40	149,090	25,850	10,960	10,960				
3648A	648	50	159,950	25,860	10,970	10,970				
3672A	672	60	166,020	27,060	12,180	12,180				
3728A	728	40	178,860	32,060	13,770	8,720	11'-9 3/4"	21'-6 1/2"	16'-4 7/8"	15'-5 1/2"
3781A	781	50	191,890	32,070	13,780	8,730				
3828A	828	60	203,230	32,290	13,990	8,940				
3872A	872	50	206,630	35,030	14,500	8,800	11'-9 3/4"	21'-6 1/2"	19'-0 7/8"	18'-1 1/2"
3923A	923	60	218,840	35,250	14,710	9,010				
3970A	970	75	230,080	36,530	16,000	10,300				
3985A	985	60	229,950	40,240	15,560	9,460	11'-9 3/4"	21'-6 1/2"	21'-8 7/8"	20'-9 1/2"
31056A	1056	75	246,700	40,330	15,650	9,550				
3583A	583	25	143,950	30,300	12,070	12,070	13'-11 1/8"	24'-0 1/2'	12'-3 1/8"	11'-3 3/4"
3618A	618	30	152,460	30,350	12,120	12,120				
3676A	676	40	166,920	30,510	12,280	12,280				
3725A	725	50	179,080	30,520	12,290	12,290				
31132A	1132	75	267,880	41,290	16,610	10,230	13'-11 1/8"	24'-0 1/2"	19'-2 7/8"	18'-1 1/2"
31213A	1213	75	282,010	44,300	17,550	10,720	13'-11 1/8"	24'-0 1/2"	21'-10 7/8"	20'-9 1/2"
31301A[2]	1301	100	302,580	46,590	19,840	13,010				

Notes:

1. Operating weight is for tower with the water level in the cold water basin at overflow. If a lower operating weight is needed to meet design requirements, your local BAC Sales Representative can provide additional assistance.
2. 31301A is supplied with a gear fan drive system as standard.
3. Models shipped with an optional gear drive or low sound fan may have heights up to 10.5" greater than shown.
4. Refer to page D24 for dimensional reference drawings.
5. Nominal tons of cooling respresents 3 gpm of water from a 95ºF entering water temperature to an 85ºF leaving water temperature at a 78ºF entering wet-bulb temperature.

See page D85
for Engineering
Considerations.

Double Cell Unit

MODEL NUMBER	NOMINAL TONNAGE[5]	MOTOR HP	FAN (CFM)	WEIGHTS (lbs)			DIMENSIONS[4]			
				OPERATING[1]	SHIPPING	HEAVIEST SECTION	L	W	H[3]	A
3240A-2	480	(2) 10	125,580	29,540	13,580	6,790	17'-2"	18'-0 1/2"	9'-3 5/8"	8'-7 3/4"
3272A-2	544	(2) 15	142,680	29,800	13,840	6,920				
3299A-2	598	(2) 20	156,220	29,920	13,960	6,980				
3333A-2	666	(2) 20	171,440	31,500	14,520	7,260	17'-2"	18'-0 1/2"	10'-7 5/8"	9'-11 3/4"
3358A-2	716	(2) 25	183,920	31,560	14,580	7,290				
3379A-2	758	(2) 30	194,800	31,660	14,680	7,340				
3412A-2	824	(2) 25	207,400	37,160	16,840	8,420	19'-9"	20'-0 1/2"	10'-9 1/8"	9'-11 3/4"
3436A-2	872	(2) 30	219,660	37,260	16,940	8,470				
3455A-2	910	(2) 25	224,500	38,960	17,480	8,740	19'-9"	20'-0 1/2"	12'-1 1/8"	11'-3 3/4"
3482A-2	964	(2) 30	237,760	39,060	17,580	8,790				
3527A-2	1,054	(2) 40	260,320	39,380	17,900	8,950				
3473A-2	946	(2) 25	237,740	46,180	20,380	10,190	23'-10"	21'-6 1/2"	10'-10 1/8"	9'-11 3/4"
3501A-2	1,002	(2) 30	251,800	46,280	20,480	10,240				
3552A-2	1,104	(2) 30	272,340	51,380	21,600	10,800	23'-10"	21'-6 1/2"	12'-2 1/8"	11'-3 3/4"
3604A-2	1,208	(2) 40	298,180	51,700	21,920	10,960				
3648A-2	1,296	(2) 50	319,900	51,720	21,940	10,970				
3672A-2	1,344	(2) 60	332,040	54,120	24,360	12,180				
3728A-2	1,456	(2) 40	357,720	64,120	27,540	8,720	23'-10"	21'-6 1/2"	16'-4 7/8"	15'-5 1/2"
3781A-2	1,562	(2) 50	383,780	64,140	27,560	8,730				
3828A-2	1,656	(2) 60	406,460	64,580	27,980	8,940				
3872A-2	1,744	(2) 50	413,260	70,060	29,000	8,800	23'-10"	21'-6 1/2"	19'-0 7/8"	18'-1 1/2"
3923A-2	1,846	(2) 60	437,680	70,500	29,420	9,010				
3970A-2	1,940	(2) 75	460,160	73,060	32,000	10,300				
3985A-2	1,970	(2) 60	459,900	80,480	31,120	9,460	23'-10"	21'-6 1/2"	21'-8 7/8"	20'-9 1/2"
31056A-2	2,112	(2) 75	493,400	80,660	31,300	9,550				
3583A-2	1,166	(2) 25	287,900	60,600	24,140	12,070	28'-0 3/4"	24'-0 1/2'	12'-3 1/8"	11'-3 3/4"
3618A-2	1,236	(2) 30	304,920	60,700	24,240	12,120				
3676A-2	1,352	(2) 40	333,840	61,020	24,560	12,280				
3725A-2	1,450	(2) 50	358,160	61,040	24,580	12,290				
31132A-2	2,264	(2) 75	535,760	82,580	33,220	10,230	28'-0 3/4"	24'-0 1/2"	19'-2 7/8"	18'-1 1/2"
31213A-2	2,426	(2) 75	564,020	88,600	35,100	10,720	28'-0 3/4"	24'-0 1/2"	21'-10 7/8"	20'-9 1/2"
31301A-2[2]	2,602	(2) 100	605,160	93,180	39,680	13,010				

Notes:

1. Operating weight is for tower with the water level in the cold water basin at overflow. If a lower operating weight is needed to meet design requirements, your local BAC Sales Representative can provide additional assistance.

2. 31301A-2 is supplied with a gear fan drive system as standard.

3. Models shipped with an optional gear drive or low sound fan may have heights up to 10.5" greater than shown.

4. Refer to page D24 for dimensional reference drawings.

5. Nominal tons of cooling respresents 3 gpm of water from a 95ºF entering water temperature to an 85ºF leaving water temperature at a 78ºF entering wet-bulb temperature.

Engineering Data

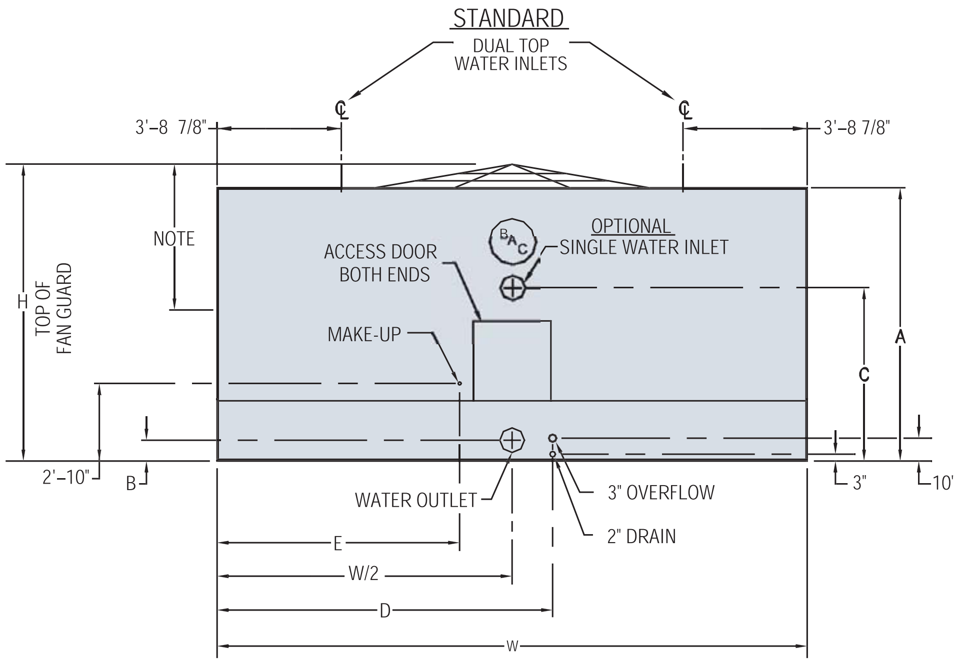
Do not use for construction. Refer to factory certified dimensions. This brochure includes data current at time of publication, which should be reconfirmed at the time of purchase. Up-to-date engineering data, free product selection software, and more can be found at **www.BaltimoreAircoil.com**.

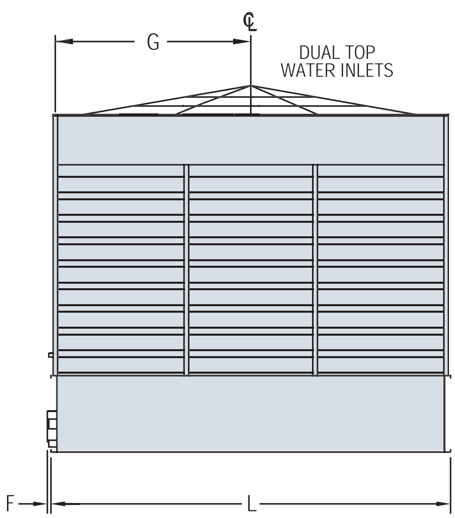
MODEL NUMBER	DIMENSIONS							CONNECTION SIZES[1,3]			
	B	C	D	E	F	G	J	MAKE-UP WATER	TOP INLET	SINGLE INLET	OUTLET
3240A 3272A 3299A	8 1/16"	5'-8 1/4"	10'-4 1/2"	7'-1 1/4"	1/4"	4'-2 7/8"	8'-8 1/4"	1-0"	(2) 6"	8"	8"
3333A 3358A 3379A	8 1/16"	6'-1 1/4"	10'-4 1/2"	7'-1 1/4"	1/4"	4'-2 7/8"	8'-8 1/4"	1-0"	(2) 6"	8"	8"
3412A 3436A	8 1/16"	6'-1 1/4"	11'-4 1/2"	8'-1 1/4"	1-1/4"	4'-10 5/8"	9'-11 3/4"	1-1/2"	(2) 6"	8"	8"
3455A 3482A 3527A	9 1/8"	6'-6 3/4"	11'-4 1/2"	8'-1 1/4"	1-1/4"	4'-10 5/8"	9'-11 3/4"	1-1/2"	(2)6"	10"	10"
3473A 3501A	9 1/8"	6'-6 3/4"	12'-1 1/2"	8'-10 1/4"	1-1/4"	5'-10 7/8"	12'-0 1/4"	1-1/2"	(2) 8"	10"	10"
3552A 3604A 3648A 3672A	9 1/8"	6'-6 3/4"	12'-1 1/2"	8'-10 1/4"	1-1/4"	5'-10 7/8"	12'-0 1/4"	1-1/2"	(2) 8"	10"	10"
3728A 3781A 3828A	9 1/8"	10'-4 1/2"	12'-1 1/2"	8'-10 1/4"	1-1/4"	5'-10 7/8"	12'-0 1/4"	1-1/2"	(2) 8"	12"	12"
3872A 3923A 3970A	9 1/8"	13-0 1/2"	12'-1 1/2"	8'-10 1/4"	1-1/4"	5'-10 7/8"	12'-0 1/4"	1-1/2"	(2) 8"	12"	12"
3985A 31056A	9 1/8"	15'-8 1/2"	12'-1 1/2"	8'-10 1/4"	1-1/4"	5'-10 7/8"	12'-0 1/4"	1-1/2"	(2) 8"	12"	12"
3583A 3618A 3676A 3725A	9 1/8"	6'-6 3/4"	13'-4 1/2"	10'-1 1/4"	5/8"	6'-11 5/16"	14'-1 5/8"	1-1/2"	(2) 8"	10"	10"
31132A	9 5/8"	13'-0 1/2"	13'-4 1/2"	10'-1 1/4"	5/8"	6'-11 5/16"	14'-1 5/8"	2"	(2) 10"	14"	14"
31213A 31301A	9 5/8"	15'-8 1/2"	13'-4 1/2"	10'-1 1/4"	5/8"	6'-11 9/16"	14'-1 5/8"	2"	(2) 10"	14"	14"

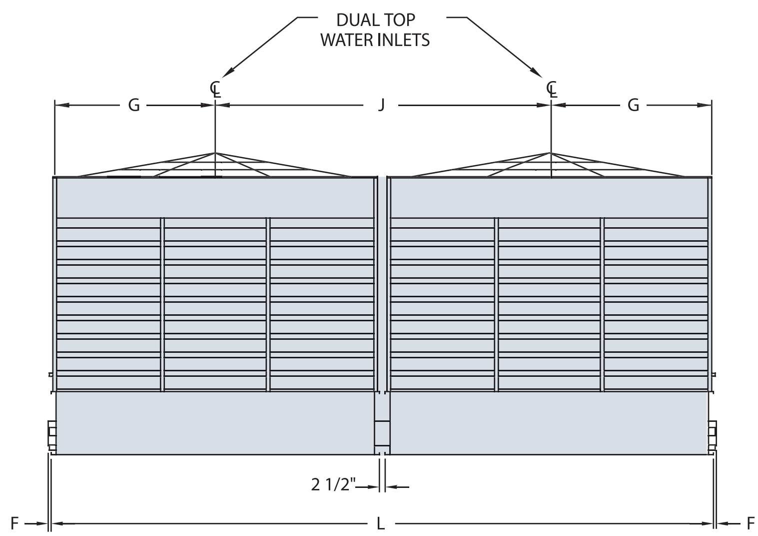
Notes:

1. The actual size of the inlet and outlet connection may vary with the design flow rate.
2. Unless otherwise indicated, all connections 3" and smaller are MPT, and connections 4" and larger are beveled for welding and grooved to suit a mechanical coupling.
3. On double cell units, connections are the same size but are located on both ends of the unit.

Series 3000







Single Cell Unit

Double Cell Unit

Note:

3728A thru 31056A and 31132A thru 31301A ship in two sections per cell.

The top section is the heaviest and tallest.

Top section heights are:

- 3728A thru 3970A: 10' 3-1⁄8"
- 31132A: 10' 11-1⁄8"
- 3985A thru 31056A: 11' 7-1⁄8"
- 31213A: 12' 3-1⁄8"
- 31301A: 12' 6-1⁄2"

See page D85 for Engineering Considerations.

Concrete Basin Engineering Data for Optional Basinless Units

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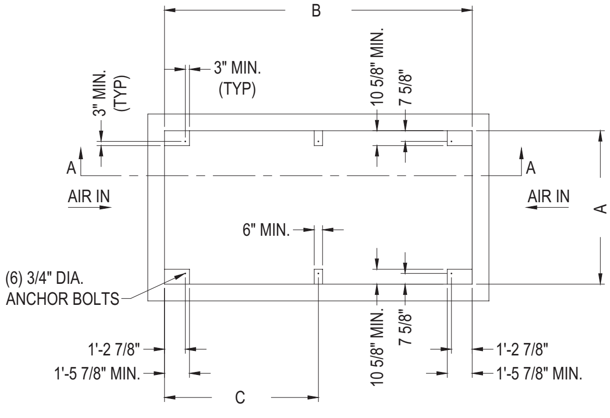
Single Cell Unit

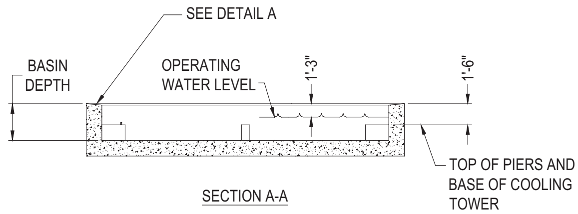
MODEL NUMBER	OPERATING LOAD VERTICAL	MAXIMUM OPERATING WEIGHT (lbs)	A	B	C	D
3240A	2,420	9,690	9'-1 3/4"	18'-4 1/2"	9'-2 1/4"	N/A
3272A	2,460	9,820	9'-1 3/4"	18'-4 1/2"	9'-2 1/4"	N/A
3299A	2,470	9,880	9'-1 3/4"	18'-4 1/2"	9'-2 1/4"	N/A
3333A	2,670	10,670	9'-1 3/4"	18'-4 1/2"	9'-2 1/4"	N/A
3358A	2,680	10,700	9'-1 3/4"	18'-4 1/2"	9'-2 1/4"	N/A
3379A	2,690	10,750	9'-1 3/4"	18'-4 1/2"	9'-2 1/4"	N/A
3412A	3,130	12,510	10'-5 1/4"	20'-4 1/2"	10'-2 1/4"	N/A
3436A	3,140	12,560	10'-5 1/4"	20'-4 1/2"	10'-2 1/4"	N/A
3455A	3,350	13,410	10'-5 1/4"	20'-4 1/2"	10'-2 1/4"	N/A
3482A	3,370	13,460	10'-5 1/4"	20'-4 1/2"	10'-2 1/4"	N/A
3527A	3,410	13,620	10'-5 1/4"	20'-4 1/2"	10'-2 1/4"	N/A
3473A	3,770	15,070	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3501A	3,780	15,120	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3552A	4,100	16,140	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3604A	4,140	16,570	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3648A	4,150	16,580	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3672A	4,450	17,780	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3728A	5,640	22,570	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3781A	5,650	22,580	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3828A	5,700	22,800	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3872A	6,390	25,540	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3923A	6,440	25,760	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3970A	6,760	27,040	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3985A	7,690	30,750	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
31056A	7,710	30,840	12'-5 3/4"	21'-10 1/2"	10'-11 1/4"	N/A
3583A	3,100	18,630	14'-7 1/8"	24'-4 1/2"	7'-8 1/4"	9'-0"
3618A	3,110	18,680	14'-7 1/8"	24'-4 1/2"	7'-8 1/4"	9'-0"
3676A	3,140	18,840	14'-7 1/8"	24'-4 1/2"	7'-8 1/4"	9'-0"
3725A	3,140	18,850	14'-7 1/8"	24'-4 1/2"	7'-8 1/4"	9'-0"
31132A	4,940	29,620	14'-7 1/8"	24'-4 1/2"	7'-8 1/4"	9'-0"
31213A	5,440	32,630	14'-7 1/8"	24'-4 1/2"	7'-8 1/4"	9'-0"
31301A	5,820	34,920	14'-7 1/8"	24'-4 1/2"	7'-8 1/4"	9'-0"

Note:

1. Purchaser to design, construct and furnish basin (including anchor bolts) in accordance with requirements given. Purchaser must also supply sump, overflow, drain, cleanout and water make-up to suit requirements.
2. All anchor bolts shall be 3/4” diameter, 1-1/2” projection (+/- 1/4”), fully threaded. Bolt to have one nut and washer. Anchor bolt and column bearing point locations and elevations must be maintained +/- 1/8”.
3. Pier dimensions shown are minimum bearing surfaces required for the tower structure and do not include corner chamfers on the concrete piers.
4. Wet deck to be located below the operating water level. (see section A-A, next page)
5. Maximum operating weight does not include concrete basin or water retained in the basin.

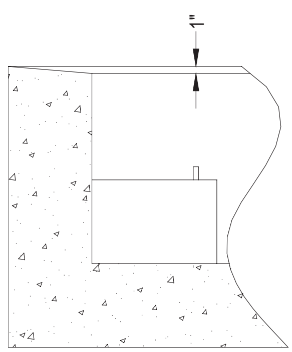


PLAN VIEW OF BASIN



SECTION A-A

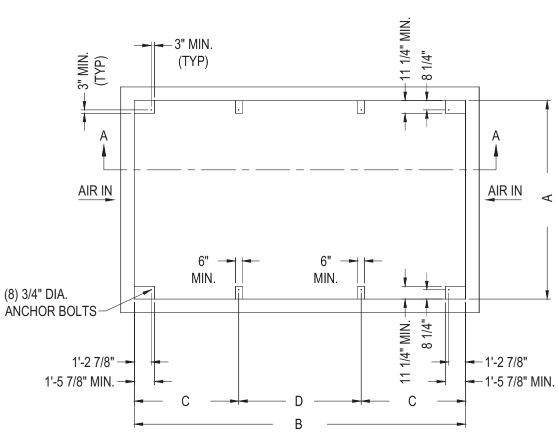
Models 3240A thru Models 31056A



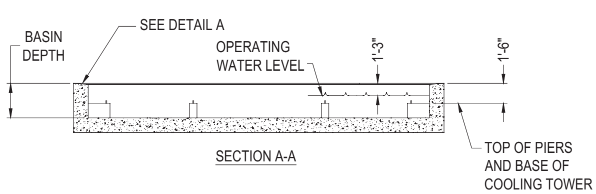
DETAIL A
CONCRETE BASIN WALL SLOPE

See page D85 for Engineering Considerations.

All Models



PLAN VIEW OF BASIN



SECTION A-A

Models 3583A thru Models 31301A

Concrete Basin Engineering Data for Basinless Units

Series 3000

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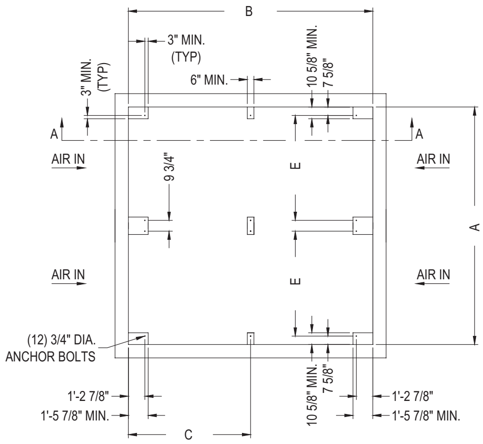
Double Cell Unit

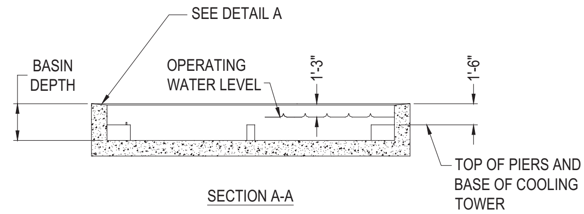
<table>
<tr><th>MODEL NUMBER</th><th>OPERATING LOAD VERTICAL</th><th>MAXIMUM OPERATING WEIGHT (lbs)</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th></tr>
<tr><td>3240A-2</td><td>2,420</td><td>19,380</td><td rowspan="3">17'-10"</td><td rowspan="3">18'-4 1/2"</td><td rowspan="3">9'-2 1/4"</td><td rowspan="3">N/A</td><td rowspan="3">7'-10 1/2"</td></tr>
<tr><td>3272A-2</td><td>2,460</td><td>19,640</td></tr>
<tr><td>3299A-2</td><td>2,470</td><td>19,760</td></tr>
<tr><td>3333A-2</td><td>2,670</td><td>21,340</td><td rowspan="3">17'-10"</td><td rowspan="3">18'-4 1/2"</td><td rowspan="3">9'-2 1/4"</td><td rowspan="3">N/A</td><td rowspan="3">7'-10 1/2"</td></tr>
<tr><td>3358A-2</td><td>2,680</td><td>21,400</td></tr>
<tr><td>3379A-2</td><td>2,690</td><td>21,500</td></tr>
<tr><td>3412A-2</td><td>3,130</td><td>25,020</td><td rowspan="2">20'-5"</td><td rowspan="2">20'-4 1/2"</td><td rowspan="2">10'-2 1/4"</td><td rowspan="2">N/A</td><td rowspan="2">9'-2"</td></tr>
<tr><td>3436A-2</td><td>3,140</td><td>25,120</td></tr>
<tr><td>3455A-2</td><td>3,350</td><td>26,820</td><td rowspan="3">20'-5"</td><td rowspan="3">20'-4 1/2"</td><td rowspan="3">10'-2 1/4"</td><td rowspan="3">N/A</td><td rowspan="3">9'-2"</td></tr>
<tr><td>3482A-2</td><td>3,370</td><td>26,920</td></tr>
<tr><td>3527A-2</td><td>3,410</td><td>27,240</td></tr>
<tr><td>3473A-2</td><td>3,770</td><td>30,140</td><td rowspan="2">24'-6"</td><td rowspan="2">21'-10 1/2"</td><td rowspan="2">10'-11 1/4"</td><td rowspan="2">N/A</td><td rowspan="2">11'-2 1/2"</td></tr>
<tr><td>3501A-2</td><td>3,780</td><td>30,240</td></tr>
<tr><td>3552A-2</td><td>4,100</td><td>32,820</td><td rowspan="4">24'-6"</td><td rowspan="4">21'-10 1/2"</td><td rowspan="4">10'-11 1/4"</td><td rowspan="4">N/A</td><td rowspan="4">11'-2 1/2"</td></tr>
<tr><td>3604A-2</td><td>4,140</td><td>33,140</td></tr>
<tr><td>3648A-2</td><td>4,150</td><td>33,160</td></tr>
<tr><td>3672A-2</td><td>4,450</td><td>35,560</td></tr>
<tr><td>3728A-2</td><td>5,640</td><td>45,140</td><td rowspan="3">24'-6"</td><td rowspan="3">21'-10 1/2"</td><td rowspan="3">10'-11 1/4"</td><td rowspan="3">N/A</td><td rowspan="3">11'-2 1/2"</td></tr>
<tr><td>3781A-2</td><td>5,650</td><td>45,160</td></tr>
<tr><td>3828A-2</td><td>5,700</td><td>45,600</td></tr>
<tr><td>3872A-2</td><td>6,390</td><td>51,080</td><td rowspan="3">24'-6"</td><td rowspan="3">21'-10 1/2"</td><td rowspan="3">10'-11 1/4"</td><td rowspan="3">N/A</td><td rowspan="3">11'-2 1/2"</td></tr>
<tr><td>3923A-2</td><td>6,440</td><td>51,520</td></tr>
<tr><td>3970A-2</td><td>6,760</td><td>54,080</td></tr>
<tr><td>3985A-2</td><td>7,690</td><td>61,500</td><td rowspan="2">24'-6"</td><td rowspan="2">21'-10 1/2"</td><td rowspan="2">10'-11 1/4"</td><td rowspan="2">N/A</td><td rowspan="2">11'-2 1/2"</td></tr>
<tr><td>31056A-2</td><td>7,710</td><td>61,680</td></tr>
<tr><td>3583A-2</td><td>3,100</td><td>37,260</td><td rowspan="4">28'-8 3/4"</td><td rowspan="4">24'-4 1/2"</td><td rowspan="4">7'-8 1/4"</td><td rowspan="4">9'-0"</td><td rowspan="4">13'-2 5/8"</td></tr>
<tr><td>3618A-2</td><td>3,110</td><td>37,360</td></tr>
<tr><td>3676A-2</td><td>3,140</td><td>37,680</td></tr>
<tr><td>3725A-2</td><td>3,140</td><td>37,700</td></tr>
<tr><td>31132A-2</td><td>4,940</td><td>59,240</td><td>28'-8 3/4"</td><td>24'-4 1/2"</td><td>7'-8 1/4"</td><td>9'-0"</td><td>13'-2 5/8"</td></tr>
<tr><td>31213A-2</td><td>5,440</td><td>65,260</td><td rowspan="2">28'-8 3/4"</td><td rowspan="2">24'-4 1/2"</td><td rowspan="2">7'-8 1/4"</td><td rowspan="2">9'-0"</td><td rowspan="2">13'-2 5/8"</td></tr>
<tr><td>31301A-2</td><td>5,820</td><td>69,840</td></tr>
</table>

Note:

1. Purchaser to design, construct and furnish basin (including anchor bolts) in accordance with requirements given. Purchaser must also supply sump, overflow, drain, cleanout and water make-up to suit requirements.
2. All anchor bolts shall be 3/4" diameter, 1 1-1/2" projection (+/- 1/4"), fully threaded. Bolt to have one nut and washer. Anchor bolt and column bearing point locations and elevations must be maintained +/- 1/8".
3. Pier dimensions shown are minimum bearing surfaces required for the tower structure and do not include corner chamfers on the concrete piers.
4. Base of the cooling tower to be located below the water.
5. Maximum operating weight does not include concrete basin or water retained in the basin.

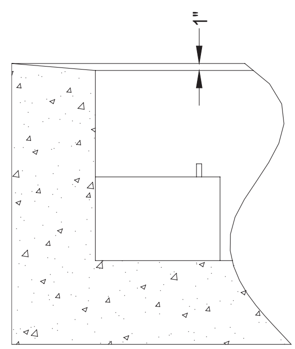


PLAN VIEW OF BASIN



SECTION A-A

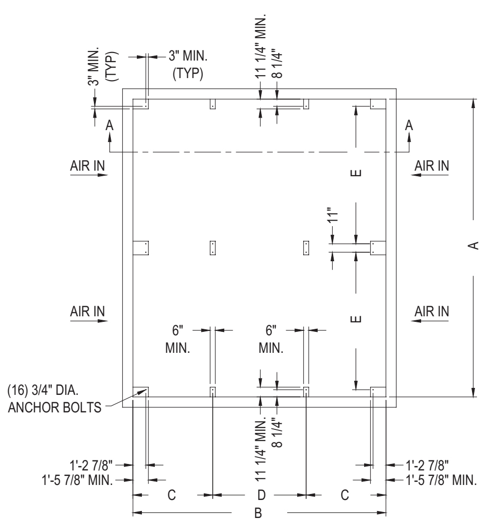
Models 3240A-2 thru Models 31056A-2



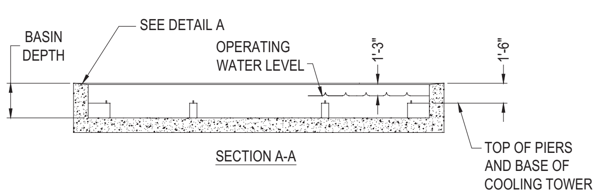
DETAIL A
CONCRETE BASIN WALL SLOPE

See page D85 for Engineering Considerations.

All Models



PLAN VIEW OF BASIN



SECTION A-A

Models 3583A-2 thru Models 31301A-2

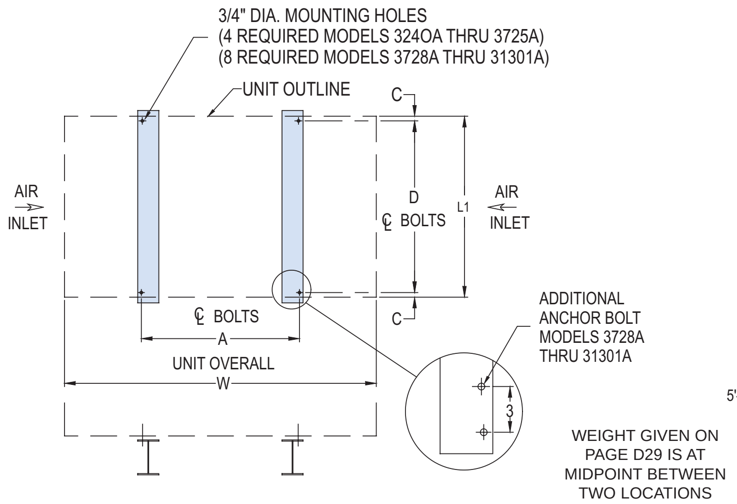
Structural Support

The recommended support arrangement for the Series 3000 Cooling Tower consists of parallel I-beams positioned as shown in the drawings. Besides providing adequate support, the steel also serves to raise the unit above any solid foundation to assure access to the bottom of the tower. The Series 3000 may also be supported on columns at the anchor bolt locations shown in Plan A or Plan C. A minimum bearing surface of twelve (12) square inches must be provided under each of the concentrated load points (See Note 7, next page). To support a Series 3000 Cooling Tower on columns, or in an alternate steel support arrangement, consult your BAC Representative.

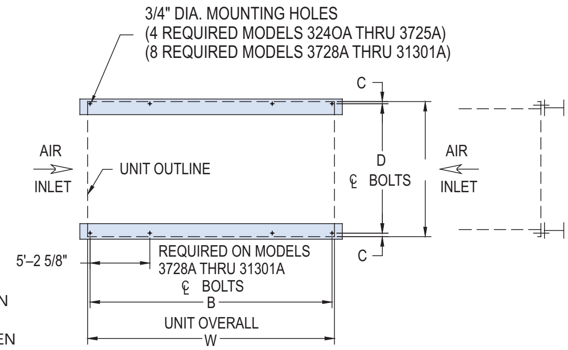
MODEL NUMBER	WEIGHTS (LBS.)			DIMENSIONS							
	SHIPPING[1]	OPERATING[1,2]	WT. AT BOLT HOLE LOCATIONS	L1	L2	W	A	B	C	D	E
3240A	6,790	14,770	3,693	8'-5 3/4"	17'-2"	18'-0 1/2"	9'-4"	16'-4 1/2"	1 1/8"	8'-3 1/2"	4 3/4"
3272A	6,920	14,900	3,725								
3299A	6,980	14,960	3,740								
3333A	7,260	15,750	3,938	8'-5 3/4"	17'-2"	18'-0 1/2"	9'-4"	16'-4 1/2"	1 1/8"	8'-3 1/2"	4 3/4"
3358A	7,290	15,780	3,945								
3379A	7,340	15,830	3,958								
3412A	8,420	18,580	4,645	9'-9 1/4"	19'-9"	20'-0 1/2"	11'-4"	18'-4 1/2"	1 1/8"	9'-7"	4 3/4"
3436A	8,470	18,630	4,658								
3455A	8,740	19,480	4,870	9'-9 1/4"	19'-9"	20'-0 1/2"	11'-4"	18'-4 1/2"	1 1/8"	9'-7"	4 3/4"
3482A	8,790	19,530	4,883								
3527A	8,950	19,690	4,923								
3473A	10,190	23,090	5,773	11'-9 3/4"	23'-10"	21'-6 1/2"	12'-10"	19'-10 1/2"	1 1/8"	11'-7 1/2"	4 3/4"
3501A	10,240	23,140	5,785								
3552A	10,800	25,690	6,423	11'-9 3/4"	23'-10"	21'-6 1/2"	12'-10"	19'-10 1/2"	1 1/8"	11'-7 1/2"	4 3/4"
3604A	10,960	25,850	6,463								
3648A	10,970	25,860	6,465								
3672A	12,180	27,060	6,765								
3728A	13,770	32,060	8,015	11'-9 3/4"	23'-10"	21'-6 1/2"	12'-10"	19'-10 1/2"	1 1/8"	11'-7 1/2"	4 3/4"
3781A	13,780	32,070	8,018								
3828A	13,990	32,290	8,073								
3872A	14,500	35,030	8,758	11'-9 3/4"	23'-10"	21'-6 1/2"	12'-10"	19'-10 1/2"	1 1/8"	11'-7 1/2"	4 3/4"
3923A	14,710	35,250	8,813								
3970A	16,000	36,530	9,133								
3985A	15,560	40,240	10,060	11'-9 3/4"	23'-10"	21'-6 1/2"	12'-10"	19'-10 1/2"	1 1/8"	11'-7 1/2"	4 3/4"
31056A	15,650	40,330	10,083								
3583A	12,070	30,300	7,575	13'-11 1/8"	28'-0 3/4"	24'-0 1/2"	15'-4"	22'-4 1/2"	1 7/16"	13'-8 1/4"	5 3/8"
3618A	12,120	30,350	7,588								
3676A	12,280	30,510	7,628								
3725A	12,290	30,520	7,630								
31132A	16,610	41,290	10,323	13'-11 1/8"	28'-0 3/4"	24'-0 1/2"	15'-4"	22'-4 1/2"	1 7/16"	13'-8 1/4"	5 3/8"
31213A	17,550	44,300	11,075	13'-11 1/8"	28'-0 3/4"	24'-0 1/2"	15'-4"	22'-4 1/2"	1 7/16"	13'-8 1/4"	5 3/8"
31301A	19,840	46,590	11,648								

See notes, next page.

Single Cell Unit



Plan A

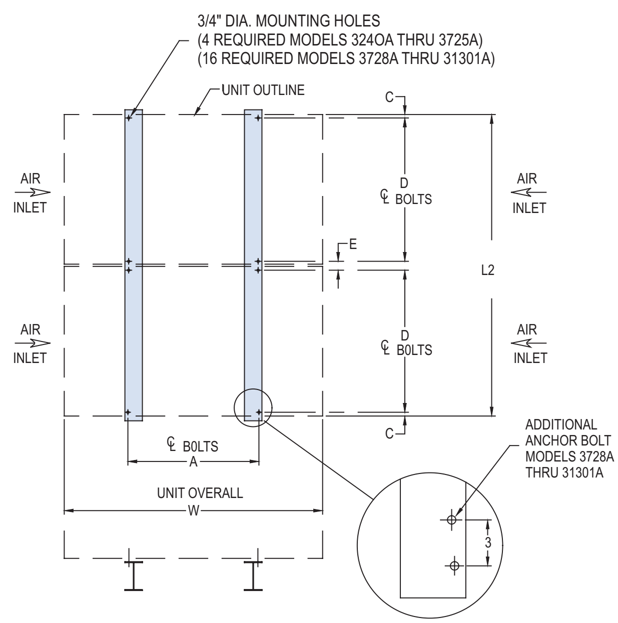


Plan B

Notes:

1. Weights are for a single cell. To obtain weights for multi-cell units, multiply by the number of cells.
2. Operating weight and weight loading are for a single cell tower with water at overflow level in the cold water basin.
3. Support beams and anchor bolts to be selected and installed by parties other than BAC.
4. All support steel must be level at the top.
5. Beams must be selected in accordance with accepted structural practice. Maximum deflection of beam under unit to be 1/360 of span, not to exceed 1/2 inch.
6. All single and double cell units can be furnished with optional vibration isolation rail packages, when required, to be installed between the tower and supporting steel. The BAC standard vibration isolation rail package is designed for support Plan A for single cell units and support Plan C for double cell units. Plan B rails are available upon request. When determining the length of the supporting steel, allow for the length of the vibration rails, as they are sometimes longer than the cooling tower dimensions shown.
7. If point vibration isolation is used with multi-cell towers, the isolators must be located under the support steel, not between the support steel and the cooling towers.

Double Cell Unit



Plan C

Engineering Specifications

See our website at www.BaltimoreAircoil.com for an electronic copy of product engineering specifications.

Series 3000

1.0 Cooling Tower

1.1 General: Furnish and install _____ factory-assembled, induced draft, crossflow cooling tower(s) with vertical air discharge, conforming in all aspects to the specifications, schedules and as shown on the plans. Overall dimensions shall not exceed approximately _____ ft (mm) long X ______ ft (mm) wide X _____ ft (mm) high. The total connected fan horsepower shall not exceed _____ HP (kW). The cooling tower(s) shall be Baltimore Aircoil Model ______.

1.2 Thermal Capacity: The cooling tower(s) shall be warranted by the manufacturer to cool _____ US gpm (lps) of water from ______ ºF(°C) to _____ ºF(°C) at _____ ºF(°C) entering wet-bulb temperature. Additionally, the thermal performance shall be certified by the Cooling Technology Institute in accordance with CTI Certification Standard STD-201. Lacking such certification, a field acceptance test shall be conducted within the warranty period in accordance with CTI Acceptance Test Code ATC-105, by the Cooling Technology Institute or other qualified independent third party testing agency. Manufacturers' performance guarantees or performance bonds without CTI Certification or independent field thermal performance test shall not be accepted. The cooling tower(s) shall comply with the energy efficiency requirements of ASHRAE Standard 90.1.

1.3 Corrosion Resistant Construction (standard): Unless otherwise noted in this specification, all steel panels and structural members shall be constructed of heavy-gauge G-235 (Z700 metric) hot-dip galvanized steel with all edges given a protective coating of zinc-rich compound.

(Alternate) 1.3 Corrosion Resistant Construction: Unless otherwise noted in this specification, all steel panels and structural members shall be protected with the BALTIBOND® Corrosion Protection System. The system shall consist of G-235 (Z700 metric) hot-dip galvanized steel prepared in a four-step (clean, pre-treat, rinse, dry) process with an electrostatically sprayed, thermosetting, hybrid polymer fuse-bonded to the substrate during a thermally activated curing stage and monitored by a 23-step quality assurance program.

(Alternate) 1.3 JE PREMIER SERIES® Construction: All steel panels and structural members, including the structural frame, hot and cold water basins, distribution covers, fan deck and fan cylinder shall be constructed of Type 304 stainless steel and assembled with Type 304 stainless steel nut and bolt fasteners. All factory seams in the cold water basin shall be welded to ensure watertight assembly and welded seams shall be warranted against leaks for five (5) years.

The entire cooling tower, including fan motor, drive system, bearings, and structure, shall be backed by a comprehensive Louver-to-Louver℠ Five-Year warranty.

1.4 Quality Assurance: The cooling tower manufacturer shall have a Management System certified by an accredited registrar as complying with the requirements of ISO-9001:2000 to ensure consistent quality of products and services.

1.5 Wind and Seismic Forces: The cooling tower shall be suitable for applications requiring equipment anchorage to resist wind loads of up to 30 psf and seismic forces of Seismic Zone 2B, Importance Factor 1.0, per the 1997 Uniform Building Code.

2.0 Construction Details

2.1 Structure: The cooling tower shall be constructed with a sturdy structural frame designed to transmit all wind, seismic and mechanical loads to the equipment anchorage. The frame shall be constructed of heavy-gauge steel angles and channels.

2.2 Casing Panels: Casing panels shall be constructed of corrosion and UV-resistant fiberglass reinforced polyester (FRP) to minimize maintenance requirements and prolong equipment life.

(Alternate) 2.2 FM approval (Multi-cell): The cooling towers shall be constructed with galvanized steel casing panels and louvers that shall meet the requirements of FM.

(Alternate) 2.2 FM Approval (Multi-cell): The cooling towers shall be constructed with Type 304 stainless steel casing panels and louvers that shall meet the requirements of FM.

2.3 Cold Water Basin: The cold water basin shall be constructed of heavy-gauge steel panels and structural members. Basin shall include a depressed center section with drain/clean-out connection. The basin area under the wet deck surface shall be sloped toward the depressed center section to facilitate cleaning. Standard basin accessories shall include a brass make-up valve with large diameter plastic float for easy adjustment of the operating water level.

(Alternate) 2.3 Cold Water Basin: The cold water basin shall be constructed of heavy-gauge Type 304 stainless steel panels and structural members. All factory seams shall be welded to ensure watertight construction, and welded seams shall be warranted against leaks for a period of five (5) years from date of shipment. Basin shall include a depressed center section with drain/clean-out connection. The basin area under the wet deck surface shall be sloped toward the depressed center section to facilitate cleaning. Standard basin accessories shall include a brass make-up valve with large diameter plastic float for easy adjustment of the operating water level.

2.4 Water Outlet: The water outlet connection shall be beveled for welding and grooved for mechanical coupling or bolt hole circle designed to accept an ASME Class 150 flat face flange. The outlet shall be provided with large-area lift out strainers with perforated openings sized smaller than the water distribution nozzles and an anti-vortexing device to prevent air entrainment. The strainer and vortex device shall be constructed of the same materials as the cold water basin to prevent dissimilar metal corrosion.

2.5 Water Distribution System: Hot water distribution basins shall be the open gravity type and constructed of heavy-gauge, G-235 hot-dip galvanized steel. Basin weirs and plastic metering orifices shall be provided to assure even distribution of the water over the wet deck surface. Lift-off distribution covers shall be constructed of heavy-gauge G-235 hot-dip galvanized steel and designed to withstand a 50 psf live load or 200 pound concentrated load.

2.6 EASY CONNECT® Piping Arrangement with BALANCE CLEAN® Chamber (optional): Each tower cell shall be furnished with a single water inlet connection complete with the means to automatically balance flow rates to the hot water basins. Internal piping shall include an integral pre-strainer such that routine maintenance of the hot water distribution system can be performed from the unit interior.

3.0 Mechanical Equipment

3.1 Fan(s): Fan(s) shall be heavy-duty, axial flow with aluminum alloy blades selected to provide optimum cooling tower thermal performance with minimal sound levels. Air shall discharge through a fan cylinder designed for streamlined air entry and minimum tip clearance for maximum fan efficiency. The top of the fan cylinder shall be equipped with a conical, non-sagging removable fan guard.

3.2 Bearings: Fan(s) and shaft(s) shall be supported by heavy-duty, self-aligning, grease-packed ball bearings with moisture proof seals and integral slinger collars, designed for a minimum L10 life of 40,000 hours (280,000 Hr. Avg. Life).

3.3 Fan Drive: The fan(s) shall be driven by a one-piece, multi-groove, solid back V-type powerband with taper lock sheaves designed for 150% of the motor nameplate horsepower. The powerband shall be constructed of neoprene reinforced polyester cord and be specifically designed for cooling tower service.

3.4 Sheaves: Fan and motor sheave(s) shall be fabricated from corrosion-resistant materials to minimize maintenance and ensure maximum drive and powerband operating life.

3.5 Fan Motor: Fan motor(s) shall be totally enclosed air over (TEAO), reversible, squirrel cage, ball bearing type designed specifically for cooling tower service. The motor shall be furnished with special moisture protection on winding, shafts and bearings.

(Alternate) 3.5 Fan Motor: Fan motor(s) shall be totally enclosed air over (TEAO), reversible, squirrel cage, ball bearing type designed specifically for cooling tower service. The motor shall be furnished with special moisture protection on winding, shafts and bearings. Fan motors shall be inverter duty type designed per NEMA Standard MG1, Section IV, Part 31.

3.6 Mechanical Equipment Warranty: The fan(s), fan shaft(s), sheaves, bearings, mechanical equipment support and fan motor shall be warranted against defects in materials and workmanship for a period of five (5) years from date of shipment.

3.7 ENERGY-MISER® Fan System (optional): Two-single speed fan motors, one sized for full speed and load, the other sized for 2/3 speed and approximately 1/3 the full load horsepower shall be provided in each cell for capacity control and stand-by protection from drive or motor failure. Two-speed motor(s) are not an acceptable alternative.

4.0 Wet Deck Surface and Drift Eliminators

4.1 Wet Deck Surface and Drift Eliminators: The wet deck surface and integral drift eliminators shall be formed from self-extinguishing (per ASTM D-568) polyvinyl chloride (PVC) having a flame spread rating of 5 per ASTM E84 and shall be impervious to rot, decay, fungus and biological attack. The wet deck shall be suitable for entering water temperatures up to 130ºF. The wet deck surface shall be manufactured, tested and rated by the cooling tower manufacturer and shall be elevated above the cold water floor to facilitate cleaning.

5.0 Air Inlet Louvers

5.1 Air Inlet Louvers: Air Inlet louvers shall be separate from the wet deck surface and removable to provide easy access for inspection of the air/water interface at the louver face. Louvers shall prevent water splash out during fan cycling and be constructed of maintenance free, corrosion and UV resistant, fiberglass reinforced polyester (FRP).

6.0 Access

6.1 Plenum Access: Two hinged access doors shall be provided for access into the plenum section.

7.0 Sound

7.1 Sound Level: To maintain the quality of the local environment, the maximum sound pressure levels (dB) measured 50 ft from the cooling tower operating at full fan speed shall not exceed the sound levels detailed below.

(Alternate) 7.1 Sound Level: To maintain the quality of the local environment, the cooling tower shall be furnished with a low sound fan. The thermal performance of the cooling tower when furnished with the low sound fan shall be certified by the Cooling Technology Institute in accordance with paragraph 1.2 of this specification. Maximum sound pressure levels (dB) measured 50 ft from the cooling tower operating at full fan speed shall not exceed the sound levels detailed below.

Location	63	125	250	500	1000	2000	4000	8000	dB(A)
Discharge									
Air Inlet									
Cased Face									

Engineering Considerations - Cooling Towers

Location

Units must have an adequate supply of fresh air to the air inlet(s). When units are located adjacent to building walls or in enclosures, care must be taken to ensure that the warm, saturated discharge air is not deflected off surrounding walls or enclosures and drawn back to the air inlet(s).

CAUTION:

Each unit should be located and positioned to prevent the introduction of the warm discharge air and the associated drift, which may contain chemical or biological contaminants including *Legionella*, into the ventilation systems of the building on which the unit is located or those of adjacent buildings.

For detailed recommendations on layout, refer to our web site, www.BaltimoreAircoil.com, or consult your local BAC Representative.

For Series V products, bottom screens or solid bottom panels may be desirable or necessary for safety, depending on the location and conditions at the installation site.

Piping and Valves

Piping must be sized and installed in accordance with good piping practice. All piping should be supported by pipe hangers or other supports, not by the unit. On open systems, in order to prevent basin overflow at shutdown and to ensure satisfactory pump operation at start-up, all heat exchangers and as much piping as possible should be installed below the operating level of the cooling tower.

Some units may require flow balancing valves (supplied by others) at the hot water inlets to balance the flow to individual inlets and cells. External shutoff valves (supplied by others) may also be required if the system design necessitates the isolation of individual cells.

When multiple cells are used on a common system, equalizing lines should be installed between the cold water basins to ensure balanced water level in all cells. It is good engineering practice to valve the inlet and outlet of each tower separately for servicing. The shut-off valves can be used, if necessary, to adjust any minor unbalanced condition in water flow to or from the units.

Capacity Control

Variable Frequency Drives (VFD)

Installations which are to be controlled by Variable Frequency Drives (VFD) require the use of an inverter duty motor as designed per NEMA Standard MG.1, Section IV, Part 31, which recognizes the increased stresses placed on motors by these drive systems. Inverter duty motors must be furnished on VFD applications in order to maintain the motor warranty.

WARNING:

When the fan speed is to be changed from the factory-set speed, including through the use of a variable speed control device, steps must be taken to avoid operating at or near fan speeds that cause a resonance with the unit or its supporting structure. At start-up, the variable frequency drive should be cycled slowly between zero and full speed and any speeds that cause a noticeable resonance in the unit should be "locked out" by the variable speed drive.

Fan Cycling

Fan cycling is the simplest method of capacity control. The number of steps of capacity control can be increased using the ENERGY-MISER® Fan System, the independent fan motor option, or two-speed fan motors in conjunction with fan cycling (see the "Custom Features & Options" section of the appropriate product line to determine whether the ENERGY-MISER® Fan System or the independent fan motor option are available; two-speed motors are available for all products). These options provide substantial energy savings when compared to simple fan cycling.

WARNING:

Rapid on-off cycling can cause the fan motor to overheat. It is recommended that controls be set to allow a maximum of 6 on-off cycles per hour.

Capacity Control Dampers (Series V Models Only)

On Series V models, modulating capacity control dampers are available to provide better leaving water temperature control than can be obtained from fan cycling alone. See page C73 or contact your local BAC Representative for more details.

Vibration Cutout Switches

Vibration cutout switches are recommended on all installations. Vibration cutout switches are designed to interrupt power to the fan motor and can provide an alarm to the operator in the event of excessive vibration. BAC offers both electronic and mechanical vibration cutout switches on all cooling tower models.

Water Treatment

As water evaporates in an evaporative cooling unit, the dissolved solids originally present in the water remain in the system. The concentration of these dissolved solids increases rapidly and can cause scale and corrosion. In addition, airborne impurities and biological contaminants, including *Legionella*, may be introduced into the circulating water. To control all potential contaminants, a water treatment program must be employed. In many cases, a simple bleed-off may be adequate for control of scale and corrosion. *Note: Bleed lines are to be provided and installed by others.* However, biological contamination, including *Legionella*, can be controlled only through the use of biocides. Such treatment should be initiated at system startup, after periods of equipment shutdown, and continued regularly thereafter. Accordingly, it is strongly recommended a biocide treatment be initiated when the unit is first filled with water and continued regularly thereafter. For more information, consult the appropriate Operating and Maintenance Manual.

When a water treatment program is employed, it must be compatible with construction materials. The pH of the circulating water must be maintained between 6.5 and 9.0. Units having galvanized steel construction and a circulating water pH of 8.3 or higher will require periodic passivation of the galvanized steel to prevent the accumulation of white, waxy, nonprotective zinc corrosion called white rust. Batch feeding of chemicals into the unit is not recommended. If units are constructed with optional corrosion resistant materials, acid treatment may be considered; however, the water quality must be maintained within the guidelines set forth in the Operating and Maintenance Instructions.

For complete Water Quality Guidelines, see the appropriate Operating and Maintenance Instruction Manual, available at www.BaltimoreAircoil.com

For specific recommendations on water treatment, contact a competent water treatment supplier.

Wet Deck Surface Compatibility

BAC’s standard wet deck is constructed of polyvinyl chloride (PVC) and has a flame spread rating of 5 per ASTM Standard E84. The PVC wet deck surface is compatible with the water found in most evaporative cooling applications. The maximum allowable water temperature for each product is as shown in the following table

Maximum Allowable Water Temperature by Wet Deck Material

PRODUCT LINE	STANDARD PVC	HIGH TEMPERATURE PVC	GALVANIZED or STAINLESS STEEL
Series 3000	130ºF (54.4ºC)	135ºF (57.2ºC)	N/A
Series 1500	120ºF (48.9ºC)	135ºF (57.2ºC)	N/A
FXT	125ºF (51.7ºC)	140ºF (60.0ºC)	N/A
Series V	130ºF (54.4ºC)	140ºF (60.0ºC) for BALTIBOND® Corrosion Protection System Units; 150ºF (65.6ºC) for Galvanized & Stainless Steel Units	170ºF (76.7ºC)

For applications where the entering water temperature exceeds the limits shown above, contact your local BAC Representative for assistance.

Sound Levels

Sound rating data is available for all BAC Cooling Towers. When calculating the sound levels generated by a unit, the designer must take into account the effects of the geometry of the tower as well as the distance and direction from the unit to noise-sensitive areas. Low sound fans and intake and discharge sound attenuation can be supplied on certain models to provide reduced sound characteristics (see the "Custom Features and Options" section of the appropriate product line for details). The ENERGY-MISER® Fan System, two-speed motors, or variable frequency drives can also be used to reduce sound during periods of non-peak thermal loads. For more information on sound and how it relates to evaporative cooling equipment, see page J20. For detailed low sound selections, please consult your local BAC Representative.

Protection Against Basin Water Freezing

When a unit is shut down in freezing weather, the basin water must be protected by draining to an indoor auxiliary remote sump tank (see page H5 for remote sump engineering data; page J12 for sizing guidelines) or by providing supplementary heat to the cold water basin. Supplementary heat can be provided by electric immersion heaters or in some cases, hot water or steam coils, or steam injectors. All exposed water piping, make-up lines, and spray pumps (if applicable) that do not drain at shutdown should be traced with electric heater tape and insulated.

Indoor Installations (Applicable to Series V Models Only)

Many indoor installations require the use of inlet and/or discharge ductwork. **Units installed with inlet ductwork must be ordered with solid bottom panels**. Generally, intake ducts are used only on smaller units while the equipment room is used as a plenum for larger units. Discharge ductwork will normally be required to carry the saturated discharge air from the building.

Both intake and discharge ductwork must have access doors to allow servicing of the fan assembly, drift eliminators, and water distribution system. All ductwork should be symmetrical and designed to provide even air distribution across the face of air intakes and discharge openings.

WARNING:

The discharge opening must be positioned to prevent the introduction of discharge air into the fresh air intakes serving the unit or the ventilation systems of adjacent buildings.

Note: Axial fan units are not suitable for indoor installations.

Safety

Adequate precautions, appropriate for the installation and location of these products, should be taken to safeguard the public from possible injury and the equipment and the premises from damage. Operation, maintenance and repair of this equipment should be undertaken only by personnel qualified to do so. Proper care, procedures and tools must be used in handling, lifting, installing, operating, maintaining, and repairing this equipment to prevent personal injury and/or property damage.

Warranties

Please refer to the Limitation of Warranties applicable to and in effect at the time of the sale/purchase of these products.

APPENDIX E: CONDENSER PUMP

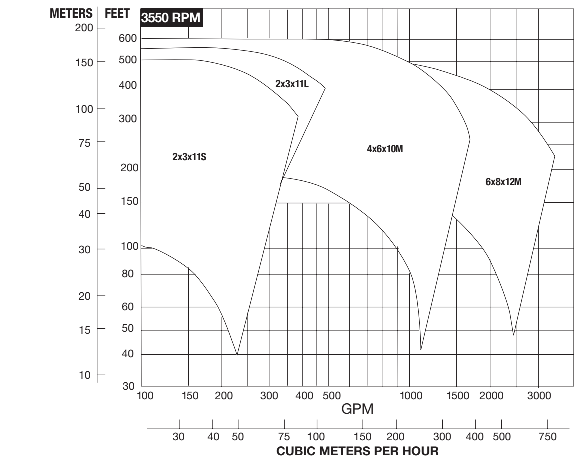
Condenser Water Pumps
Bell & Gossett, HSC3 Series, 10x12x12M
3823 GPM, 80 Ft. Head, 1800RPM, 11" Impeller
100 HP motor, 460 volt / 3 Phase / 60 Hz
Cost: $19,000.00

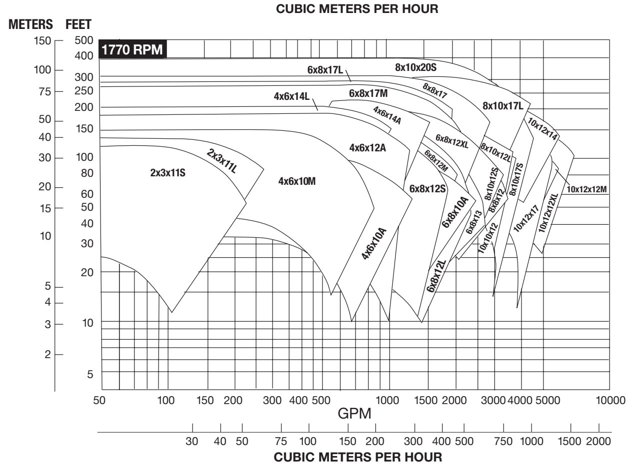
Jim Little
Total Equipment Co.
400 Fifth Ave.
Caraopolis, PA 15108

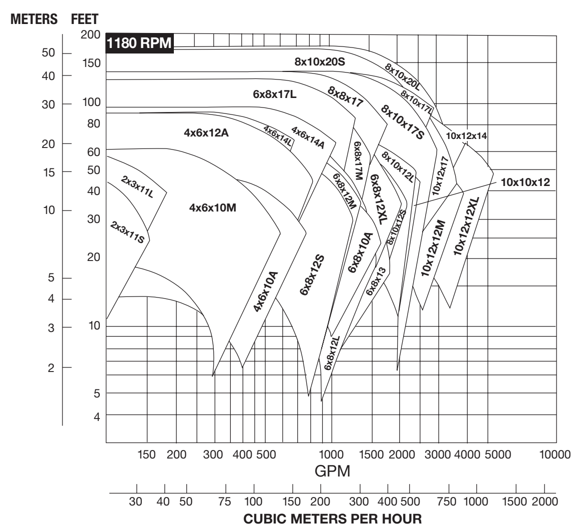
BELL & GOSSETT

CURVE BOOKLET

B-560H







Horizontal Split Case Base Mounted – Double Suction Pump Performance Curves

Bell & Gossett

ITT Industries
Engineered for life

SERIES HSC³ & HSC-S

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USEFUL PUMP FORMULAS

$$\text{Pressure (PSI)} = \frac{\text{Head (Feet)} \times \text{Specific Gravity}}{2.31}$$

$$\text{Head (Feet)} = \frac{\text{Pressure (PSI)} \times 2.31}{\text{Specific Gravity}}$$

$$\text{Vacuum (Inches of Mercury)} = \text{Dynamic Suction Lift (Feet)} \times .883 \times \text{Specific Gravity}$$

$$\text{Horsepower (Brake)} = \frac{\text{GPM} \times \text{Head (Feet)} \times \text{Specific Gravity}}{3960 \times \text{Pump Efficiency}}$$

$$\text{Horsepower (Water)} = \frac{\text{GPM} \times \text{Head (Feet)} \times \text{Specific Gravity}}{3960}$$

$$\text{Efficiency (Pump)} = \frac{\text{Horsepower (Water)}}{\text{Horsepower (Brake)}} \times 100 \text{ Per Cent}$$

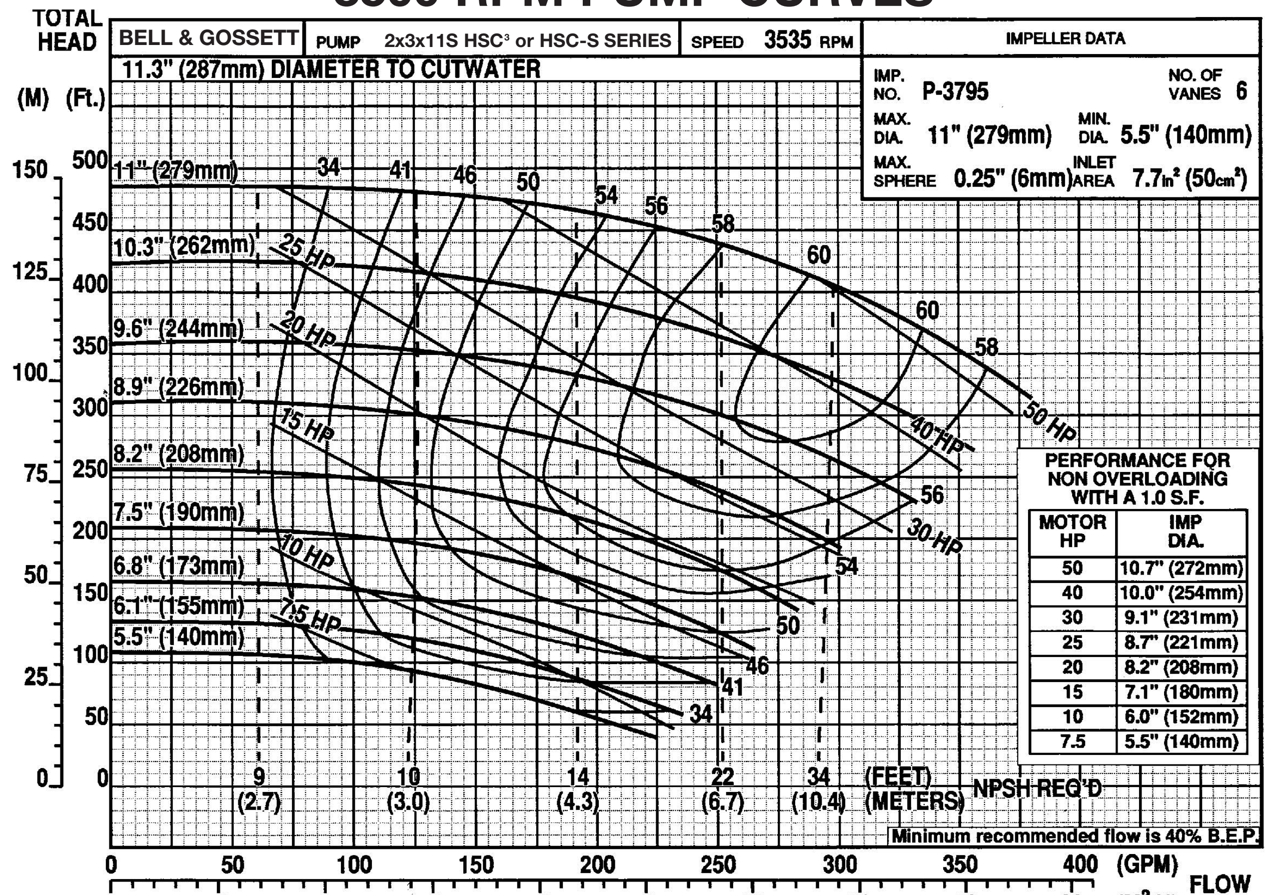
$$\text{NPSH (Available)} = \text{Positive Factors} - \text{Negative Factors}$$

Affinity Laws: Effect of change of speed or impeller diameter on centrifugal pumps.

	GPM Capacity	Ft. Head	BHP
Impeller Diameter Change	$Q_2 = \frac{D_2}{D_1} Q_1$	$H_2 = \left(\frac{D_2}{D_1}\right)^2 H_1$	$P_2 = \left(\frac{D_2}{D_1}\right)^3 P_1$
Speed Change	$Q_2 = \frac{RPM_2}{RPM_1} Q_1$	$H_2 = \left(\frac{RPM_2}{RPM_1}\right)^2 H_1$	$P_2 = \left(\frac{RPM_2}{RPM_1}\right)^3 P_1$

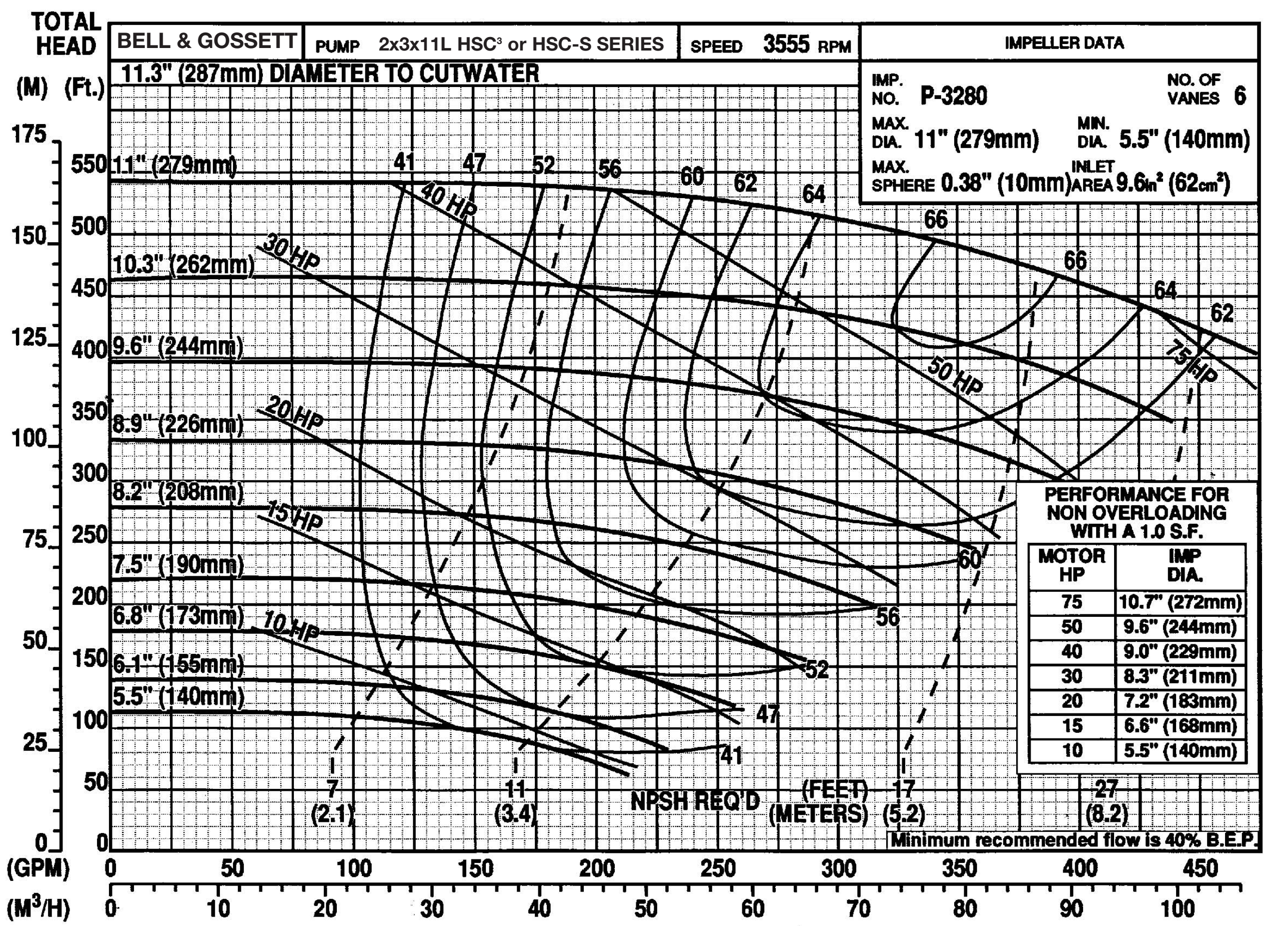
Where Q = GPM, H = Head, P = BHP, D = Impeller Dia., RPM = Pump Speed

3500 RPM PUMP CURVES



PERFORMANCE FOR NON OVERLOADING WITH A 1.0 S.F.

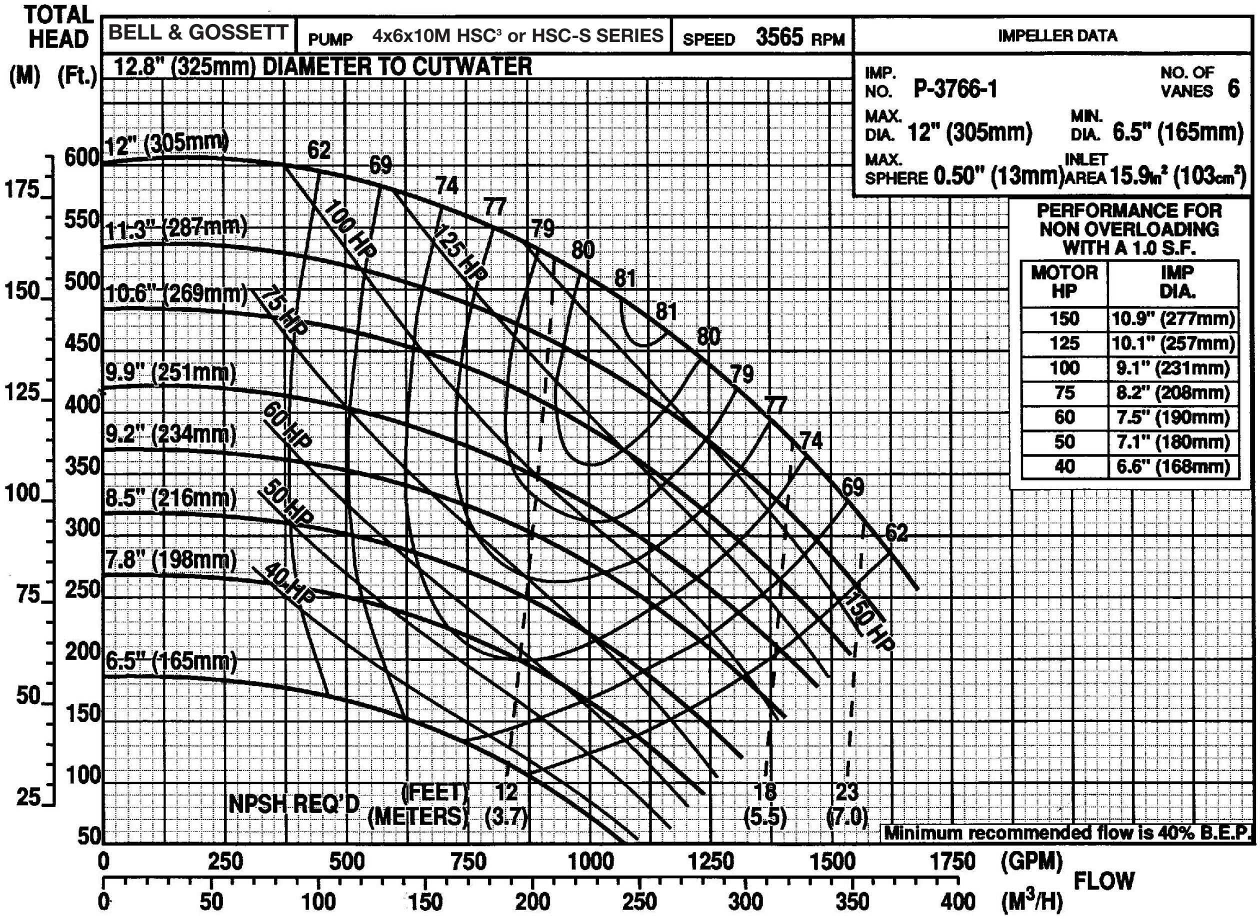
MOTOR HP	IMP DIA.
50	10.7" (272mm)
40	10.0" (254mm)
30	9.1" (231mm)
25	8.7" (221mm)
20	8.2" (208mm)
15	7.1" (180mm)
10	6.0" (152mm)
7.5	5.5" (140mm)

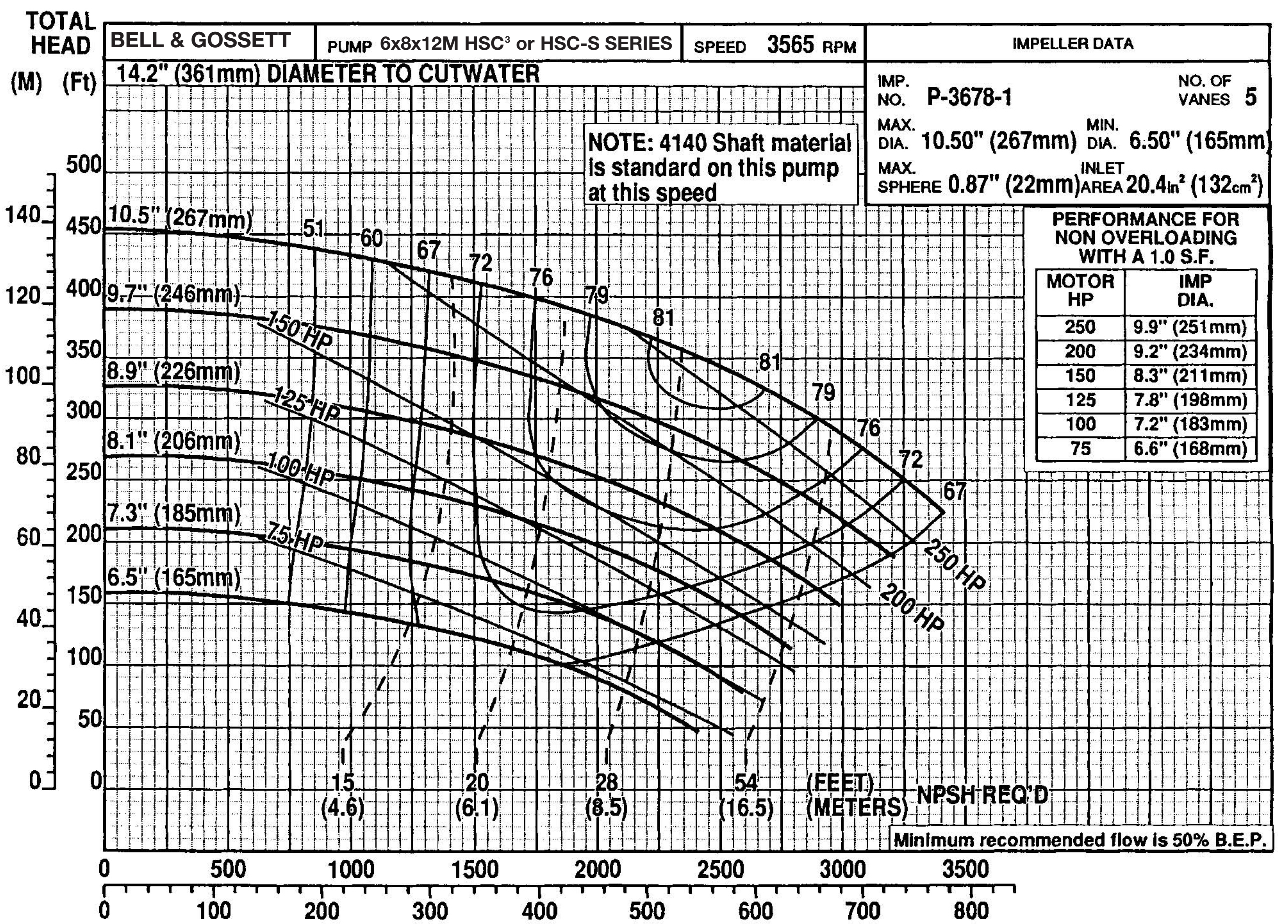


PERFORMANCE FOR NON OVERLOADING WITH A 1.0 S.F.

MOTOR HP	IMP DIA.
75	10.7" (272mm)
50	9.6" (244mm)
40	9.0" (229mm)
30	8.3" (211mm)
20	7.2" (183mm)
15	6.6" (168mm)
10	5.5" (140mm)

3500 RPM PUMP CURVES





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CANADA
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55 Royal Road
Guelph, Ontario,
N1H 1T1, Canada
Phone: (519) 821-1900

APPENDIX F: SMOKE EXHAUST CONTROLLING CODES

[B] 909.8 Exhaust method.
When approved by the fire code official, mechanical smoke control for large enclosed volumes, such as in atriums or malls, shall be permitted to utilize the exhaust method. The design exhaust volumes shall be in accordance with this section.

> [B] 909.8.1 Exhaust rate.
> The height of the lowest horizontal surface of the accumulating smoke layer shall be maintained at least 10 feet (3048 mm) above any walking surface which forms a portion of a required egress system within the smoke zone. The required exhaust rate for the zone shall be the largest of the calculated plume mass flow rates for the possible plume configurations. Provisions shall be made for natural or mechanical supply of air from outside or adjacent smoke zones to make up for the air exhausted. Makeup airflow rates, when measured at the potential fire location, shall not exceed 200 feet per minute (60 960 mm per minute) toward the fire. The temperature of the makeup air shall be such that it does not expose temperature-sensitive fire protection systems beyond their limits.

[B] 909.9 Design fire.
The design fire shall be based on a Q of not less than 5,000 Btu/s (5275 kW) unless a rational analysis is performed by the registered design professional and approved by the fire code official. The design fire shall be based on the analysis in accordance with Section 909.4 and this section.

> [B] 909.9.1 Factors considered.
> The engineering analysis shall include the characteristics of the fuel, fuel load, effects included by the fire, and whether the fire is likely to be steady or unsteady.

[B] 909.10 Equipment.
Equipment such as, but not limited to, fans, ducts, automatic dampers and balance dampers, shall be suitable for their intended use, suitable for the probable exposure temperatures that the rational analysis indicates, and as approved by the fire code official.

> [B] 909.10.1 Exhaust fans.
> Components of exhaust fans shall be rated and certified by the manufacturer for the probable temperature rise to which the components will be exposed.
> This temperature rise shall be computed by:
> $T_s = (Q_c / mc) + (T_a)$ (Equation 9-9)
> where:
> c = Specific heat of smoke at smokelayer temperature, Btu/lb°F. (kJ/kg · K).
> m = Exhaust rate, pounds per second (kg/s).
> Q_c = Convective heat output of fire, Btu/s (kW).

Ta = Ambient temperature,°F (°K).
Ts = Smoke temperature,°F (°K).
Exception: Reduced Ts as calculated based on the assurance of adequate dilution air.

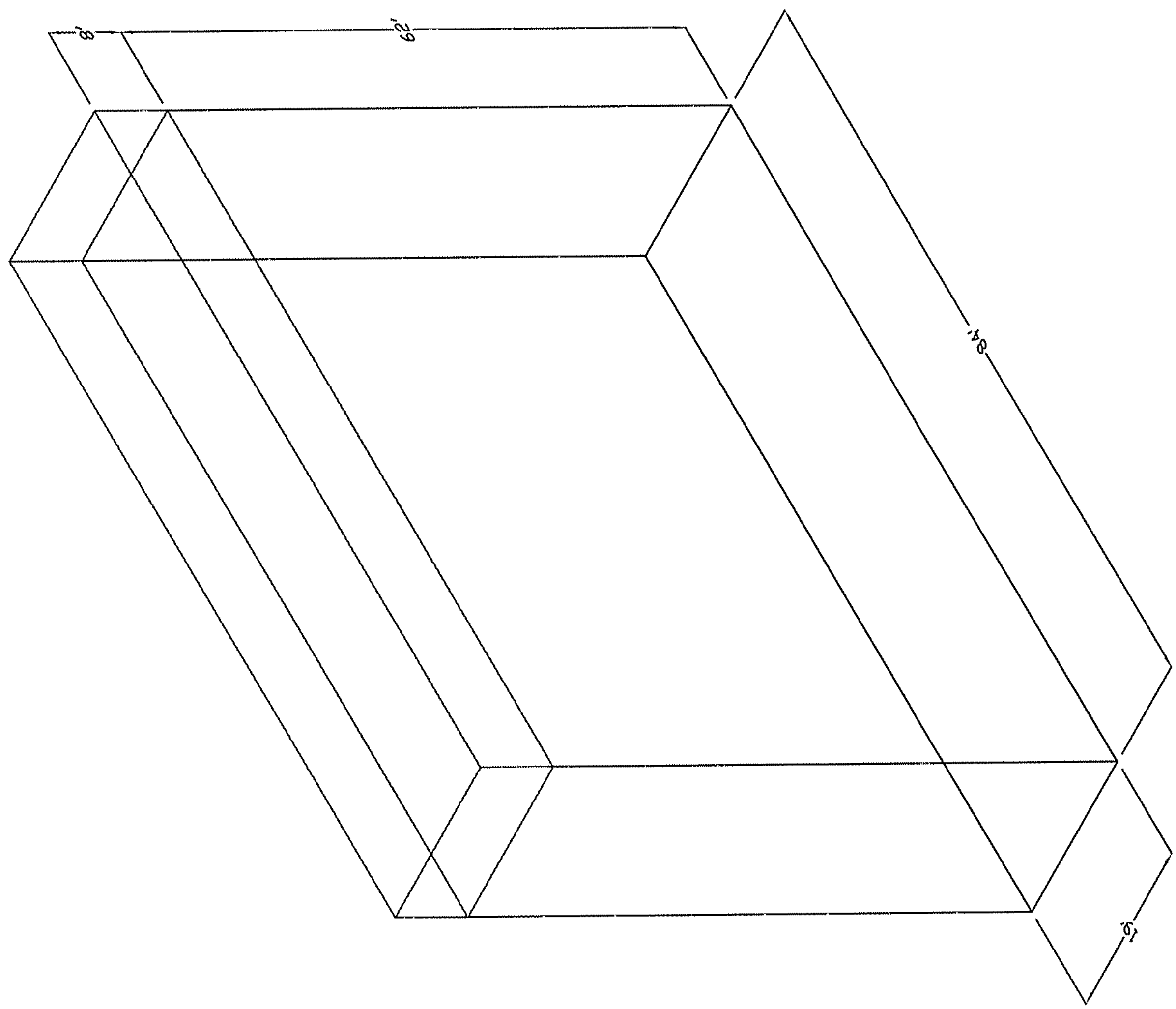
[B] 909.10.2 Ducts.
Duct materials and joints shall be capable of withstanding the probable temperatures and pressures to which they are exposed as determined in accordance with Section 909.10.1. Ducts shall be constructed and supported in accordance with the International Mechanical Code. Ducts shall be leak tested to 1.5 times the maximum design pressure in accordance with nationally accepted practices. Measured leakage shall not exceed 5 percent of design flow. Results of such testing shall be a part of the documentation procedure. Ducts shall be supported directly from fire-resistance-rated structural elements of the building by substantial, noncombustible supports.
Exception: Flexible connections (for the purpose of vibration isolation) complying with the International Mechanical Code and which are constructed of approved fire-resistance-rated materials.

[B] 909.10.3 Equipment, inlets and outlets.
Equipment shall be located so as to not expose uninvolved portions of the building to an additional fire hazard. Outside air inlets shall be located so as to minimize the potential for introducing smoke or flame into the building. Exhaust outlets shall be so located as to minimize reintroduction of smoke into the building and to limit exposure of the building or adjacent buildings to an additional fire hazard.

[B] 909.10.4 Automatic dampers.
Automatic dampers, regardless of the purpose for which they are installed within the smoke control system, shall be listed and conform to the requirements of approved recognized standards.

[B] 909.10.5 Fans.
In addition to other requirements, belt-driven fans shall have 1.5 times the number of belts required for the design duty with the minimum number of belts being two. Fans shall be selected for stable performance based on normal temperature and, where applicable, elevated temperature. Calculations and manufacturer's fan curves shall be part of the documentation procedures. Fans shall be supported and restrained by noncombustible devices in accordance with the structural design requirements of Chapter 16 of the International Building Code. Motors driving fans shall not be operated beyond their nameplate horsepower (kilowatts) as determined from measurement of actual current draw and shall have a minimum service factor of 1.15.

APPENDIX G: ATRIUM SMOKE EVACUATION



8'
62'
84'
16'

Narrow Atrium 19' wide and 84' long
Zone Model Prediction of Exhaust Fan Size
Smoke Control Analysis
Prepared by
Newcomb & Boyd
Consulting Engineering Group

Space area .... 1596 square feet
Ceiling height .... 70 feet
Total simulation time .... 1200 seconds
Ambient temperature .... 75 deg-F

Maintain smoke layer above .... 62 feet
Total smoke exhaust capacity .... 280000 cfm
Estimated fan starting time .... 220 seconds
Estimated smoke layer temp. .... 93 deg-F

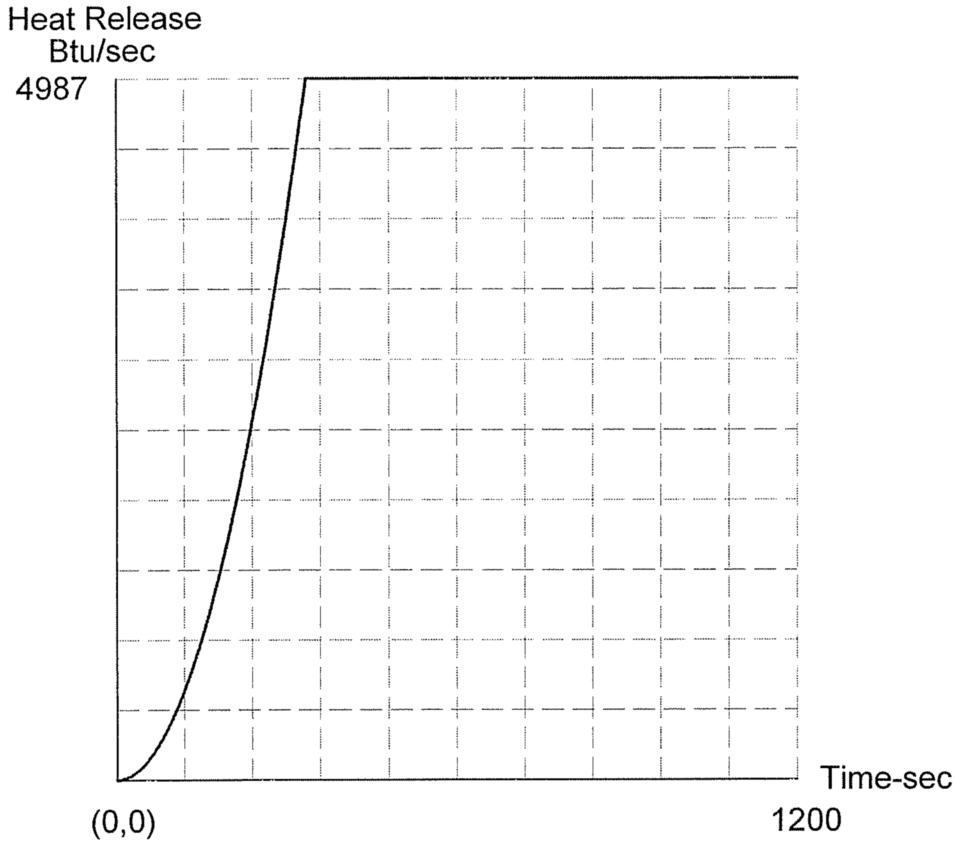
Design fire: fast growth rate proportional to time^2.
The space is equipped with smoke exhaust fans.
The fans start automatically upon activation of a
smoke detector or sprinkler.

Narrow Atrium 19' wide and 84' long
Smoke Control Analysis
Prepared by
Newcomb & Boyd Consulting Engineers
Atlanta, Georgia

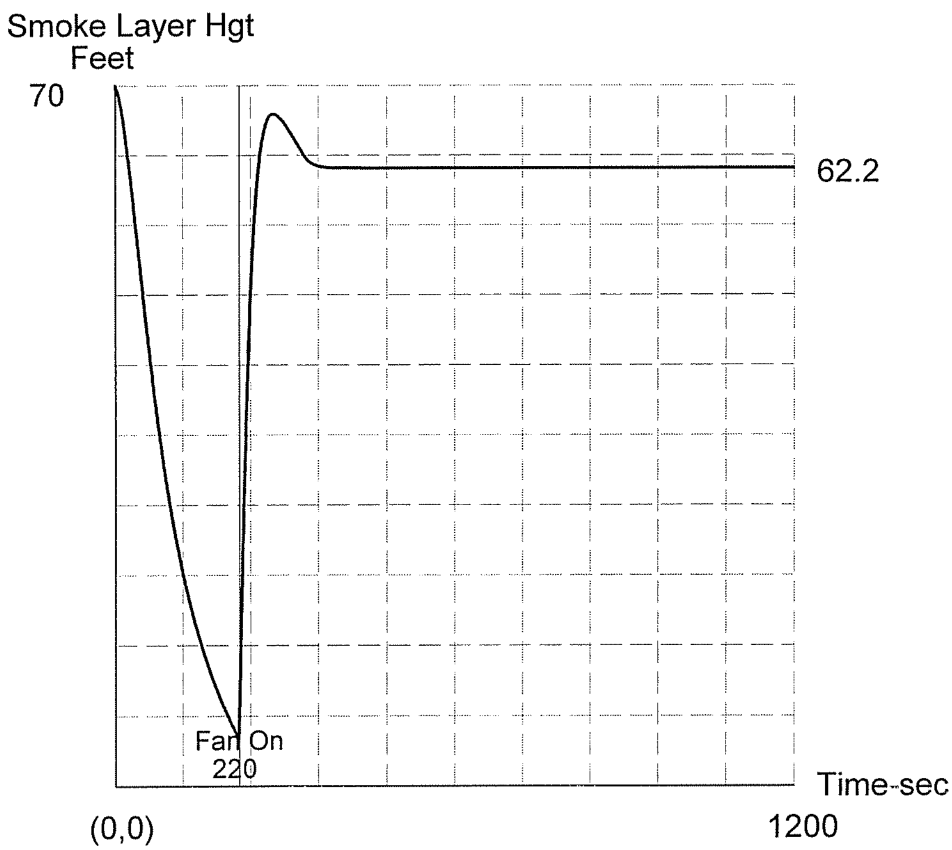
Time sec	Heat Release Btu/sec	Smoke Layer Height-Ft	Smoke Layer Temp-F
		69.8	75
10	4	67.7	75
20	18	63.8	75
30	40	58.9	75
40	71	53.6	76
50	111	48.4	76
60	160	43.3	76
70	218	38.6	77
80	284	34.3	77
90	360	30.5	78
100	444	27.0	79
110	538	23.9	80
120	640	21.2	81
130	751	18.7	82
140	871	16.5	83
150	1000	14.5	85
160	1138	12.7	87
170	1284	11.1	89
180	1440	9.6	91
190	1604	8.2	93
200	1778	6.9	96
210	1960	5.7	99
220	2151	8.0	102
230	2351	32.6	105
240	2560	49.5	101
250	2778	59.4	92
260	3004	64.4	88
270	3240	66.6	88
280	3484	67.1	88
290	3737	66.9	89
300	4000	66.2	89
310	4271	65.3	90
320	4551	64.4	91
330	4840	63.4	92
340	4987	62.6	93
350	4987	62.1	93
360	4987	61.9	94
370	4987	61.8	94
380	4987	61.8	94
390	4987	61.8	94
400	4987	61.7	94

Time sec	Heat Release Btu/sec	Smoke Layer Height-Ft	Smoke Layer Temp-F
400	4987	61.7	94
410	4987	61.7	94
420	4987	61.7	94
430	4987	61.7	94
440	4987	61.7	94
450	4987	61.7	94
460	4987	61.7	94
470	4987	61.7	94
480	4987	61.7	94
490	4987	61.7	94
500	4987	61.7	94
510	4987	61.7	94
520	4987	61.7	94
530	4987	61.7	94
540	4987	61.7	94
550	4987	61.7	94
560	4987	61.7	94
570	4987	61.7	94
580	4987	61.7	94
590	4987	61.7	94
600	4987	61.7	94
610	4987	61.7	94
620	4987	61.7	94
630	4987	61.7	94
640	4987	61.7	94
650	4987	61.7	94
660	4987	61.7	94
670	4987	61.7	94
680	4987	61.7	94
690	4987	61.7	94
700	4987	61.7	94
710	4987	61.7	94
720	4987	61.7	94
730	4987	61.7	94
740	4987	61.7	94
750	4987	61.7	94
760	4987	61.7	94
770	4987	61.7	94
780	4987	61.7	94
790	4987	61.7	94
800	4987	61.7	94

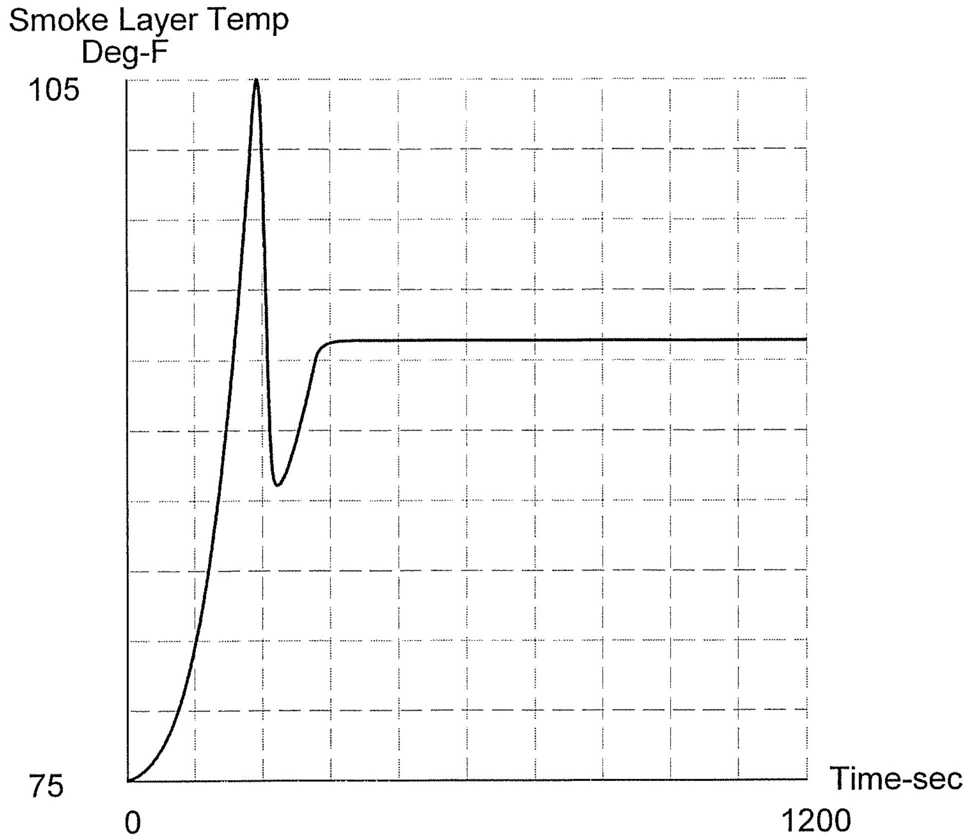
Time sec	Heat Release Btu/sec	Smoke Layer Height-Ft	Smoke Layer Temp-F
800	4987	61.7	94
810	4987	61.7	94
820	4987	61.7	94
830	4987	61.7	94
840	4987	61.7	94
850	4987	61.7	94
860	4987	61.7	94
870	4987	61.7	94
880	4987	61.7	94
890	4987	61.7	94
900	4987	61.7	94
910	4987	61.7	94
920	4987	61.7	94
930	4987	61.7	94
940	4987	61.7	94
950	4987	61.7	94
960	4987	61.7	94
970	4987	61.7	94
980	4987	61.7	94
990	4987	61.7	94
1000	4987	61.7	94
1010	4987	61.7	94
1020	4987	61.7	94
1030	4987	61.7	94
1040	4987	61.7	94
1050	4987	61.7	94
1060	4987	61.7	94
1070	4987	61.7	94
1080	4987	61.7	94
1090	4987	61.7	94
1100	4987	61.7	94
1110	4987	61.7	94
1120	4987	61.7	94
1130	4987	61.7	94
1140	4987	61.7	94
1150	4987	61.7	94
1160	4987	61.7	94
1170	4987	61.7	94
1180	4987	61.7	94
1190	4987	61.7	94
1200	4987	62.2	94



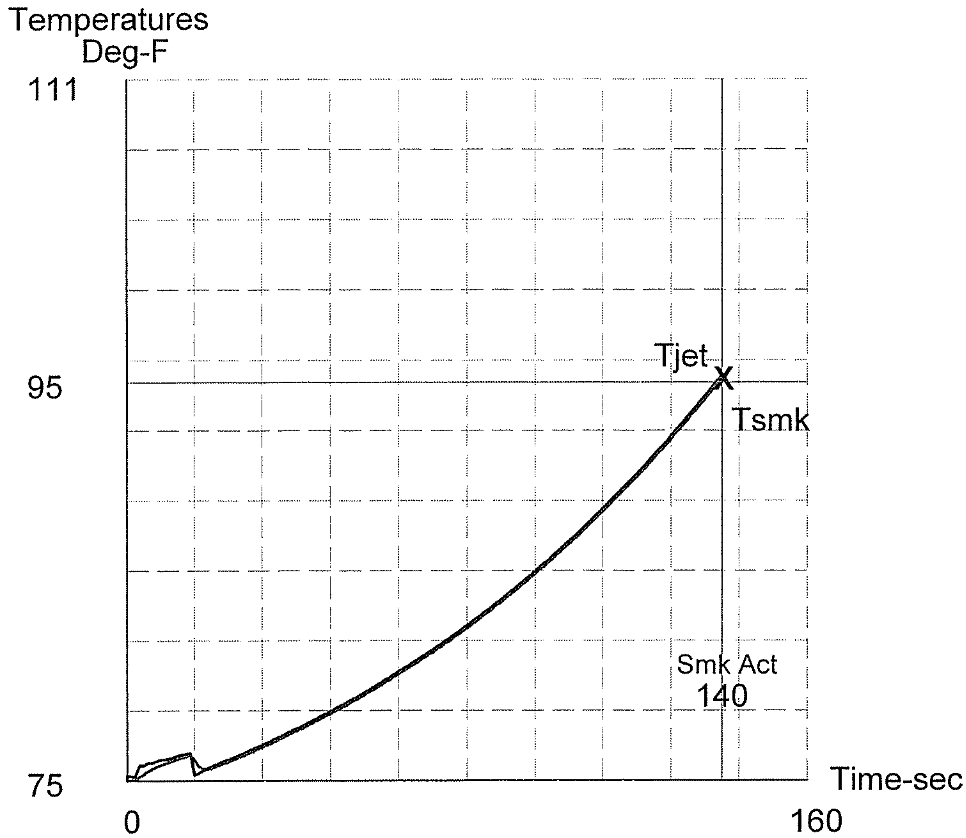
Design-Basis Fire



Smoke Layer Height



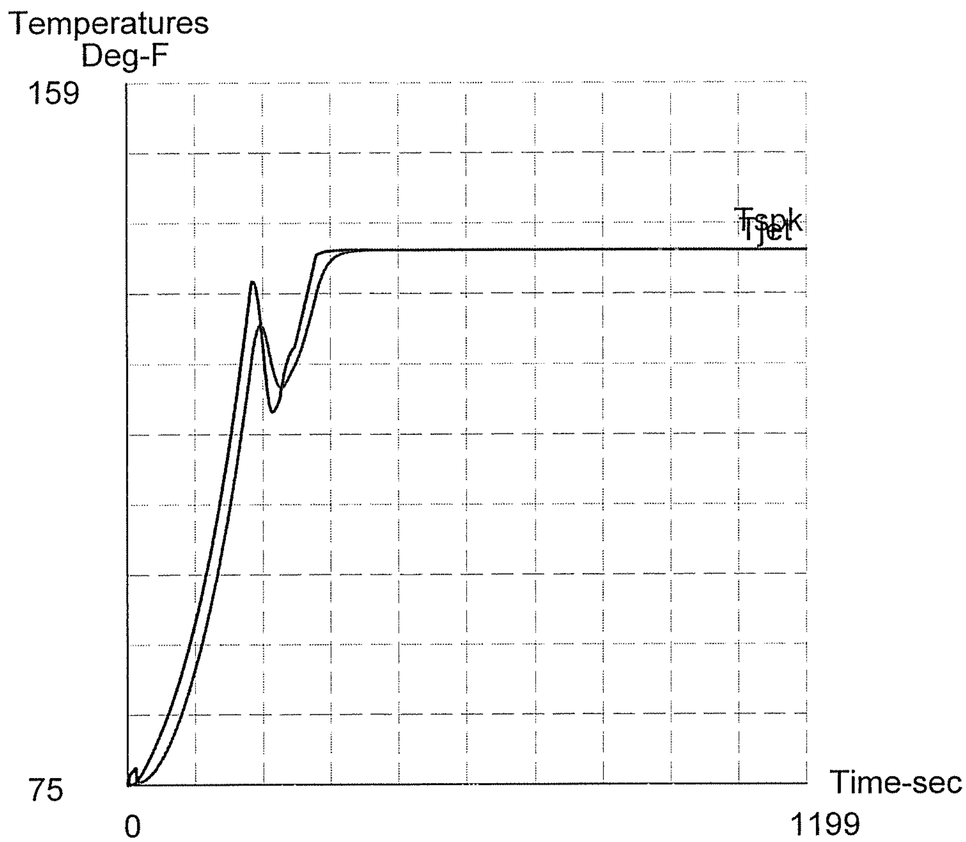
Smoke Layer Average Temperature



Ceiling Jet and Smoke Det. Temperatures

The ceiling jet is a stream of hot gases radiating outward from the fire centerline axis. Temperatures within the ceiling jet are higher than the average smoke layer temperature and are proportional to the fire size, ceiling height, and radial distance.

This graph shows the ceiling jet temperature and the smoke detector temperature at the smoke detector closest to the fire. Smoke detectors are modeled as heat detectors with low RTI values and activation temperatures 20 degrees above the room temperature. The closest smoke detector is located within the ceiling jet at a radial distance of 21 feet from the fire axis.



Ceiling Jet and Sprinkler Temperatures

The sprinklers did not activate during this simulation.

This graph shows the ceiling jet temperature and the sprinkler element temperature at the sprinkler closest to the fire. The element temperature will lag the ceiling jet temperature by an amount that is proportional to the sprinkler RTI factor. If the element temperature reaches its activation temperature, the sprinkler will open. Sprinkler heads used in this simulation have an activation temperature of 165 deg-F and a response time index (RTI) of 70 (ft-sec)^.5 . The closest sprinkler is located within the ceiling jet at a radial distance of 11 feet from the fire axis.

Data File = C:\Documents and Settings\hlw\My Documents\Atrium Zone Mod

Appendix
Smoke Control Analysis

When a fire occurs within an enclosed space, a smoke layer will accumulate at the ceiling and begin to descend toward the floor. If this smoke layer descends into exit paths, the toxic elements in the smoke and the reduction in visibility will be hazards to persons leaving the building. Exhaust fans are frequently required to maintain the smoke layer above the exit paths for a sufficient time to allow occupants to leave safely. The function of this program is to calculate the exhaust fan capacity required to accomplish this task. Several simplifying assumptions are made for the analysis:

* Heat losses from the hot gas layer to the adjoining ceiling and wall surfaces are modeled as a simple percentage of the fire heat release rate. The user may select this percentage.

* The smoke plume is modeled as a point source. The effect of a "virtual origin" for the fire plume is ignored.

* The space is always at a constant pressure.

* The space has an ample supply of oxygen for combustion so that the fire is not oxygen-limited.

Nomenclature for the following narrative is shown in a figure at the end of the narrative. The program uses a two-zone fire model consisting of a hot gas layer in the upper portion of the space and a cool air layer in the lower part of the space. The design fire is input by the user and may be a t^2 type, or a custom fire. The t^2 fire may have a maximum heat release value and a decay period if input by the user. The t^2 fire grows proportionally to the square of the time from ignition and is categorized as "slow", "medium", "fast", or "ultra-fast" according to the following formula:

$$Q = \alpha t^2$$

where

Q = heat release rate in Btu/second; α = growth constant; t = time

$\alpha = 0.002778$ (slow)

$\alpha = 0.0111$ (medium)

$\alpha = 0.0444$ (fast)

$\alpha = 0.1778$ (ultra-fast)

A custom fire can be modeled using up to 20 data pairs, input by the user, representing the heat release rate of the fire versus time. Heat release rates for custom fires are calculated by interpolation between these data pairs.

The smoke in the fire plume consists of a relatively small amount of combustion products mixed with large quantities of entrained air.

The quantity of entrained air depends on several factors, including the fire size, the average flame height, and the clear height to the bottom of the smoke layer. The average flame height is estimated using the following relation:

$$\mathbf{z_f = 0.533Q_c^{2/5}}$$

where

Qc = convective heat release rate in Btu/sec

When the smoke layer is above the average flame height, the smoke production rate is estimated by:

$$\mathbf{m = 0.022Q_c^{1/3}z^{5/3} + 0.0042Q_c}$$

where

m = mass production rate lbs/sec; Qc = convective heat release rate Btu/sec
z = clear height of the smoke layer

When the smoke layer is below the average flame height, the following relation is used:

$$\mathbf{m = 0.0208Q_c^{3/5}z}$$

The convective portion of the heat release rate is generally taken as 70% of the total heat release but may be edited.

$$Q_c = 0.7\ Q$$

The smoke production rate is normally expressed in cubic feet per minute rather than lbs/second. The conversion to cubic feet per minute (cfm) depends on the density of the smoke according to the following relationship:

$$cfm = \frac{60m}{\rho}$$

The density of smoke (ρ) is taken as 0.075 lbs/ cubic foot at 70^0F and varies with the absolute temperature according to the following relationship:

$$\rho = 39.709 / T$$

$$\text{where } T = T^0F + 460$$

Since the smoke production rate is a function of the fire size and the instantaneous height to the bottom of the smoke layer, the program uses a numerical integration technique to solve differential equations at 1-second intervals to obtain values of smoke layer height and average smoke layer temperature during the simulation period.

The effects of a fire at the floor of a large space are not felt instantly at the ceiling, but are delayed due to the transport time required for the smoke to reach the ceiling. This delay can be important when predicting the operating times of detection devices or sprinklers. The total transport time for smoke to reach a point on the ceiling includes both vertical and radial components and may be estimated from plume theory by the following equation:

$$t_{delay} = \frac{0.67H^{4/3}}{Q^{1/3}} + \frac{r^{11/16}}{1.2Q^{1/3}H^{1/2}}$$

If selected by the user, the program can incorporate the transport time delays to calculate both the actual fire and the sensed fire as a function of time.

The activation time of smoke detectors, heat detectors, and sprinklers is modeled using the concept of the Response Time Index (RTI) in conjunction with Alpert's ceiling jet equations for unconfined ceilings.

$$\text{Sprinkler response} \quad dT_e/dt = ((U_g)^{1/2}/RTI)(T_g - T_e)$$

where
T_e = sprinkler element temperature
U_g = ceiling jet velocity
RTI = response time index
T_g = ceiling jet temperature

and

$$T_g = ((0.433\ Q^{2/3}\ Tu) / H^{5/3}) + Tu \qquad \text{for } r/H < 0.18$$

$$T_g = (0.138(Q/r)^{2/3}(Tu) / H) + Tu \qquad \text{for } r/H > 0.18$$

$$U_g = 4.72(Q/H)^{1/3} \quad \text{for } r/H < 0.15$$

$$U_g = 0.972(Q^{1/3})(H^{1/2}) / r^{5/6} \quad \text{for } r/H > 0.15$$

where
Tu = upper layer temperature - ^{0}R
r = radial distance from the plume centerline to the detector – ft
H = ceiling height - ft

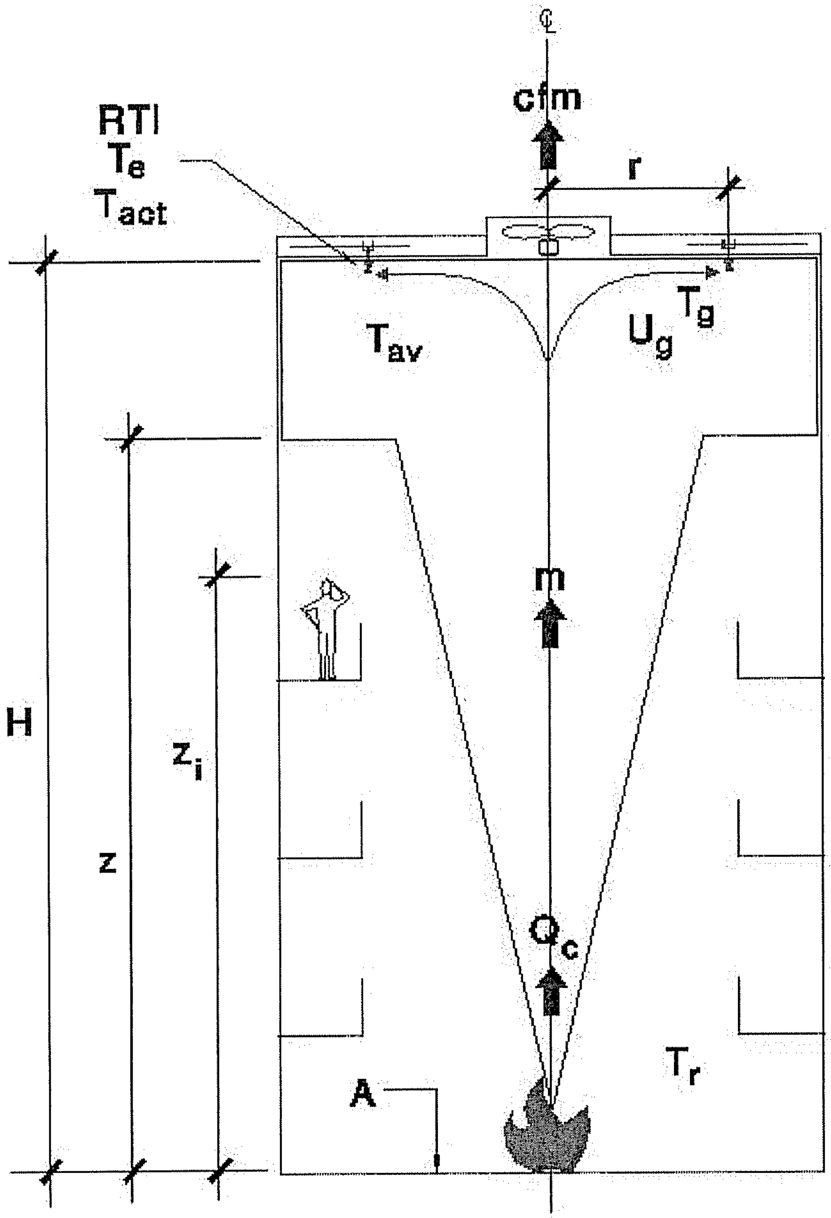
Heat detectors are modeled as either fixed-temperature type or as fixed-temperature and rate-of-rise type as selected by the user. A rate-of-rise detector is considered to operate if the element temperature increases faster than 0.25°F per second for 10 consecutive seconds.

As a layer of hot gases collects at the ceiling, the ceiling jet from the fire plume will entrain gas from this hot layer. This results in higher ceiling jet temperatures and velocities which affect the response times of detection devices. The effect of the hot gas layer on the ceiling jet is modeled by adjusting the values of **Q** and **H** according to the method developed by David Evans of the National Institute of Standards and Technology.

Sprinklers and heat detectors operate when the element temperature reaches the activation point. Smoke detector activation is assumed to occur when the detector temperature is 20 degrees above normal room ambient temperature. The response of detectors and sprinklers is also a time-varying function and is modeled using the same numerical integration technique.

If selected by the user, the operation of a sprinkler head will stabilize the heat release of the fire at the rate where the sprinkler operates. The sprinkler stabilizes but does not reduce the heat release rate.

Smoke exhaust fans, if present, are started when any detector or sprinkler operates.



Nomenclature

APPENDIX H: PHOENICS CFD MODEL SLICES

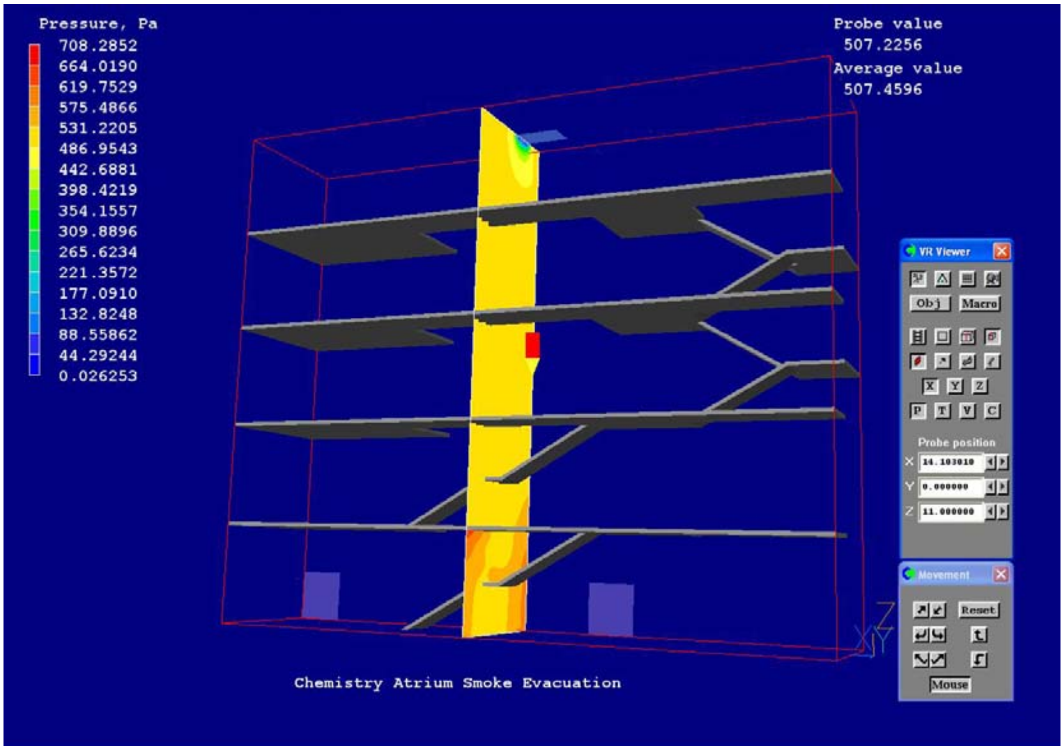


***Figure 1**:* Phoenics Pressure X Slice 1

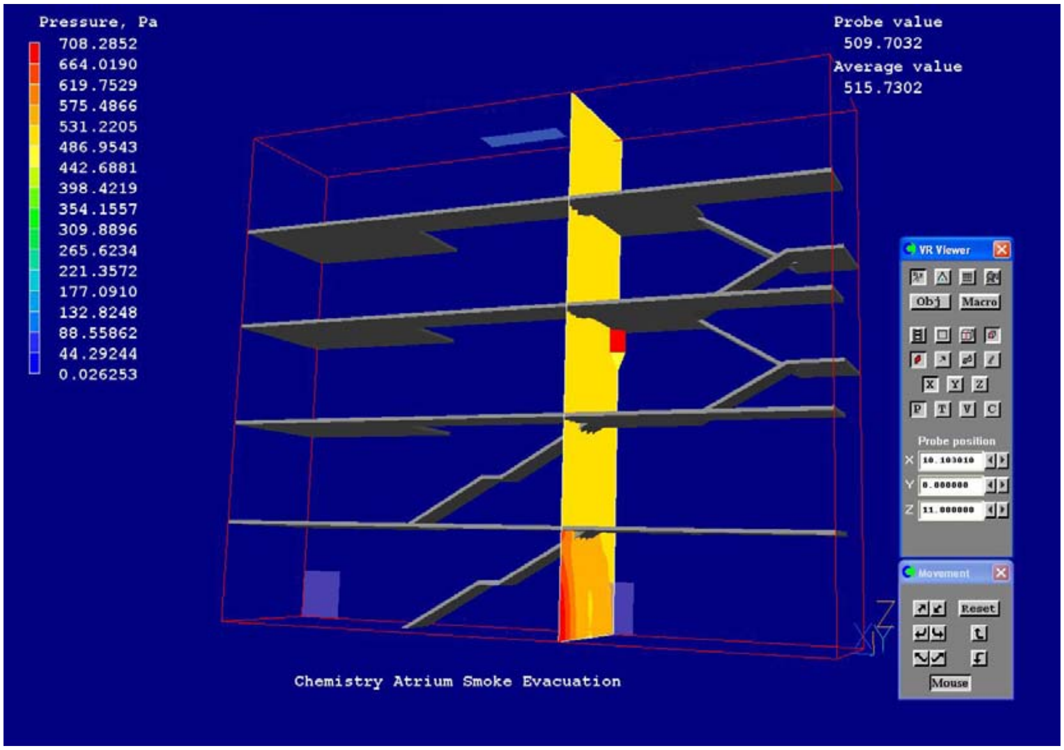


Figure 2: Phoenics Pressure X Slice 2

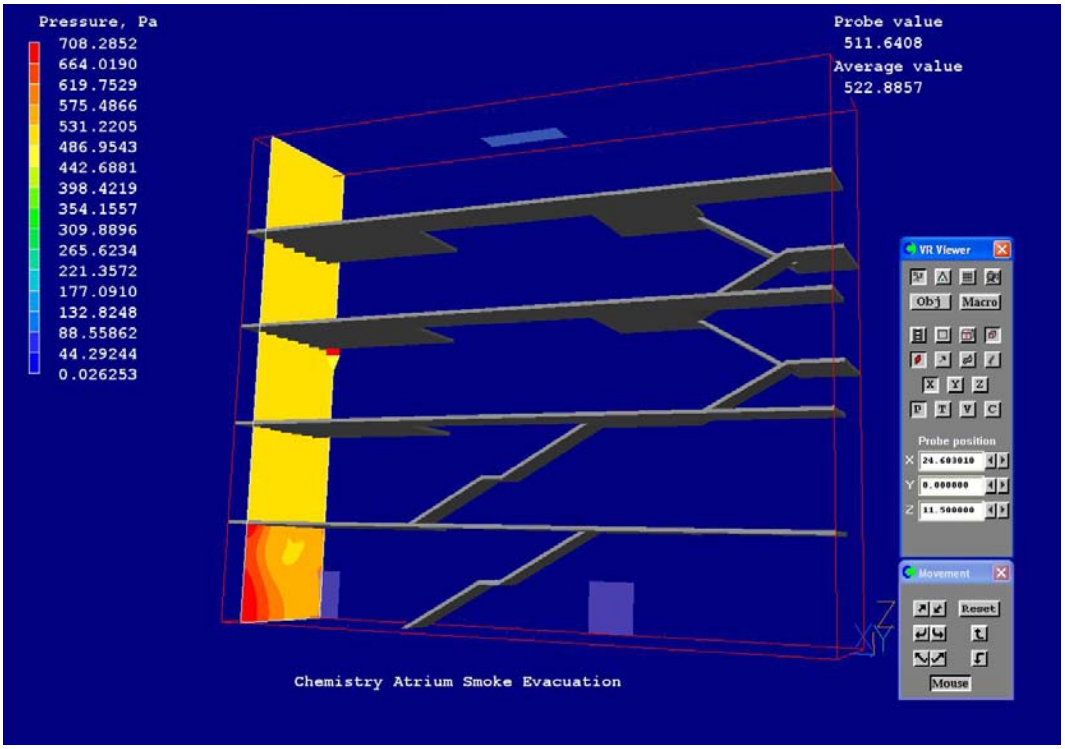


Figure 3: Phoenics Pressure X Slice 3

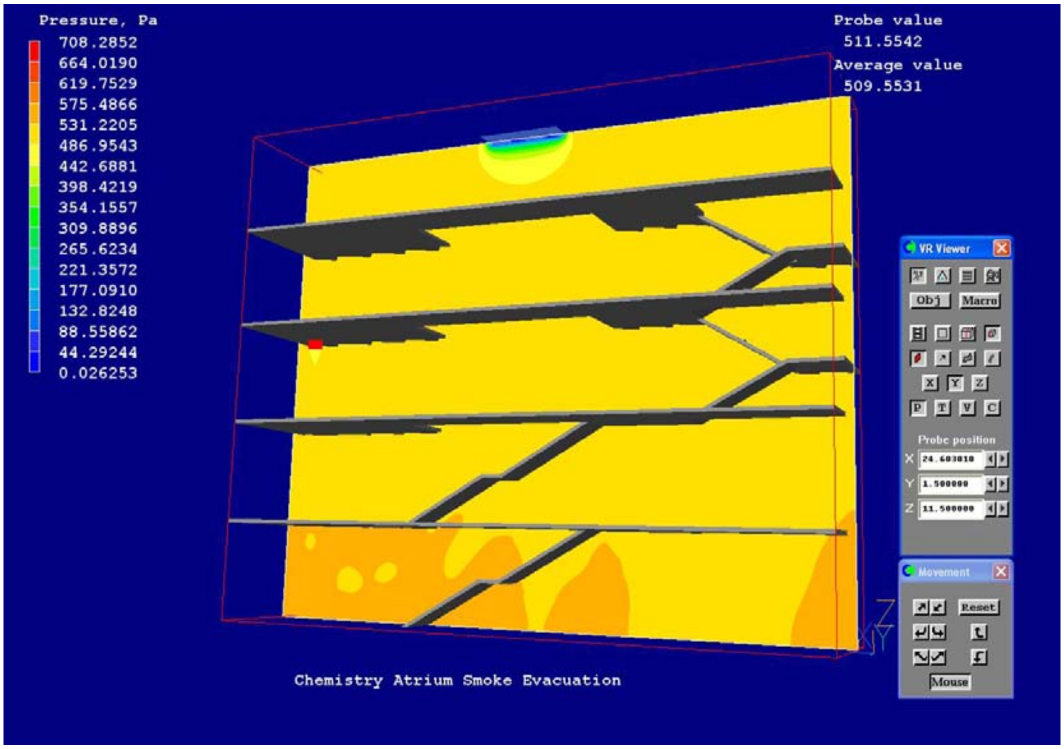


Figure 4: Phoenics Pressure Y Slice 1

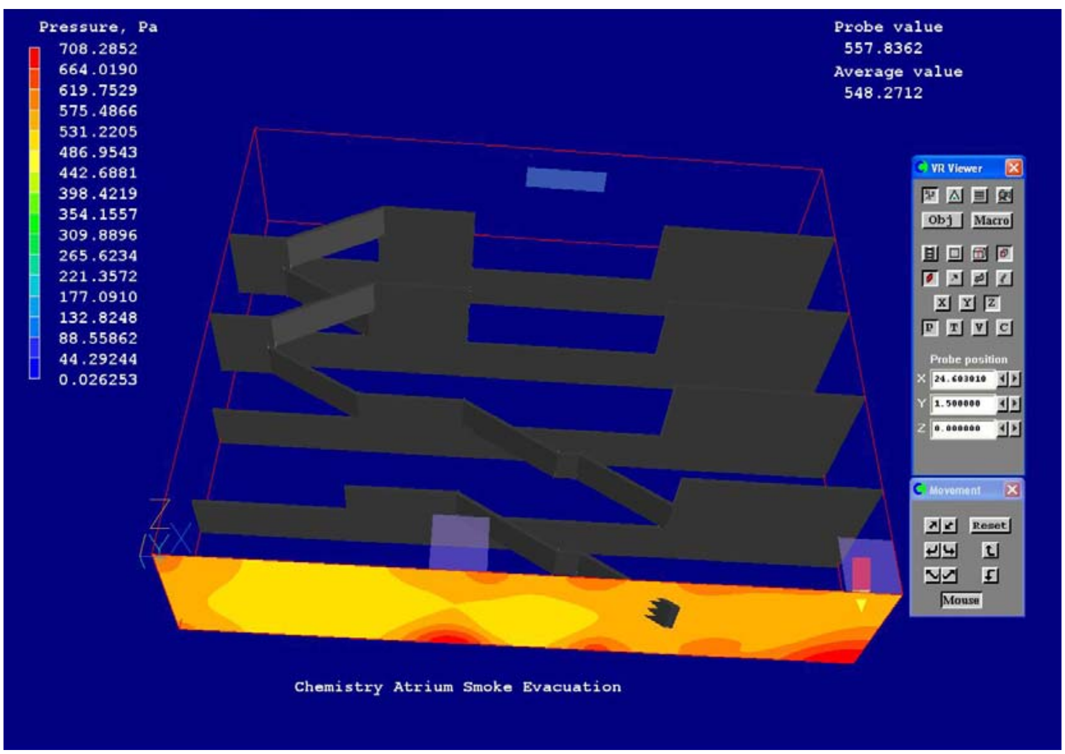


Figure 5: Phoenics Pressure Z Slice 1

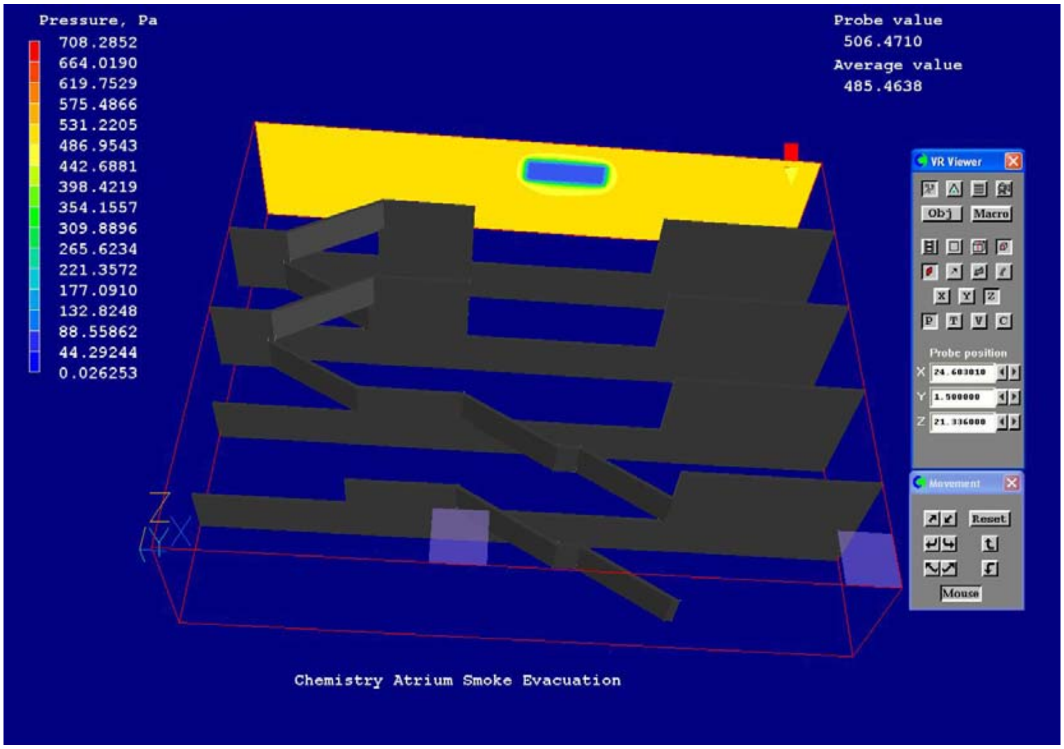


Figure 6: Phoenics Pressure Z Slice 2

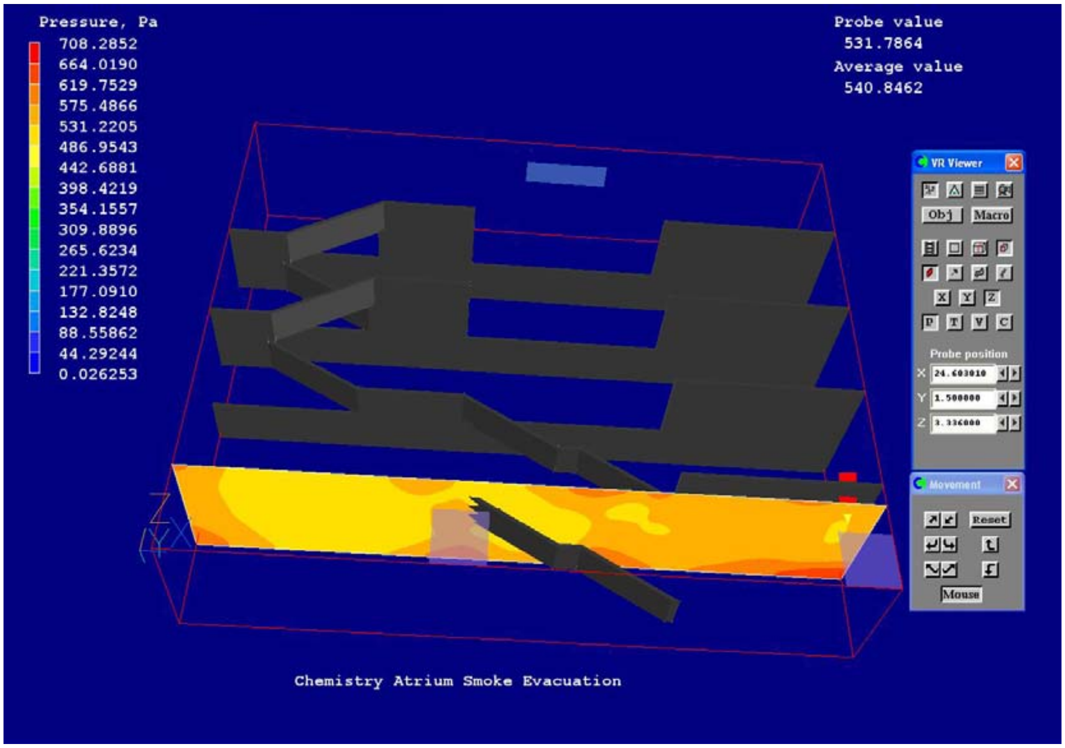


Figure 7: Phoenics Pressure Z Slice 3

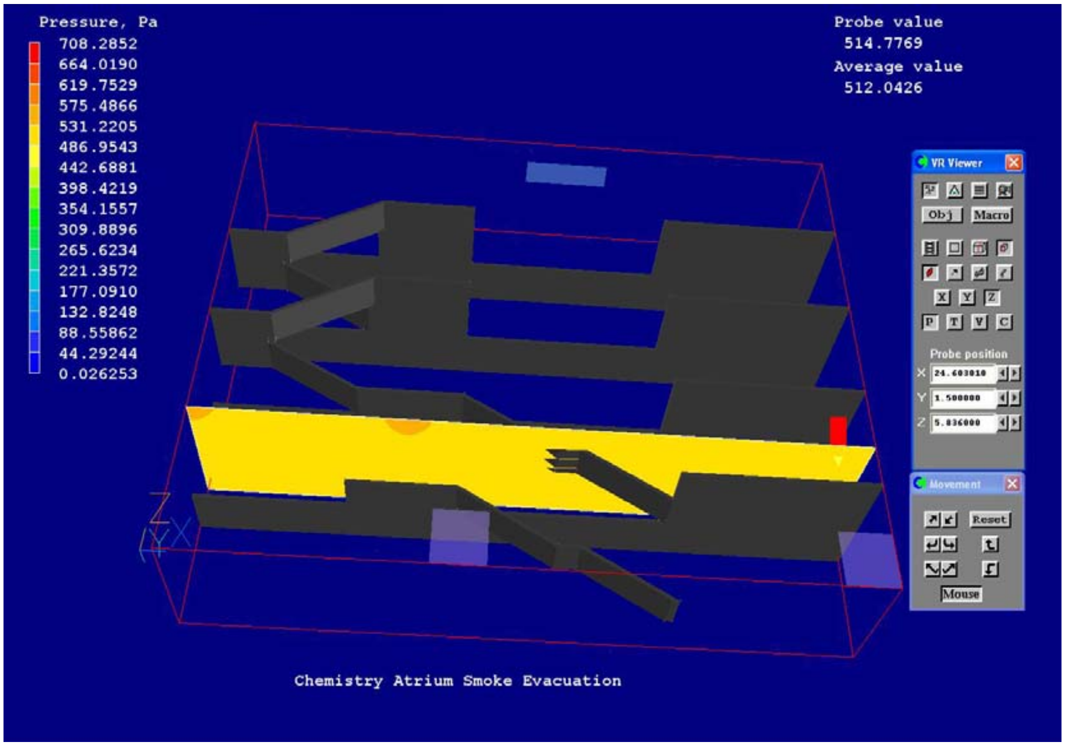


Figure 8: Phoenics Pressure Z Slice 4

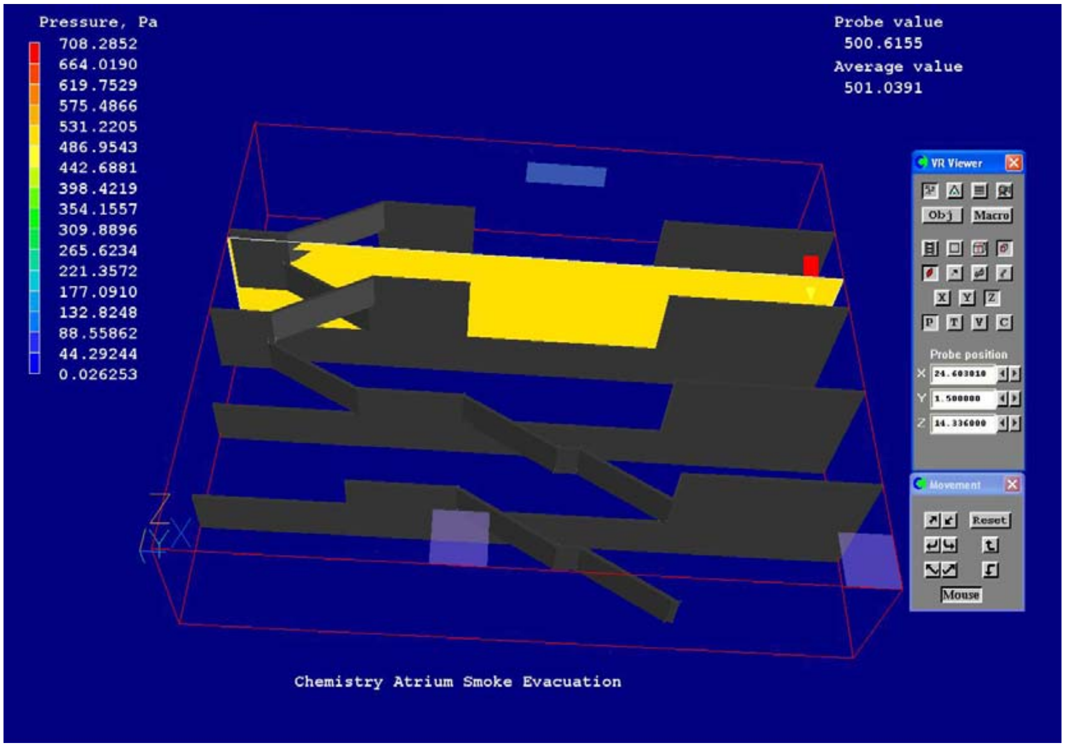


Figure 9: Phoenics Pressure Z Slice 5

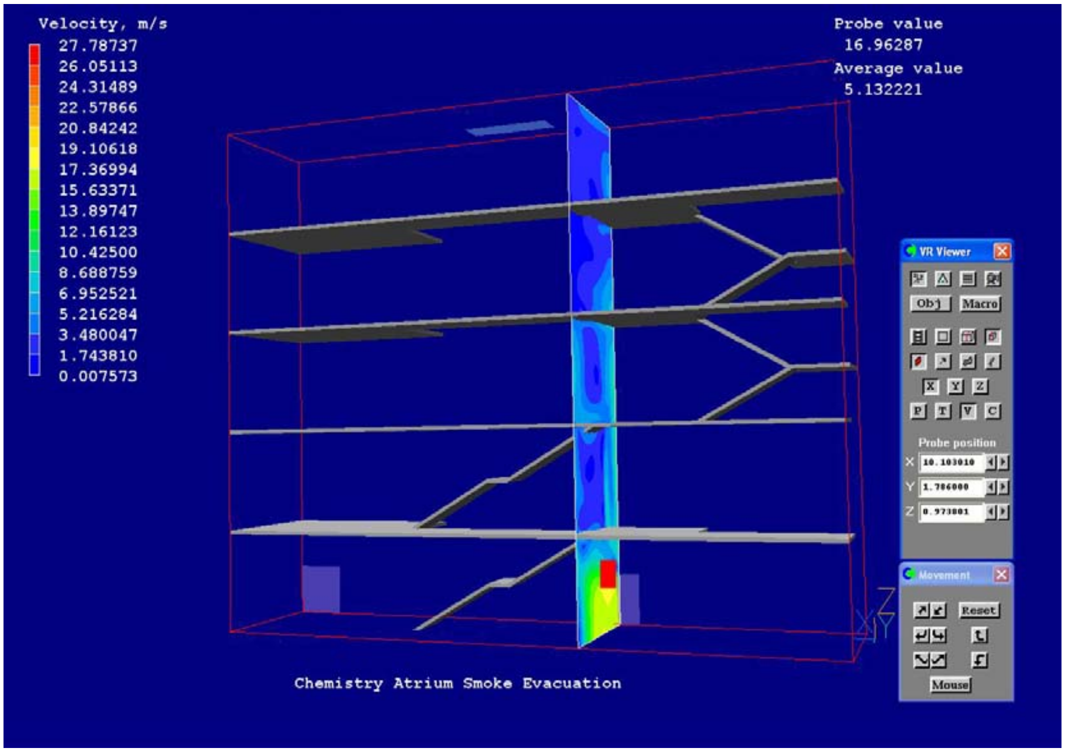


Figure 10: Phoenics Velocity X Slice 1

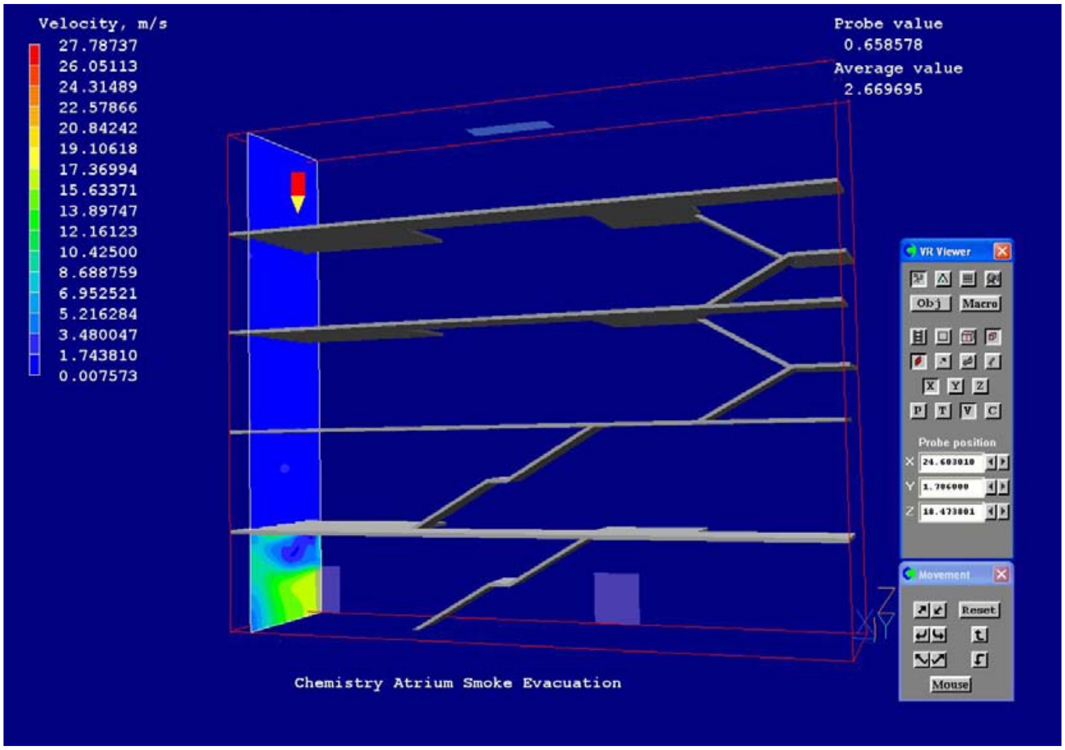


Figure 11: Phoenics Velocity X Slice 2

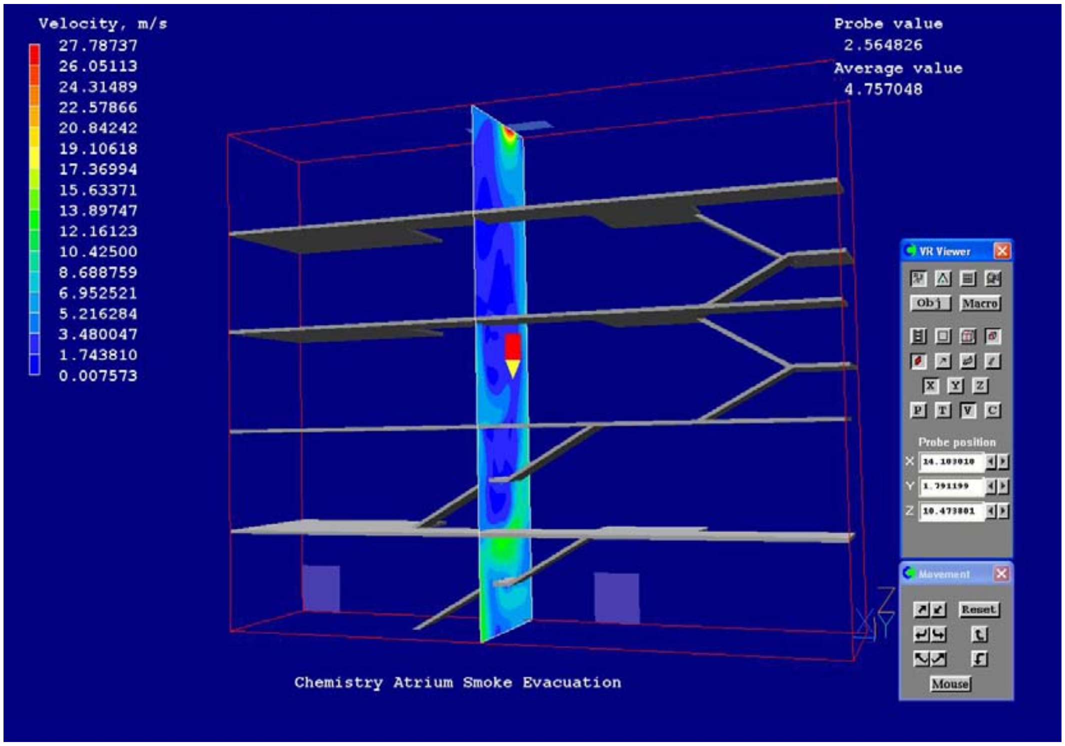


Figure 12: Phoenics Velocity X Slice 3

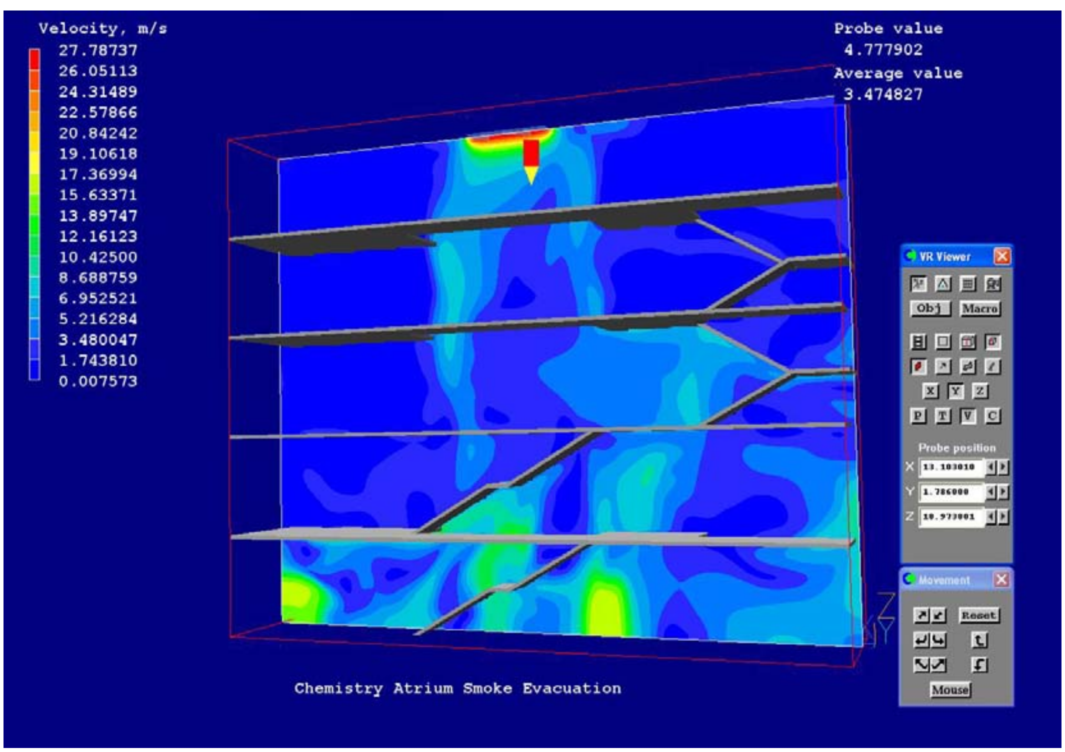


Figure 13: Phoenics Velocity Y Slice 1

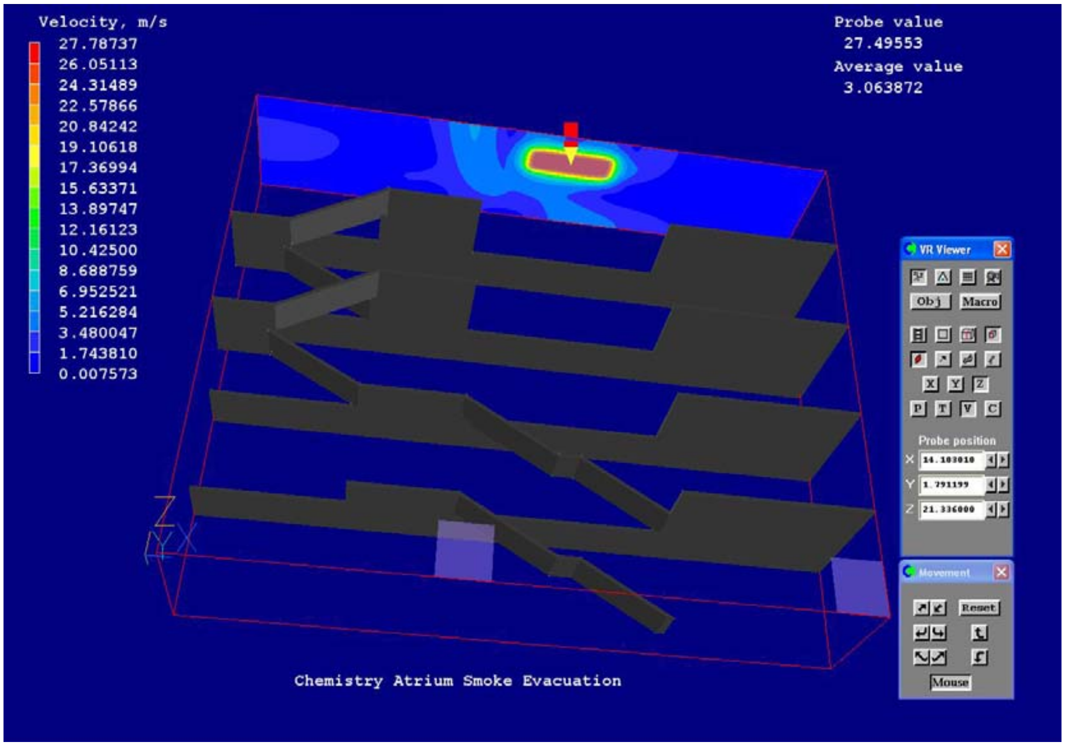


Figure 14: Phoenics Velocity Z Slice 1

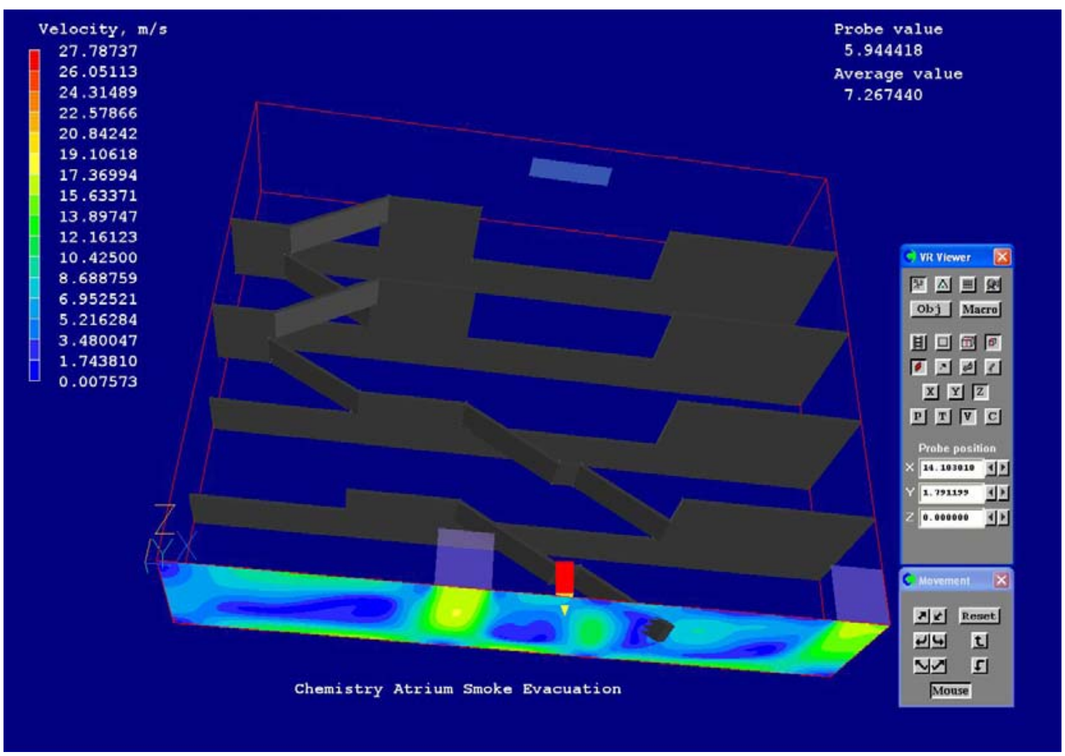


Figure 15: Phoenics Velocity Z Slice 2

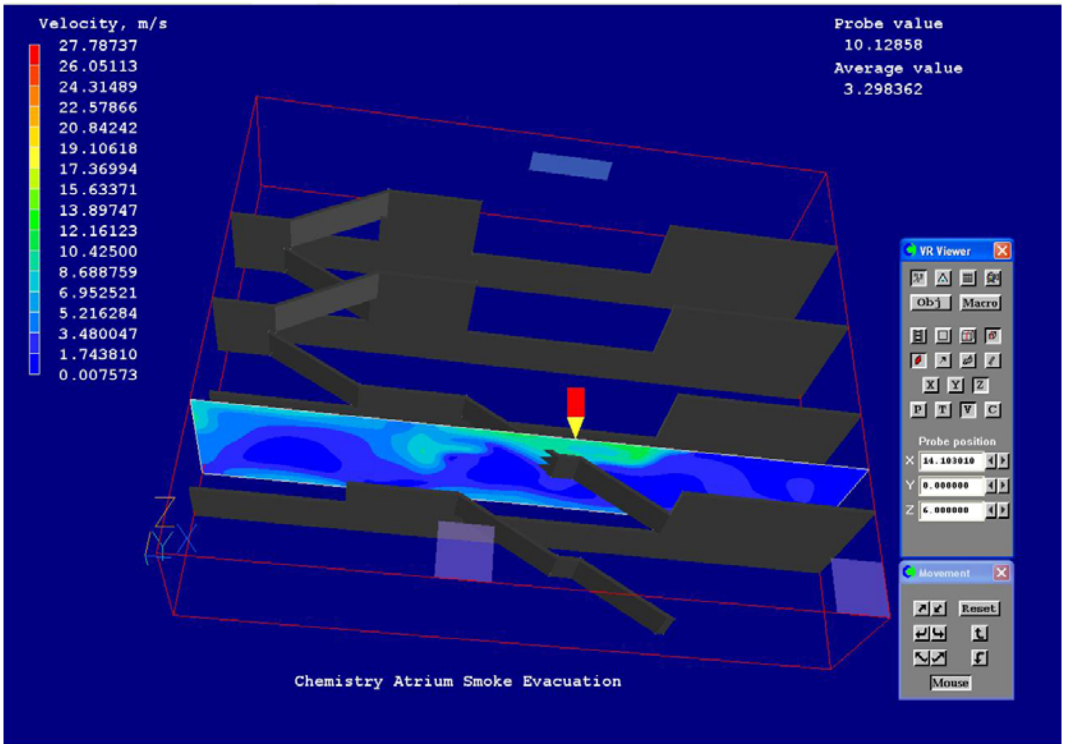


Figure 16: Phoenics Velocity Z Slice 3

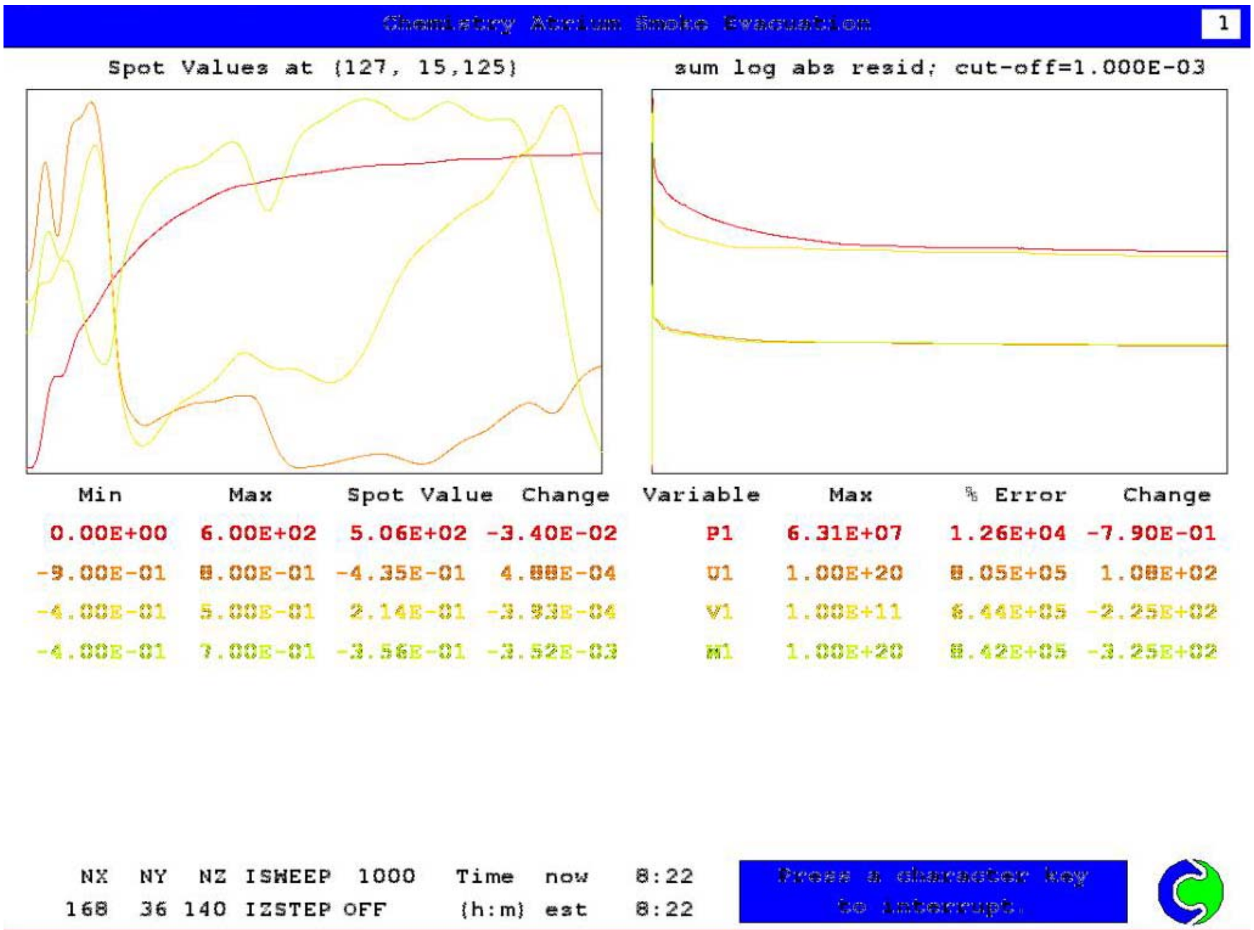


Figure 17: Phoenics Result

APPENDIX I: ATRIUM SMOKE CONTAMINATION

CONTAMINATION STUDY CHEMISTYRY ATRIUM

Developed Using ASHRAE 1997 Fundamentals Chapter 15

VARIABLES

$U_{crit,o}$=Critical Wind Speed [Zero Stack Height]

U_{crit}=Critical Wind Speed [Stack Height]

$D_{crit,o}$=Dilution at Critical Wind Speed [Zero Stack Height]

D_{crit}=Dilution at Critical Wind Speed [Stack Height]

Y=Height-to-Spread Parameter

V_e=Velocity of Discharged Air [fpm]

S=String Distance to Air Intake

A_e=Cross Sectional Area of Stack [ft]

B_1=Exhaust Jet Trajectory

H_S=Stack Height

DEFINED VARIABLES

$S = 56$ *ft*

$A_e = 78.54$ *ft²*

$B_1 = 0.059$ *Default Value, Unitless*

$V_e = 4000$ *fpm*

$H_s = 18$ *ft*

FORMULAS

$$U_{crito} = V_e \cdot \frac{3.6}{S} \cdot \left[\frac{A_e}{B_1}\right]^{0.5}$$

$$D_{crito} = \frac{\left[1 + 26 \cdot \frac{V_e}{U_{crito}}\right]^2}{1 + 13 \cdot \frac{V_e}{U_{crito}}}$$

$$Y = 28.9 \cdot \frac{H_s^{\,2}}{S^{\,2}}$$

$$U_{crit} = \frac{U_{crito}}{[Y + 1]^{0.5} - Y^{0.5}}$$

$$D_{crit} = D_{crito} \cdot \left[\frac{U_{crit}}{U_{crito}} \right]^{\left[Y + Y^{0.5} + (Y + 1)^{0.5} \right]}$$

SOLUTION
Unit Settings: [F]/[psia]/[lbm]/[degrees]

A_e = 78.54	B_1 = 0.059	D_{crit} = 150563	D_{crito} = 22.17
H_s = 18	S = 56	U_{crit} = 34942	U_{crito} = 9382 [-]
V_e = 4000	Y = 2.986 [-]		

No unit problems were detected.
Purple units were automatically set. Right click on the variable to confirm or change the units.

APPENDIX J: CENTRIFUGAL FAN

Centrifugal Fan
Greenheck, 73BISW21
100,000 CFM
150HP, 1725 RPM, 460 Volt / 60 Hz / 3 Phase
Cost: $23,125

Douglas E. Leonard
H&H Sales Associates, Inc.
4510A Westport Drive
Mechanicsburg, PA 17055

Greenheck 03/17/06 JOB: PENN STATE UNIVERSITY - 3-17-06

Fan **MARK:** SMOKE EVACUATION FAN

BISW Series 21 Backward Inclined Single Width

ENGINEERING DATA

Approx. Fan Weight (lb)	Class	Max. T Motor Frame Size	WR^2 (lb•ft^2)
4,370	II	404	4,780

**Weight does NOT include motor, drives, or accessories.

Motor Location	Drive Type
N/A	Constant

CONFIGURATION

Arrangement	Rotation	Discharge Position	Material Type
10	CW	UB	Steel

INSTALLATION

Inlet Conditions	Outlet Conditions
Standard	Standard

MOTOR SPECS

Size (hp)	RPM	V/C/P	Enclosure	Motor Frame...
100	1725	460/60/3	ODP	404

Tag: SMOKE EVACUATION FAN

STANDARD CONSTRUCTION FEATURES

HOUSING: Series 21 class I and II fans feature Perma-Lock construction on sizes 7-49 and continuously welded housing on sizes 54-73 and all class III fans • Inlet collars on Arr. 1, 9, 10 • Unpunched outlet flange standard on class I and II sizes 33-73, all class III fans, and all downblast fans (DB) • All structural steel parts phosphatized and coated with Permatector BEARINGS, SHAFT, AND WHEEL: Heavy duty, self-aligning ball or roller pillow block bearings • Polished, solid steel shafts • Fully welded centrifugal wheel

SELECTED OPTIONS & ACCESSORIES

Flange - Outlet, Punched
Heat Slinger
Structural Base, Free Standing Isolator w/ 1" Defl.,Base Field Mntd
High Temp. Alum. Paint, Entire Fan and Accessories
Drive Service Factor of 1.5 - Standard
Weatherhood, w/ High Temp Alum. Ctg.
UL/cUL-705 - "Power Ventilators"
Drain Conn. - 1" Pipe Thread w/ Plug
Extended Lube Lines
HFP (251-500º F / 122-260º C)
Access door - Bolted
High Temp. Shaft Seal
Energy Efficient Motor meets EPACT and NEMA 1210

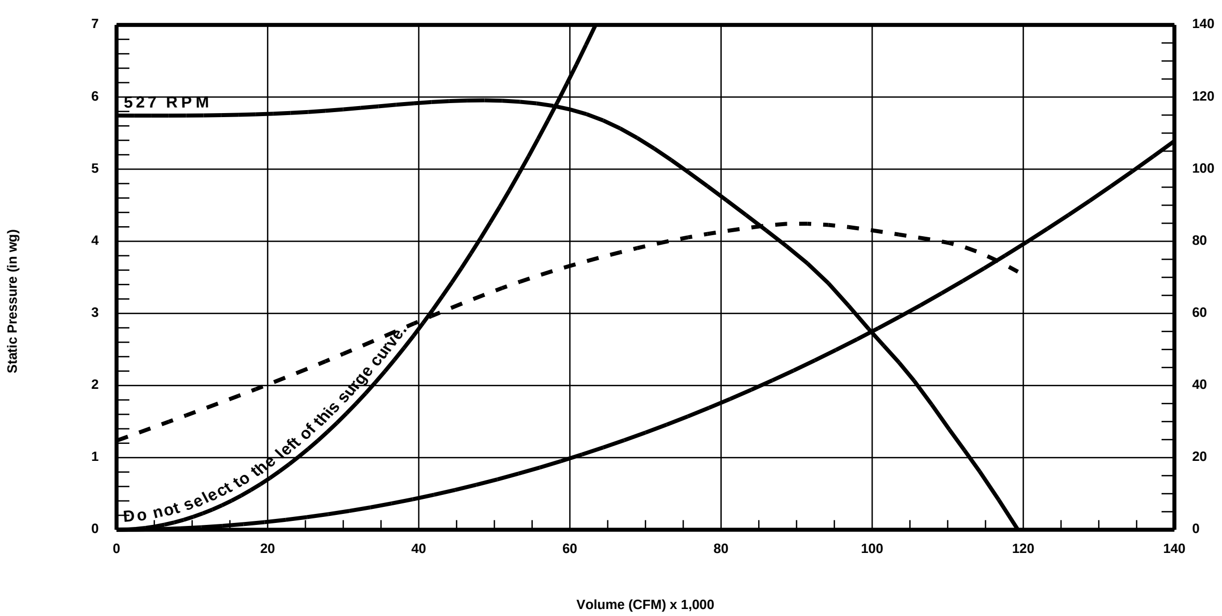
PERFORMANCE (Elevation ft = 0, Airstream Temperature ºF = 70, Start Up Temperature ºF = 70) Drive Loss (%) 3

Qty	Model	Volume (CFM)	SP (in wg)	TS (ft/min)	OV (ft/min)	FRPM	Max Class FRPM	Operating Power (hp)	SE %
1	73-BISW-21	100,000	2.75	10,072.0	3,264.0	527	673	83.37	54

SOUND

Inlet / Outlet Sound Power by Octave Band								LwA	dBA
63	125	250	500	1000	2000	4000	8000		
110 / 113	102 / 105	96 / 101	94 / 97	91 / 94	85 / 88	80 / 83	76 / 78	96 / 99	85 / 88

LwA - A weighted sound power level, based on ANSI S1.4. dBA - A weighted sound pressure level, based on 11.5 dB attenuation per octave band at 5.0 ft.



CAPS 2.8.1.0

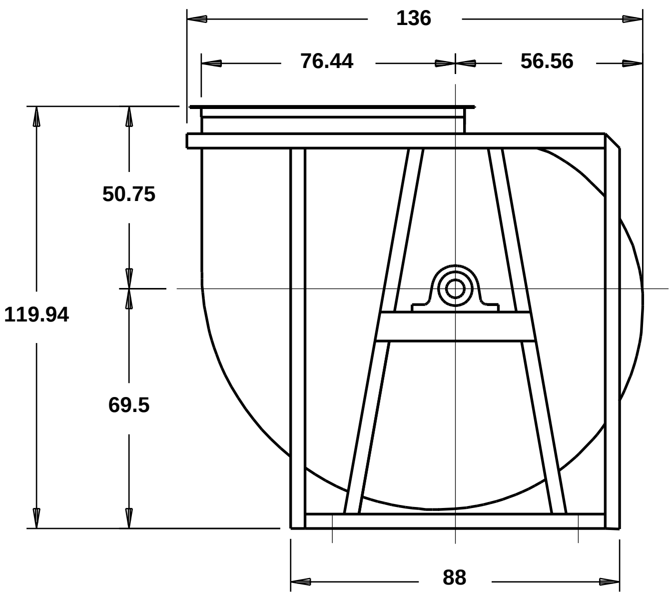
Greenheck 03/17/06 **JOB:** PENN STATE UNIVERSITY - 3-17-06

Fan **MARK:** SMOKE EVACUATION FAN

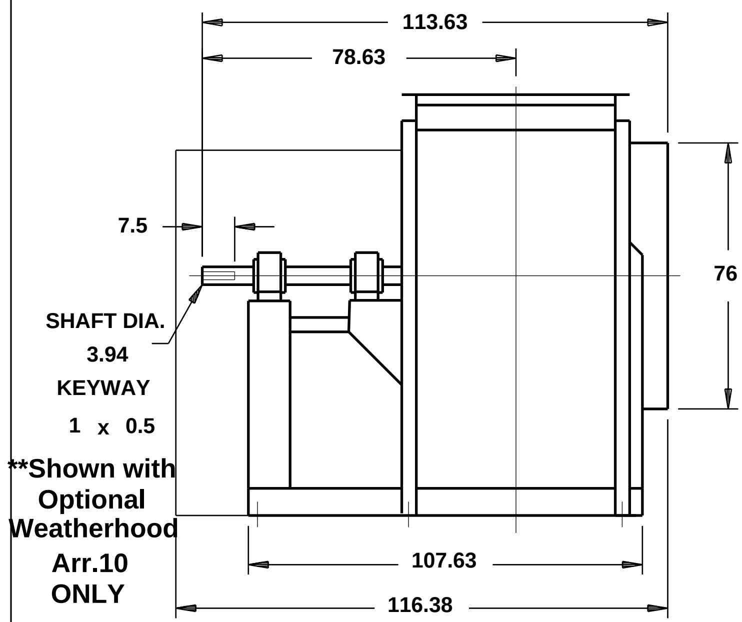
Size: 73
Arrangement: 10
Class: II

BISW Series 21 Backward Inclined Single Width

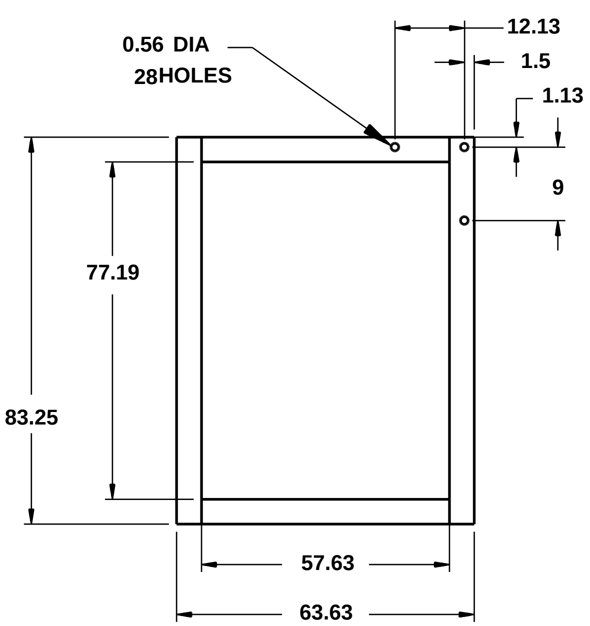
NOTES: All dimensions shown are in units of inches.
Drawings are not to scale. Drawings are of standard unit and do not include dimensions for accessories or design modifications.



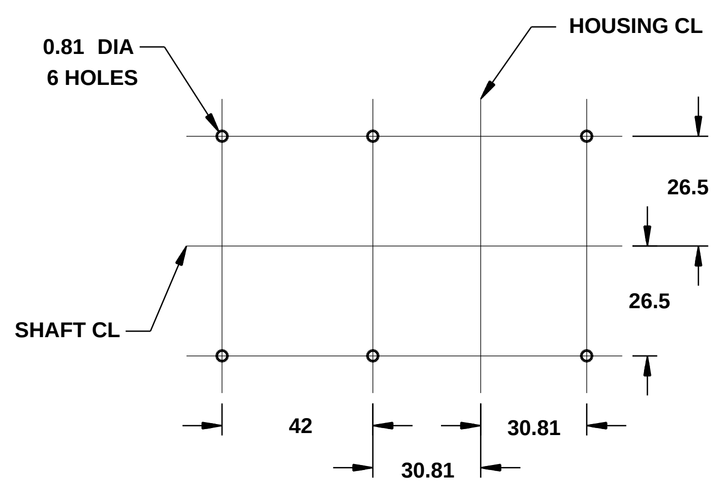
SIDE VIEW



END VIEW



OUTLET



FOOTPRINT

APPENDIX K: STRUCTURAL IMAGES

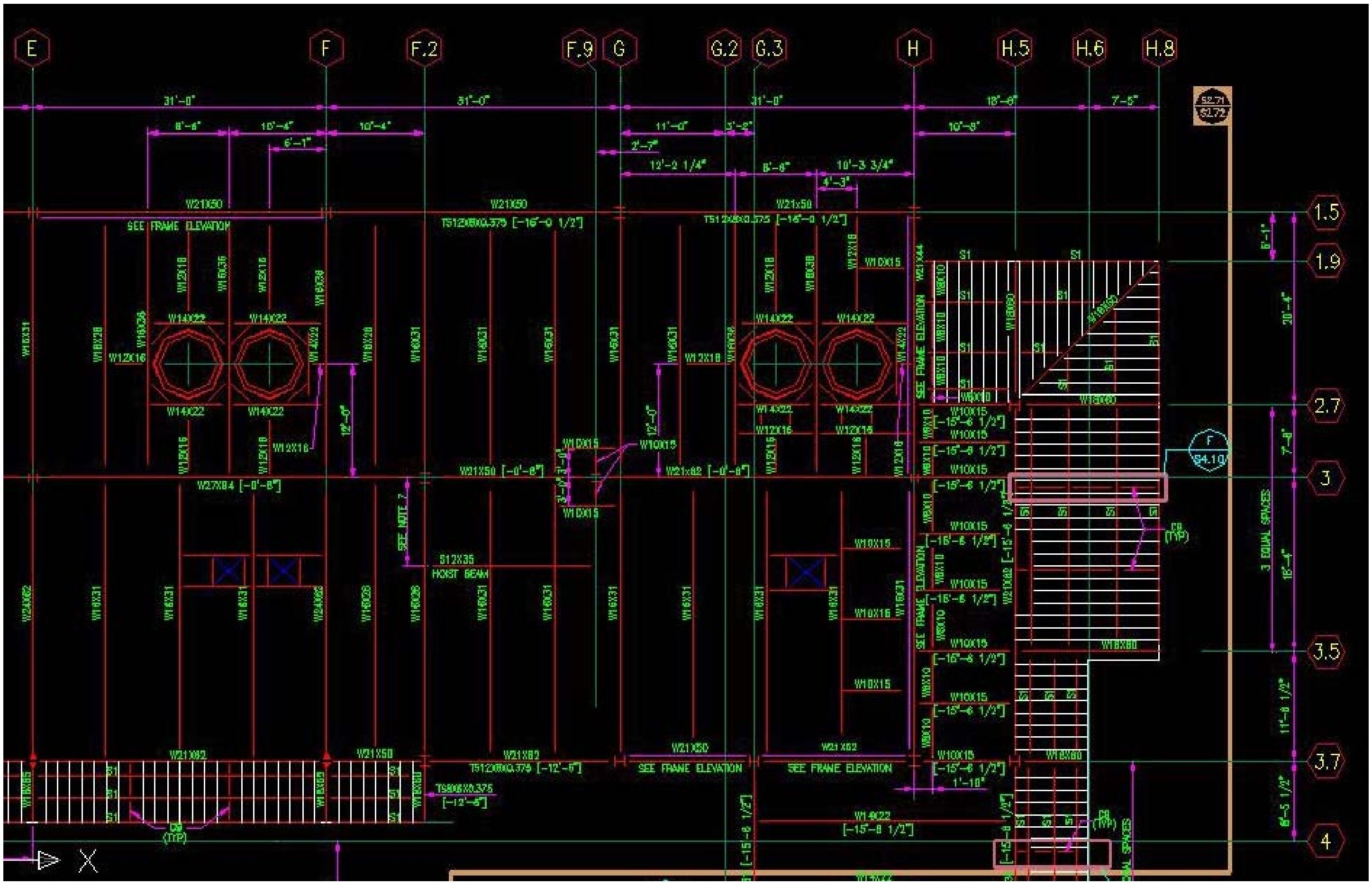


Figure 1: AutoCAD Structural Framing Plan

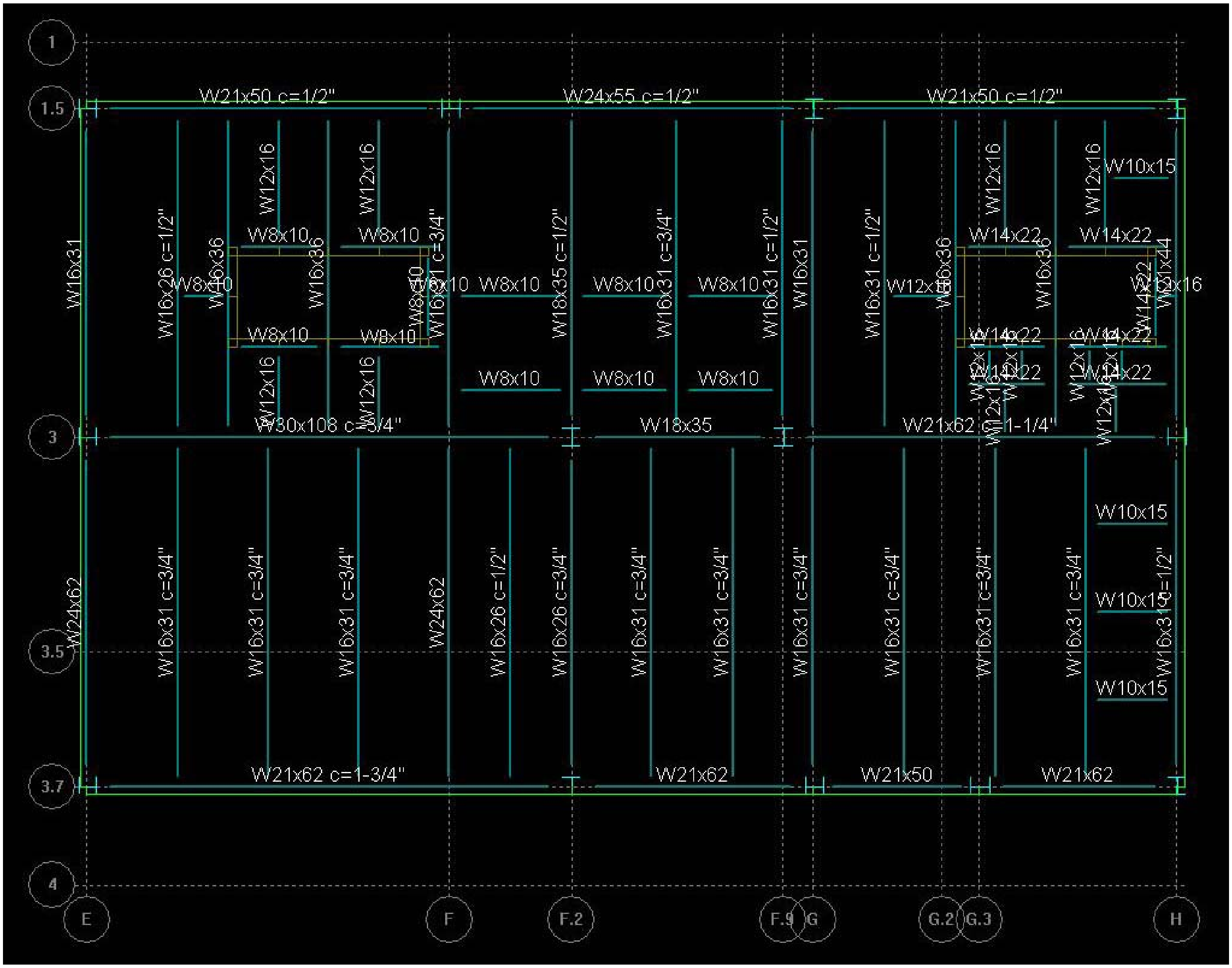


Figure 2: RAM Structural Redesign and Resize of Members for Atrium Smoke Evacuation Fans

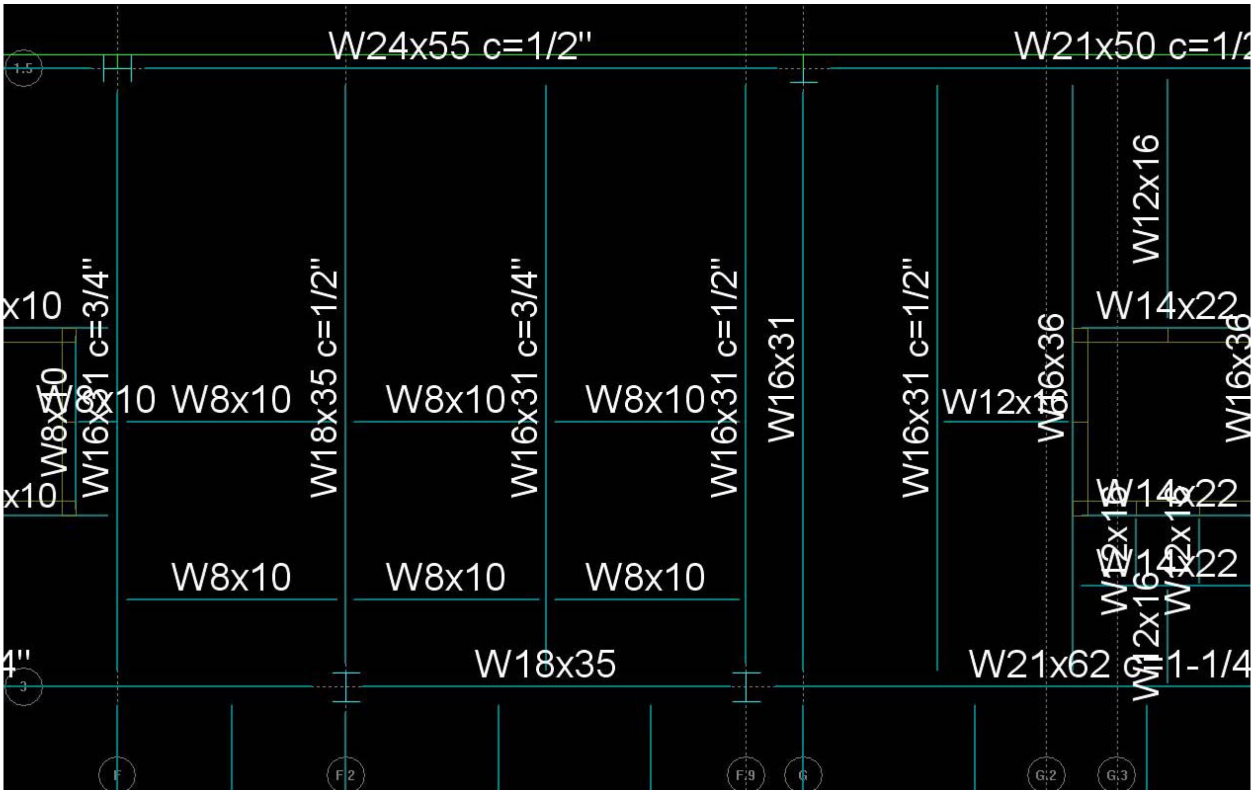


Figure 3: RAM Enlarged Structural Redesign and Resize of Members for Atrium Smoke Evacuation Fans

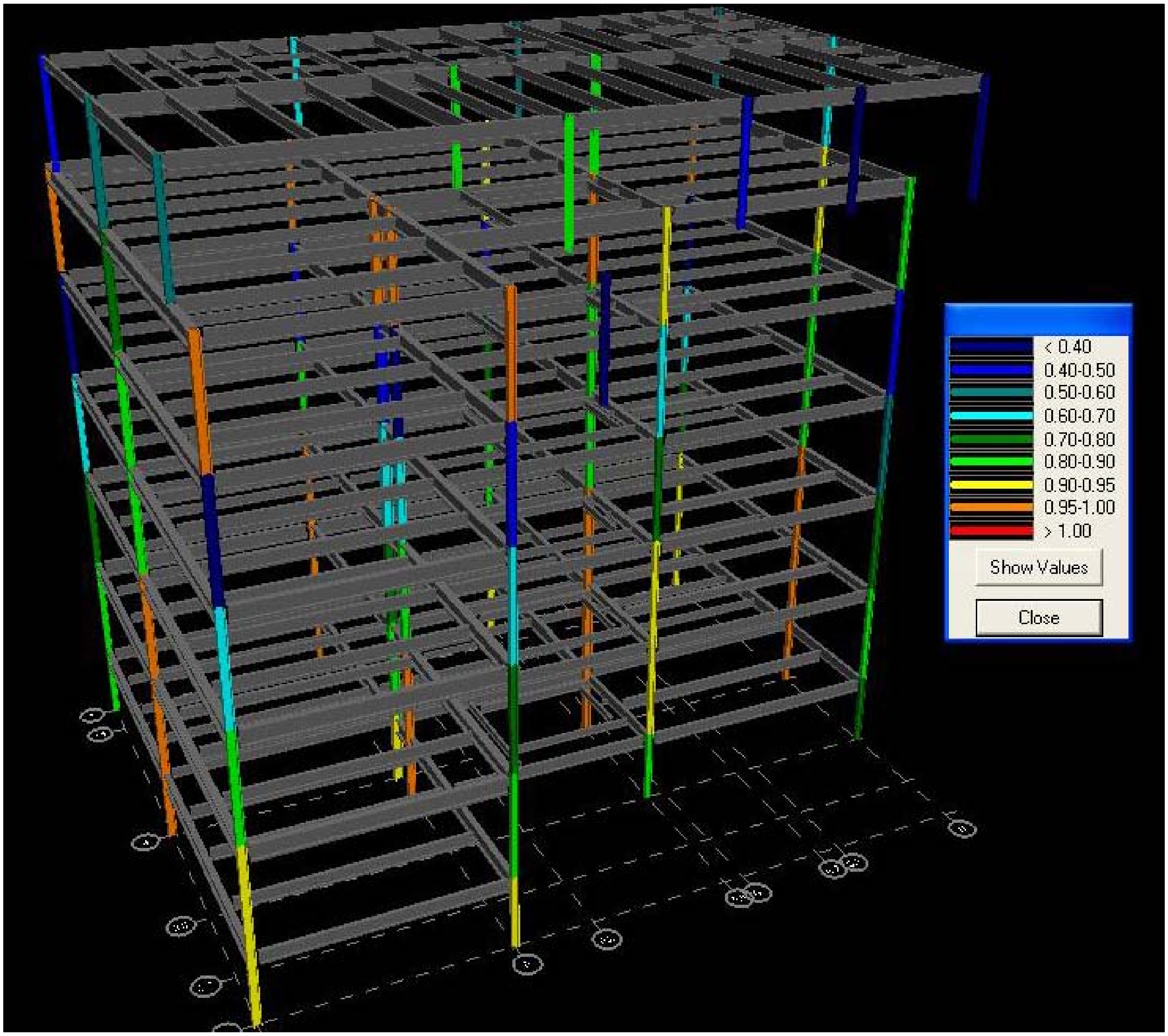


Figure 4: RAM 3D Column Load Evaluation

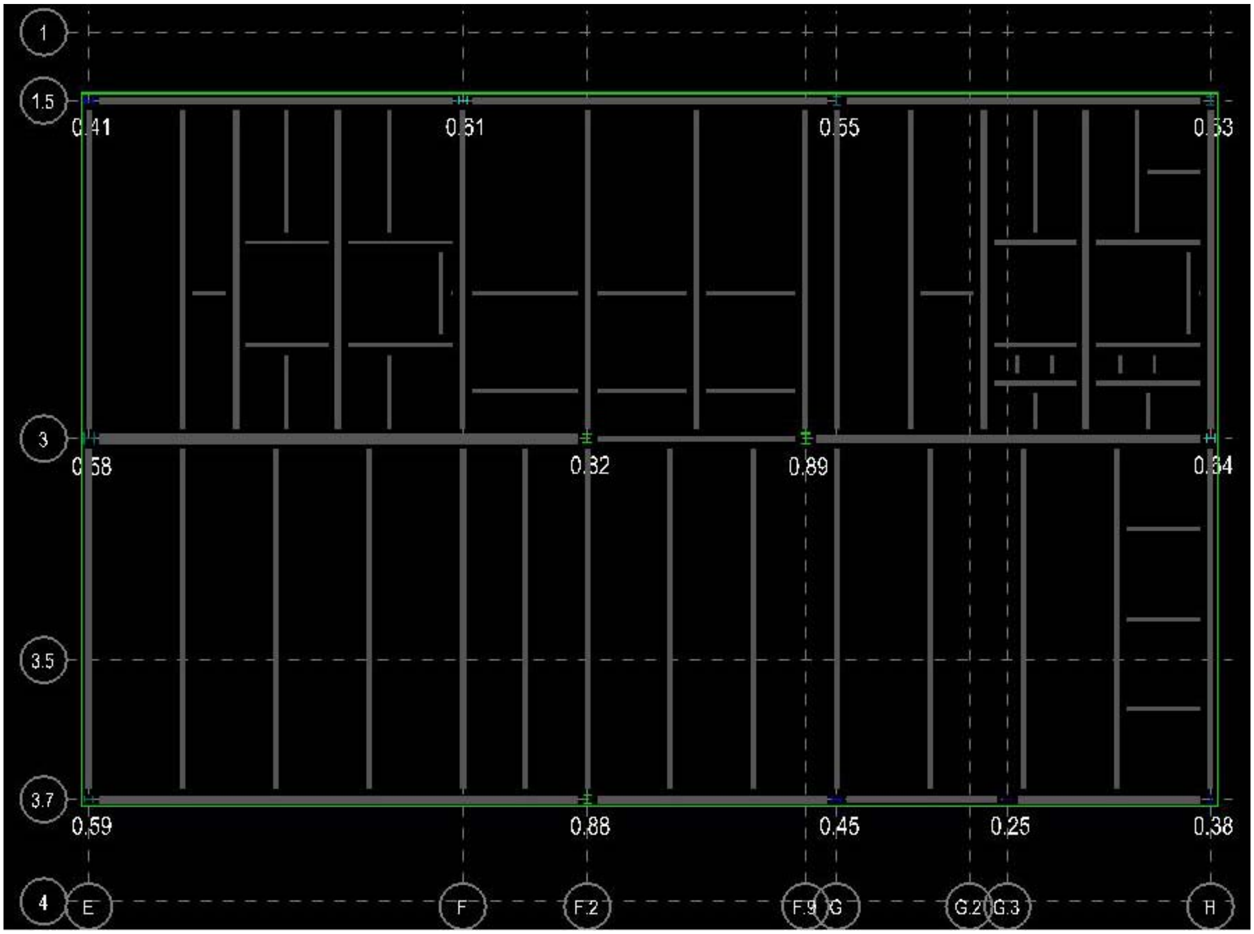


Figure 5: RAM Column Plan Load Evaluation

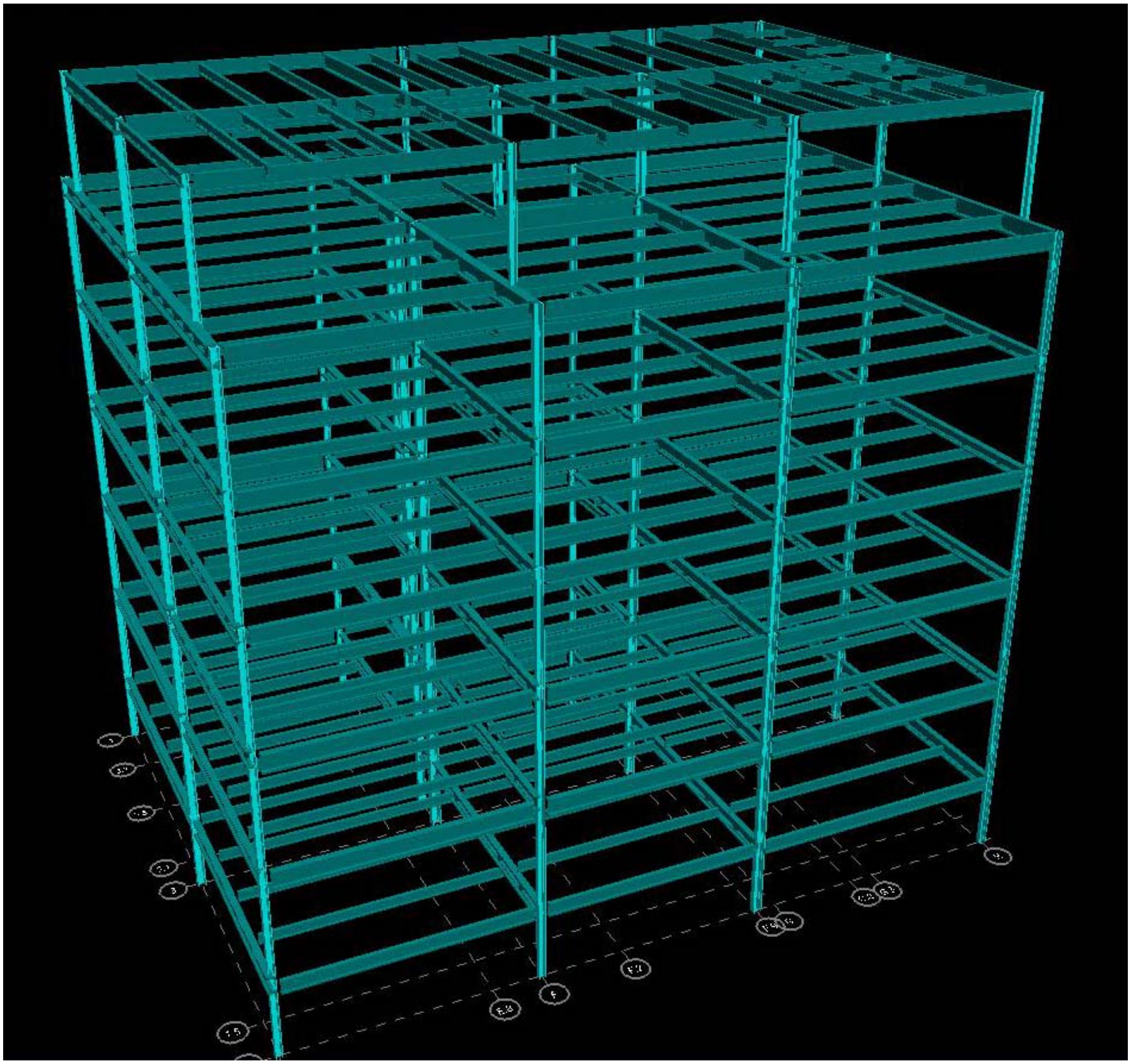


Figure 6: RAM 3D Entire Structure

APPENDIX L: EXISTING BUILDING EQUIPMENT

WATER PUMP SCHEDULE												
UNIT	LOCATION	SERVICE	TYPE	GPM	TOTAL HEAD (FT H20)	MAX. NPSH	MOTOR DATA @ 60HZ				
							BHP	MHP	RPM	VOLTS	PHASE
CMP-1	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-2	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-3	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-4	Basement	Cond. Water	HSC	3,823	80	17	89	100	1,750	480	3
CMP-5	Basement	Cond. Water	End Suction	360	70	6	8.5	10	1,750	480	3
CMP-6	Basement	Cond. Water	End Suction	360	70	6	8.5	10	1,750	480	3
HMP-1	Penthouse	Hot Water	End Suction	570	50	7	8.5	10	1,750	480	3
HMP-2	Penthouse	Hot Water	End Suction	570	50	7	8.5	10	1,750	480	3
HMP-3	Penthouse	Zone Façade (N)	In-Line	32	35	4	0.8	1	1,750	480	3
HMP-4	Penthouse	Zone Façade	In-Line	44	35	4	0.8	1	1,750	480	3
HMP-5	Penthouse	Zone Façade (S)	In-Line	44	35	4	0.8	1	1,750	480	3
HMP-6	Penthouse	Zone Façade (E)	In-Line	20	35	4	0.5	0.75	1,750	480	3
HMP-7	Penthouse	Zone Façade	In-Line	25	35	4	0.5	0.75	1,750	480	3
HMP-8	Penthouse	Zone Façade (W)	In-Line	10	35	4	0.5	0.75	1,750	480	3
CHP-1	Basement	Chilled Water	HSC	2,022	110	10	71	100	1,750	480	3
CHP-2	Basement	Chilled Water	HSC	2,022	110	10	71	100	1,750	480	3
CHP-3	Basement	Chilled Water	HSC	2,022	110	10	71	100	1,750	480	3
CHP-4	Basement	Chilled Water	HSC	2,022	110	10	71	100	1,750	480	3
PCHP-1	Basement	Proc. Chilled	End Suction	360	60	6	6.5	10	1,750	480	3
PCHP-2	Basement	Proc. Chilled	End Suction	360	60	6	6.5	10	1,750	480	3

Figure 1: Existing Water Pump Schedule

CONDENSATE PUMP SCHEDULE												
UNIT	LOCATION	MIN. REC. CAPACITY (GAL)	MIN. VENT SIZE (INCH)	GPM	SUCTION TEMP.	DISCH. PRESS. (PSIG)	# PUMPS	MOTOR DATA @ 60HZ			
								MHP EA	RPM	VOLTS	PHASE
CP-2	BASEMENT	52	2.5	45	212	15	2	2	3,500	480	3

Figure 2: Existing Condensate Pump Schedule 1

CONDENSATE PUMP SCHEDULE							
UNIT	LOCATION	#'s/HR	GPM	STEAM PSI	SUCTION TEMP	BACK-PRESS PSI	# OF PUMPS
CP-1	BASEMENT	30000	350	90	212	60	1

Figure 3: Existing Condensate Pump Schedule 2

CENTRIFUGAL CHILLER SCHEDULE																			
UNIT	# TONS	ELEC. DATA		EVAPORATOR							CONDENSOR						COMPRESSOR DATA		
		VOLTS	PHASE	EWT (°F)	LWT (°F)	GPM	FLUID	# PASSES	FOULING FACTOR	ΔP (FT H20)	EWT (°F)	LWT (°F)	GPM	# PASSES	FOULING FACTOR	ΔP (FT H20)	RLA	KW RATING	KW/TON MAX
CH-1	1,350	4,160	3	56	40	2,022	Water	2	0.0005	34	83	93	3,822	2	0.001	24	130	833	0.617
CH-2	1,350	4,160	3	56	40	2,022	Water	2	0.0005	34	83	93	3,822	2	0.001	24	130	833	0.617
CH-3	1,350	4,160	3	56	40	2,022	Water	2	0.0005	34	83	93	3,822	2	0.001	24	130	833	0.617

Figure 4: Existing Centrifugal Chiller Schedule

COOLING TOWER SCHEDULE												
UNIT	TONS	EWT (°F)	LWT (°F)	EAT (°F)	GPM	QUANITY FANS	MOTOR DATA @ 60HZ					
							MHP	RPM	SPEEDS	REVERS.	VOLTS	PHASE
CT-1	1,015	93	83	75	2,867	1	75	X	2	Y	480	3
CT-2	1,015	93	83	75	2,867	1	75	X	2	Y	480	3
CT-3	1,015	93	83	75	2,867	1	75	X	2	Y	480	3
CT-4	1,015	93	83	75	2,867	1	75	X	2	Y	480	3

Figure 5: Existing Cooling Tower Schedule

EXPANSION TANK SCHEDULE							
UNIT	LOCATION	SYSTEM SERVED	INIT. CHARGE (PSIG)	TANK CAPACITY (GAL)	STYLE	TANK LENGTH (IN) x DIA. (IN)	RELIEF VALVE SETTING (PSIG)
TK-1	Penthouse	Hot Water	50	370	VERT.	100x36	90
TK-2	Basement	Chilled Water	50	211	VERT.	83x30	90
TK-3	Basement	Chilled Water	50	150	VERT.	65x30	90

Figure 6: Existing Expansion Tank Schedule

HEAT EXCHANGER (STEAM-WATER) SCHEDULE														
UNIT	LOCATION	TUBE LENGTH	SHELL DIAMETER	# OF PASSES	WATER SIDE (TUBE)							STEAM SIDE (SHELL)		
					EWT (°F)	LWT (°F)	GPM	ΔP (FT H20)	MIN. MBH	FOULING FACTOR	PRESS. RATING	OPER. PRESS	#'s PER HOUR	PRESS. RATING
HE-1	Penthouse	48	18	4	150	190	570	1.9	9,000	0.001	150	5	11,500	150
HE-2	Penthouse	48	18	4	150	190	570	1.9	9,000	0.001	150	5	11,500	150

Figure 7: Existing Heat Exchanger Schedule 1

PLATE & FRAME HEAT EXCHANGER SHEDULE																
UNIT	LOCATION	MIN. # PLATES	SIDE A							SIDE B						
			EWT (°F)	LWT (°F)	GPM	ΔP (PSI)	FLUID	FOULING FACTOR	PRESS. RATING	EWT (°F)	LWT (°F)	GPM	ΔP (PSI)	FLUID	FOULING FACTOR	PRESS. RATING
HE-3	Basement	53	40	56	225	5	Water	0.00025	130	60	50	360	10	Water	0.00025	130
HE-4	Basement	101	47	57	360	5	Water	0.00025	130	60	50	360	10	Water	0.00025	130

Figure 8: Existing Heat Exchanger Schedule 2

AHU																					
AHU	LOCATION	CFM	OA	SUPPLY FAN						PREHEAT COIL				COOLING COIL							
										AIR SIDE			STEAM	AIR SIDE				WATER SIDE			
				Quantity	FAN Type	Min. SP	Max. BHP	Min. BHP	RPM	Max. Face Velocity (FPM)	EDB (°F)	LDB (°F)	Flow (llbs/hr)	EDB (°F)	EWB (°F)	LDB (°F)	LWB (°F)	Fluid	Flow GPM	EWT (°F)	LWT (°F)
AHU-1	Penthouse	90,000	90,000	2	VFD	8	85	#	1,346	800	0	55	5,569	90	74	47	47	Water	1,008	40	56
AHU-2	Penthouse	100,000	100,000	2	VFD	8	97	#	1,406	800	0	55	6,188	90	74	47	47	Water	1,062	40	56
AHU-3	Penthouse	72,500	72,500	2	VFD	8	68	#	1,489	800	0	55	4,486	90	74	47	47	Water	765	40	56
AHU-4	Penthouse	72,000	18,000	2	VFD	8	68	#	1,489	800	45	55	810	79	66	47	47	Water	491	40	56

Figure 9: Existing Air Handeler Unit Schedule

FAN SCHEDULE											
UNIT	LOCATION	SERVICE	CFM	S.P. (IN.H2O)	RPM	WHEEL DIA. (IN.)	MOTOR DATA @ 60HZ				FAN TYPE
							MBHP	MHP	VOLTS	PHASE	
EX-1	Penthouse	Lab EXH	90,000	4.5	549	73	93	125	480	3	SWSI
EX-2	Penthouse	Lab EXH	90,000	4.5	549	73	93	125	480	3	SWSI
EX-3	Penthouse	Lab EXH	100,000	4.5	563	73	101	125	480	3	SWSI
EX-4	Penthouse	Lab EXH	100,000	4.5	563	73	101	125	480	3	SWSI
EX-5	Penthouse	Lab EXH	72,500	4.5	1,770	48	66	75	480	3	AXIAL
EX-6	Penthouse	Lab EXH	72,500	4.5	1,770	48	66	75	480	3	AXIAL
EX-7	Penthouse	Load EXH	2,000	1.5	1,940	15	0.9	1.5	480	3	SWSI
EX-8A	Penthouse	R.I. EXH	1,850	6	2,420	13.5	2.9	5	480	3	SWSI
EX-8B	Penthouse	R.I. EXH	1,850	6	2,420	13.5	2.9	5	480	3	SWSI
EX-9A	Basement	MER EXH	5,000	0.5	1,300	24	x	0.8	480	3	PROP
EX-9B	Basement	MER EXH	5,000	0.5	1,300	24	x	0.8	480	3	PROP
EX-9C	Basement	MER EXH	5,000	0.5	1,300	24	x	0.8	480	3	PROP
EX-9D	Basement	MER EXH	5,000	0.5	1,300	24	x	0.8	480	3	PROP
EX-10A	Basement	ELEC EXH	7,500	0.5	968	30	x	1	480	3	PROP
EX-10B	Basement	ELEC EXH	7,500	0.5	968	30	x	1	480	3	PROP
EX-11	Penthouse	Penthouse Vent	20,000	1.5	1,770	30	10	15	480	3	PROP
EX-12	Penthouse	Toilet EXH	4,625	2	1,610	18	2.5	3	480	3	PROP
EX-13	Penthouse	Atrium EXH	15,000	2	1,770	30	8	10	480	3	PROP
RF-1	Penthouse	AHU-4	36,000	4	1,770	42	41	50	480	3	AXIAL
RF-2	Penthouse	AHU-5	36,000	4	1,770	42	41	50	480	3	AXIAL
SF-1A	Basement	ELEC EXH	7,500	1.5	1,770	24	3.4	5	480	3	IN-LINE
SF-1B	Basement	ELEC EXH	7,500	1.5	1,770	24	3.4	5	480	3	IN-LINE
SF-2	Basement	EMER ELEC	1,000	0.5	1,160	16	x	0.3	120	1	PROP

Figure 10: Existing Fan Schedule