

# Outreach Innovation Building

Penn State Research Park  
State College, PA



**The Pennsylvania State University Department of Architectural Engineering  
Senior Thesis**

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Mechanical Option  
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# Outreach Innovation Building

Penn State Research Park  
State College, PA

## PROJECT TEAM

- Owner/Developer—Penn State Research Park Developers Inc.
- Architect — GBQC Architects, PC
- CM — Poole Anderson Construction LLC
- Structural/MEP/Fire Prot. Eng — Associated Engineering Consultants
- Civil Engineer — Gannett-Fleming, Inc.

## STRUCTURAL SYSTEM

- Foundation — 4" Slab on Grade
- Composite slab decking
- Masonry wall construction
- Pier Foundations — Typical size 24"x26"
- "LOK-Floor" Composite Floor Deck. Continuous over 3 Spans Supporting 5-1/2" Total Depth (Typical).

## LIGHTING/ELECTRICAL SYSTEM

- Primary Distribution — 12.47kV
- Secondary Distribution — 480/277
- Critical and Life Safety Panels
- Mainly Direct/Indirect Fluorescent and Metal Halide Lighting

## PROJECT OVERVIEW

- Total Cost — \$27 Million
- Date of Construction — August 2003 to February 2005
- Building Size — 97,000 Gross Sq. Ft.
- 3 Stories Above Grade
- 2 Story Glass Façade on North-East corner of Building
- Usage — One main and several smaller television production studios, radio production facility, equipment room, resource library, various offices, conference rooms, and a centrally located multi-purpose space

## MECHANICAL SYSTEM

- 2-175 Ton Air-cooled Rooftop Chillers
- 1-54 Ton Air-cooled Rooftop Chiller
- 6 Air Handling Units in Penthouse supply air through a zoned VAV duct system
- Units range 10,000-35,000cfm, 24.2-81.2 ton Cooling Coil

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## Executive Summary

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This report is the summary of a year long analysis and design of the Outreach Innovation Building located in State College, PA. The depth of this report deals with the redesign of the mechanical systems within the building. Breadth work within this report is an analysis and design of a clean agent fire protection system and an analysis of the effects of the mechanical redesign on the existing mechanical systems.

The mechanical redesign focused on implementing a dedicated outdoor air system with fan coil units. This new system was found to reduce energy use by 692,632 KWh/Year, which is a 16% annual reduction in energy use. Cost savings due to this reduction in energy use was \$43,623 per year. The DOAS had an increase in initial cost of \$60,200 compared to the original design. This results in a payback period of approximately 1 year and 5 months. This is an acceptable payback period and therefore it is advised that the new DOAS system be implemented.

The clean agent fire protection system was designed to protect valuable and sensitive electrical equipment. Such equipment is found in the server room, video archive room, and the UPS/Dimmer room. HFC-227ea was selected as the chemical to be used due to its effectiveness and it is environmentally safe. Currently there is a dry pipe system installed in these areas, and it is recommended that this system still be installed in the event of failure of the primary (clean agent) system. This can be done at a minimal cost and can prevent the spread of fire throughout the building. The clean agent system should be used in order to prevent the loss of valuable data and expensive electrical equipment.

The effects of the mechanical redesign on the electrical system were analyzed. The redesigned mechanical equipment reduced the electrical demand on the building. This was due to the reduction in chiller size and replacing 4 large air handling units with 1 smaller unit. Panelboard can be reduced. With the redesigned mechanical system there is more than adequate room for future electrical expansion.

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## General Description and Background Information

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The Outreach Innovation Building is located at Penn State Research Park in State College, PA. The 97,000 gross square foot building is home to Penn State Public Broadcasting and World Campus. The broadcasting includes WPSX-TV and WPSU-FM. The building features one main and several smaller television production studios, radio production facilities, a World Campus resource library, and various offices and conference rooms.

## Building Envelope

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The 3 story building consists of a brick façade typical of Penn State buildings. It is a steel structure with cavity walls and extruded polystyrene board insulation and gypsum wall board. There is a steel roof deck, roof insulation and EPDM roof membrane.

## Lighting / Electrical

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Main floor areas consist of direct/indirect fluorescent lighting. Hallways within open office spaces also have compact fluorescent lighting. Recessed metal halide lighting is present in entrance areas.

The building is a radial system that has an incoming 15kV service cable into a 12.47kV – 480Y/277V transformer. The transformer is protected on the secondary side by a disconnect switch. The main building operating voltage is 480Y/277V and is fed from a 2400A, 3-phase, 4-wire main switchboard. The system is backed by a 100 kVA emergency generator and contains capacity for a second. The system also incorporates a UPS for loads that require uninterruptible power.

## Mechanical

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Chilled water is pumped to 6 variable air volume units. These units supply air through zoned ductwork and under-floor air distribution systems. The cooling coils range from 24.2 to 81.2 tons, and the Air Handling Units range from 10,000 to 35,000 cfm. There are 2-175 ton rooftop chillers and 1-54 ton rooftop chiller.

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### Structural

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The building sits on a typical pier size of 24"x26" and a 4" slab on grade foundation. The lateral system is a steel moment frame in both directions. Typical "LOK-Floor" composite floor decking is continuous over 3 spans supporting 5-1/2" total depth. The building consists of typical masonry wall construction with curtain walls on the east and south side of the building.

### Fire Protection

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Wet-Pipe automatic sprinkler system is broken into 3 zones (Light hazard, ordinary hazard group 1, and ordinary hazard group 2) depending on the area designation within the building. Hazard Group 1 shall be hydraulically calculated for a density of 0.15 GPM per sq.ft. for most remote 1,500sq.ft. of floor area. Hazard Group 2 shall be calculated for a density of 0.20 GPM. Flow test information resulted in 90psi static, 80psi residual at 1384 GPM flowing.

### Telecommunications

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Conduits enter from a manhole and are routed to two telecommunications closets. Data and phone lines are then routed from closets according to location within the building. All rooms within the building contain at least one data receptacle for access to provide network and internet access.

### Project Team

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Owner	Penn State Research Park Developers Inc.
Architect	GBQC Architects, PC
Construction Manager	Poole Anderson Construction LLC.
Studio Design Consultant	The Lawrence Group Architects
Struct., MEP, Fire Prot. Eng	Associated Engineering Consultants
Acoustic Consultant	Shen Milsom & Wilke, Inc.
Telecomm. Design Consult.	PSU Office of Telecommunications
Audiovisual Equip. Consult.	PSU Office of Media Technology
Civil Engineer	Gannett-Fleming, Inc.

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### **Design Objectives and Requirements**

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The design requirements for the Outreach Innovation Building are that of a type-B building in the International Building Code 2000. The mechanical systems must meet the heating/cooling loads and the ventilation requirements set by the International Building Code 2000.

Noise Criteria was also considered due to the multiple television and radio studios throughout the building. An NC of 20 to 25 was designed for such spaces. Duct sizes were increased to reduce the velocity of the supply air and therefore lower the sound pressure level in order to comply with these design standards. Isolated slabs and walls are also used in noise sensitive areas.

Under-floor air distribution was used in open office areas. This enables a floor plan that can easily be changed. Also the large amounts of telecommunication cables found throughout the building can be placed within this raised floor area.

The main goal of the redesign is to reduce energy use of the mechanical systems and therefore save money. Indoor air quality must also be taken into account. Proper IAQ and a thermally comfortable environment can increase occupant productivity and health. It was also important for the redesign to be an interesting learning experience.



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### ASHRAE Standard 62-2001 Indoor Air Quality Analysis

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An analysis for proper indoor air quality based on the ASHRAE Standard 62-2001 Addendum N was conducted for the Outreach Innovation Building in State College, PA. This analysis was done for each of the three air handling units within the building to assure proper indoor air quality for each zone. The analysis concluded that each air handling unit does comply with Standard 62-2001n, and proper IAQ is provided throughout the building.

### ASHRAE Standard 62-2001 Analysis Method

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For each zone all floor areas, total supply air quantities, and outdoor air quantities were found. Maximum supply air quantities were determined by summing the diffuser cfm per zone. Minimum supply air quantities were determined by the VAV box schedule per zone. The following air handling units consists of two separate units run in parallel with each other.

AHU-1: 2-10,000cfm VAV units = 20,000cfm Total

AHU-2: 2-17,500cfm VAV units = 35,000cfm Total

AHU-3: 2-35,000cfm VAV units = 70,000cfm Total

After all zones area's and air supplies were found, an ASHRAE Standard 62-2001n based spreadsheet was used to calculate Z critical.

See Appendix A for sample calculations

### AHU-1

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AHU-1 is a dual-duct VAV unit that mainly serves normally unoccupied areas such as server rooms, video archives, and telecommunication closets. For this reason, it was expected that the outdoor air required for this unit would be low, and the Addendum N analysis gave a low required outdoor air value.

AHU-1			
Required OA (scfm)	Actual OA (scfm)	Std. 62-2001n Comply	Unvitiated Air (scfm)
667	2000	Yes	1333

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### AHU-2

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AHU-2 is a dual-duct VAV unit located in the ceiling space. This unit serves the main studio, studio production and control rooms, lobby areas, and various open office/conference rooms.

AHU-2			
Required OA (scfm)	Actual OA (scfm)	Std. 62-2001n Comply	Unvitiated Air (scfm)
4123	6700	Yes	2577

### AHU-3

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AHU-3 is an under-floor air system with manual and automatic under-floor fan coil terminal boxes. The system has temperature based controls only and no variable air volume boxes. It serves primarily open office space. The restrooms for all three floors are also served by this unit. These restrooms have exhaust grills to maintain negative pressure within the space in order to contain odors.

AHU-3			
Required OA (scfm)	Actual OA (scfm)	Std. 62-2001n Comply	Unvitiated Air (scfm)
7287	8900	Yes	1613

### ASHRAE Standard 62-2001 Conclusion

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Each system does comply with ASHRAE Standard 62-2001 addendum N for proper indoor air quality. Each system supplies slightly more outdoor air than is required by the addendum. This excess is not large enough to cause concern or waste large amounts of energy, and will in turn improve indoor air quality. The percentage of outdoor air for each unit may appear low (between 3% and 11%), but this may be due to the presence of large curtain glass walls. These walls will increase the thermal load of the building which will therefore make the percentage of outdoor air required seem smaller. These outdoor air percentages seem reasonable for each air handler and its respective zones.

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### Design Conditions

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#### Outdoor design conditions

Summer 89 F DB, 72 F MWB (0.4%)

Winter 5 F DB (99.6%)

#### Summer Design Conditions

75 F and 50% relative humidity

#### Winter Design Conditions

70 F and 50% relative humidity

### Original System Requirements

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#### AHU-1A, 1B, 2A, 2B

##### General Description

Air units are variable air volume units, comprised of the following: mixing box with separate minimum and modulating outdoor dampers, filter section, hot water heating coil, access section, chilled water cooling coil, humidifier, access section, and plenum supply fan. The system return fans are vane axial frequency drives. These units serve production areas on the First Floor.

Freezestat shall de-energize the fans whenever the temperature falls below setpoint (36F, adj.).

Smoke Detector: The unit shall shut down upon actuation of any smoke detector and initiation by the Fire Alarm System for air unit shutdown.

Start Time Optimization: The Building Automation System (BAS) shall automatically calculate the optimum time to start the unit(s) based on space temperature, ambient temperature, and a building heat loss/gain coefficient in order to bring the space temperature to the proper setpoint no more than 15 minutes before scheduled occupancy time.

Static Pressure High Limit Sensor: System shall turn off upon actuation of duct static pressure high limit sensor.

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Fan Tracking: Supply fan air volume shall be controlled with variable frequency drive via static pressure sensors in the supply air ductwork, setpoint 0.75 in/wg, adj. Return fan shall be modulated with variable frequency drive to maintain a fixed CFM differential between supply and return as measured by air measuring devices, equal to minimum outside air and/or building exhaust, plus building pressurization CFM.

### AHU-3A and 3B

These units supply the under-floor air distribution system.  
General Description similar to AHU-1A, 1B, 2A, 2B above.

### Chilled Water Temperature Control Sequence

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#### General Description

The chilled water system is primary-secondary plant, comprised of the following components: air-cooled chillers with evaporator barrel remotely located in mechanical Penthouse, primary chilled water pumps (constant speed) dedicated to each evaporator barrel, and variable speed secondary chilled water pumps that deliver chilled water to terminal cooling coils.

To prevent short cycling, each chiller shall run for a minimum of 30 minutes and be off a minimum of 20 minutes.

On failure of the lead pump, the lag pump will run and the lead pump will be de-energized.

The chiller will shut down and an alarm set off if a refrigerant leak is detected within the mechanical penthouse.

The chiller plant shall be enabled to run whenever ambient temperature is greater than 50F.

Secondary chilled water pump(s) will be energized any time the chiller(s) is called to run. Pump speed will be modulated to maintain differential pressure sensor setpoint of 25 ft/wg.

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### **Heating Hot Water Temperature Control Sequence**

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#### **General Description**

The heating hot water system is primary-secondary plant, comprised of the following components: gas-fired hot water boilers, primary hot water pumps (constant speed) dedicated to each boiler, and variable speed secondary hot water pumps that deliver heating hot water to terminal heating units (coils, finned tube radiation, radiant ceiling panels, and cabinet unit heaters).

To prevent short cycling of the boilers, each boiler shall run for a minimum of 5 minutes and be off a minimum of 1 minute.

The boiler plant will run whenever ambient temperature is less than 65 F.

Secondary hot water pump(s) will be energized any time the boiler(s) is called to run. Pump speed will be modulated to maintain differential pressure sensor setpoint of 15 ft/wg.

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### **Redesign Introduction**

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This report is an in depth analysis of the mechanical systems of the Outreach Innovation Building located in University Park, PA and the impact these changes had on other systems within the building.

The current system design was entered into Carrier's Hourly Analysis Program in order to obtain energy usage data (See Appendix C). The redesigned DOAS was also entered into HAP in order to obtain equipment sizes of the new design. The energy usage data was also compared to the original design.

2-Pipe fan coil terminal units were selected as the parallel system to handle the remaining sensible cooling load.

The server room is maintained at 45% RH to prevent static discharge. It is also kept on a separate system, with secondary backup systems in case of primary failure. The throttle range for the data center is set at 1F with cooling at 72F and heating at 65F.

Low ambient control down to -20F is used on the current and redesigned systems. This will ensure operation in winter so the data center will be ensured cooling.

The DOAS is modeled as a CAV system, but a variable speed drive has been put on it in order to maintain pressure in the underfloor air system. This is a precautionary measure in the event a floor panel is removed for maintenance or other reasons; the floor pressure will be maintained.

### **Dedicated Outdoor Air System**

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A dedicated outdoor air system (DOAS) is any system that has a central unit which delivers only OA to a space. The remaining load is met by a parallel system. These parallel systems include such things as radiant panels, fan coil units, or a VAV system (Mumma 1). Fan coils currently exist in some areas of the Outreach Innovation Building and therefore they were selected as the parallel system in this design.

The OA is able to be supplied at any condition. Lower supply air temperatures have first and operating cost benefits. Over cooling in high occupancy areas must be considered (Mumma 2). Reheat will be required if the SAT becomes too

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low, which will increase energy use. Space dew point temperature is also a concern with DOAS. The latent and sensible loads will not be separated if the DPT is too high (Mumma 2). Condensation is not a concern in this design because fan coils are going to be used. If condensation should occur, the fan coil condensate drain will remove the moisture. Mold can form in the drain pan if moisture does occur. Given these advantages and disadvantages, the ventilation air condition was determined to be 50F DB / 50F WB. These ventilation conditions should prevent overcooling. Moisture on the fan coils should also be avoided, but the condensate drain will be there in case of moisture.

Four of the six existing AHU's will be replaced with 1 DOAS AHU. The four removed AHU's total 105,000 cfm and 290 tons of cooling supplied to the building. The new DOAS unit is 11,500 cfm and 77 tons of cooling. This is a reduction of 93,500 cfm, or 90%. This reduction can be accomplished due to the supply of only the necessary ventilation air. With the original VAV system the space with the largest percentage of OA demand influences the percentages sent to every zone within the building. This means that in a typical VAV system, some OA is conditioned and sent through the building without ever being utilized. DOAS does not allow for this waste to occur because it supplies only the amount of air required for ventilation. The air is conditioned in order to handle part of the load. The remaining sensible load is taken care of by the parallel system, in this case the fan coil units.

A Trane MCC-25 Series Modular Climate Changer Air Handler was chosen as the air handler for the redesigned system (Appendix B). For the new design, a 77 ton 11,500 cfm air handling unit is required to supply the necessary ventilation air. The Trane unit was selected due to its use as a DOAS unit and its ability to easily integrate an energy recovery wheel to reduce the load on the air handler.

### Energy (Enthalpy) Wheel

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An enthalpy wheel is a good way to recycle energy already used. Maximum efficiency can be met by the use of an enthalpy wheel in a DOAS application. As fresh air is brought into the building an equal amount of air must be exhausted. Such exhaust air has already been conditioned and used, and the enthalpy wheel is able to transfer the energy from the exhaust air to the fresh OA and precondition it before it reaches the air handling unit. The enthalpy wheel in this design reduced the cooling load by 54%.

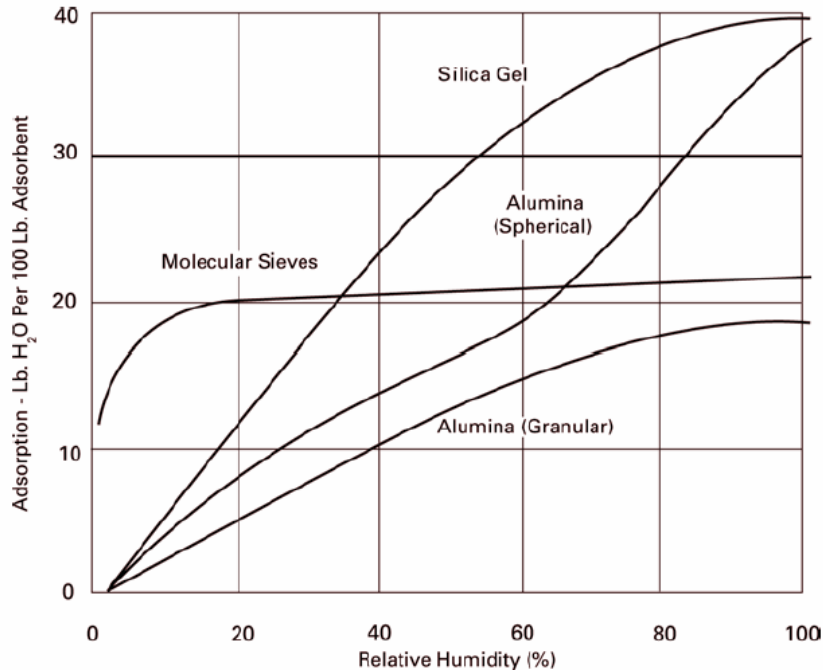
A Type-A Trane Energy wheel was selected and integrated into the M-Series Climate Changer Air Handler. Silica gel desiccant is used for water sorption in the relative humidity working range. As shown in Figure 1, silica gel has a

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greater capacity for adsorption and desorption of water than the same amount of other desiccants at relative humidity in excess of 30%.

Figure 1. Desiccant comparison (after W.R. Grace, Davison Chemical Division, "Silica Gels")



### Fan Arrangement

Energy wheels have some cross leakage, the percent of leakage depends on the pressure differentials across the wheel section and the supply and exhaust fan arrangement. The Trane energy wheel ratios are typically below 3%. The supply and exhaust air fans must be arranged to provide counter flow airflow through the energy wheel.

It was determined that a draw-thru supply, draw-thru exhaust air fan setup would be the most beneficial arrangement. Possible cross leakage with this setup is either direction depending on the static pressures in the supply and exhaust air chambers. To ensure proper indoor air quality of the supply air stream there should be minimal or no cross leakage from the exhaust to supply air stream. For this to occur the supply air stream pressure must be greater than the exhaust air stream.

### Fan Placement Airflow Calculation

Draw-thru supply fan CFM = (OA requirement CFM) x (1+EATR)

Draw-thru exhaust fan CFM = (Required Exhaust CFM) x (1+OATR)



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OATR = Outdoor Air Transfer Ratio =  $(1 + \text{EATR}) \times (\text{OACF}) - 1$

EATR = Exhaust Air Transfer Ratio (See Figure 2)

OACF = Outside Air Correction Factor (See Figure 3)

Figure 2. Exhaust air transfer ratio (EATR) for equal airflows

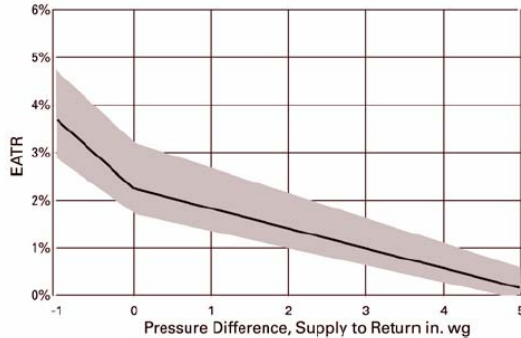
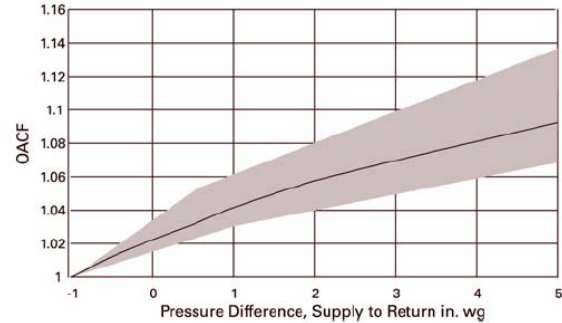
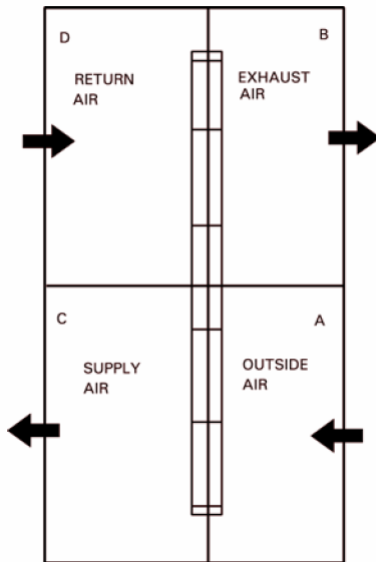


Figure 3. Outside air correction factor (OACF) for equal airflows



## Energy Wheel Orientation

Figure 4. MCC energy wheel orientation



### Draw-Thru Supply, Draw-Thru Exhaust

Pressure @ C =  $1.07'' - 0.25'' = 1.52''$

Pressure @ D =  $-1.5''$

$\Delta P, C \text{ to } D = -1.52'' - (-1.5'') = -0.02 \text{ in. wg}$

OACF = 1.02; EATR = 2.2%; OATR = 1.042

Supply Fan CFM =  $11,500 \times (1 + 0.022) = 11,750 \text{ cfm}$

Exhaust Fan CFM =  $11,500 \times (1 + 0.042) = 11,980 \text{ cfm}$

Inlet OA CFM =  $11,500 \times (1 + 0.042) = 11,980 \text{ cfm}$

Unit Supply CFM =  $11,500 \times 1.022 = 11,750 \text{ cfm}$

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### Energy Wheel Sizing

Figure 5 shows the energy wheel per AHU size. In the AHU section of the report it was determined that an MCC-25 unit would be used for the redesign. As seen in Figure 5 the wheel option for an MCC-25 AHU at 100% Outdoor Air can condition 12,500 cfm, which is adequate based on the above calculations in the "Energy Wheel Orientation" section of the report. (See Appendix D for Energy Wheel Data)

**Figure 5. MCC wheel options**

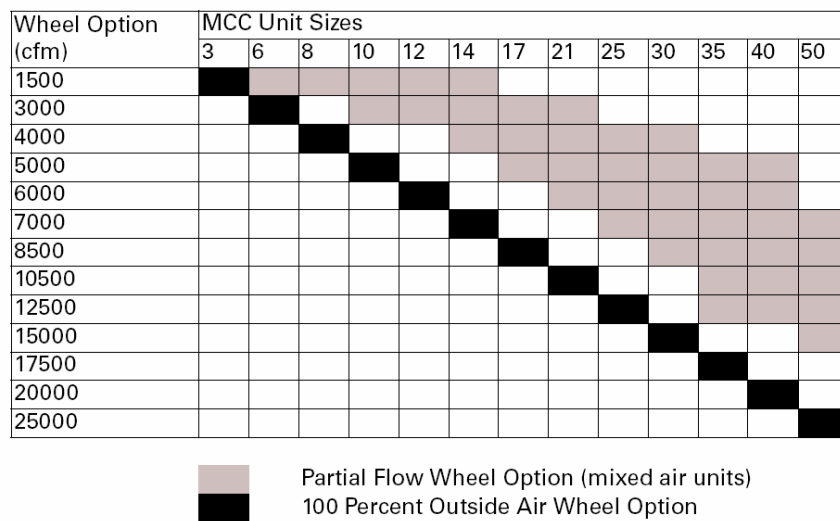


Table 4 shows energy wheel pressure loss and total effectiveness.

$\Delta P = 1.04$

% Effectiveness = 73%

**Table 4. Trane Type A energy wheel, pressure loss,  $\Delta P$  (in. wg) and total effectiveness (wheel sizes 10,500–25,000)**

Wheel Size	10,500		12,500		15,000		17,500		20,000		25,000	
Actual												
Airflow (cfm)	$\Delta P$	% Eff	$\Delta P$	% Eff	$\Delta P$	% Eff	$\Delta P$	% Eff	$\Delta P$	% Eff	$\Delta P$	% Eff
8000	0.86	76	0.70	79								
9000	0.96	75	0.79	77								
10000	1.07	73	0.87	76	0.77	78						
11000	1.17	71	0.95	75	0.84	77	0.76	78				
12000			1.04	73	0.92	75	0.83	73				
13000			1.13	72	0.99	74	0.90	76				
14000			1.21	70	1.07	73	0.97	74				
15000					1.14	71	1.03	73	0.80	77		
16000					1.22	70	1.10	72	0.86	76		
17000							1.17	71	0.91	76		
18000							1.24	70	0.96	75	0.93	75
19000									1.01	74	0.89	76
20000									1.07	73	0.93	75
21000									1.12	72	0.98	74
22000									1.17	71	1.02	74
23000									1.22	70	1.07	73
24000											1.11	72
25000											1.16	71
26000											1.20	70

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### Scroll Chiller Design and Selection

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The existing chiller design obtained from HAP was 435 tons. Redesign with DOAS reduced this load to 240 tons. This is a reduction of approximately 200 tons, or 45%. The new design also reduced the chiller from 694 gpm to 384 gpm, a reduction of 55%.

#### Capacity Requirement

1. Design Capacity in tons refrigerant= 240 tons (Acquired through HAP)
2. Entering and Leaving Liquid Temp: EWT= 57F LWT= 42F
3. Outside ambient air temp.= 95F
4. GPM chilled liquid=  $\text{ton} \times 24 / \text{Temp. Range (F)}$   
 $\text{GPM} = 240 \text{ ton} \times 24 / (57\text{F} - 42\text{F}) = 384 \text{ GPM}$

Two Trane model CAUC-D12 air-cooled scroll chillers were selected. See Appendix E for chiller data. Two chillers are used to save energy during part load conditions. During such times, both chillers will not need to be running, and therefore energy can be saved as compared to one large 240 ton chiller. Also, if 1 chiller should be shut down for maintenance, all of the buildings cooling will not be lost. There are 3 chillers which currently exist in the building. Two of these will be replaced by the above mentioned Trane CAUC-D12 chillers. The third chiller shall remain as discussed below.

The building currently uses 1 York YCAL-0060 air cooled scroll chiller for the air handling units serving the data center and server room. This area has not been converted to DOAS due to the low requirement for OA in these areas, so the existing air handling system has been unchanged. For this reason, the existing YCAL-0060 chiller shall remain in the redesign.

### Fan Coil Unit

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As previously stated, fan coils were selected as the parallel system to handle the remaining sensible load of the DOAS. Fan coils are currently in use in some areas within the Outreach Innovation Building. The current use is around some perimeter areas of the building, mainly for perimeter terminal reheat. The existing fan coils are a 2-pipe design. 2-pipe units were used in the redesign as well. This type of system does not allow for heating and cooling at the same time. In order to maintain acceptable comfort levels in all spaces within the building, some of the fan coil units will have electric heat. Piping cost is lower in a 2-pipe system as compared to a 4-pipe system, and the electric heat will

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ensure thermal comfort during intermediate seasons. This electric heat is an economical solution for the Outreach Innovation Building due to their relatively low electrical rate, and relatively moderate climate zone. The electric heat is not the primary source of heat for the fan coils, it is only used when the majority of the spaces still require cooling and a few perimeter spaces require heating to ensure thermal comfort.

Sound levels are sometimes an issue with fan coil units. Some of the spaces within the Outreach Innovation Building are acoustically sensitive, such as the radio and television production studios. "Selecting fan and coil combinations is inherently flexible for sound-sensitive applications." (Appendix F, 9). Low speed fans and high capacity coils can lower acoustical noise of fan coil units. Also, for this design, "Trane recommends three-phase motors for sound sensitive applications to avoid potential single-phase motor hum." (Appendix F, 9).

The number of fan coil units required has increased from the original design. 31 new fan coils will be installed to handle the remaining load. These units all have a maximum of 3 kW power use. Therefore, the 460/60Hz/3-phase motor will be chosen. This voltage will be used in order to decrease amperage and allow the use of 1 panel board. At this voltage 3 fan coil units can be placed onto a single 3-phase circuit. The increase in required fan coil units is due to their new use as a parallel system to the DOAS.

### Pumps and Piping

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The piping will be very similar to the original design. The pump size for the air handling unit will be greatly reduced due to the reduction in size of the required AHU. There will be an increase in piping due to the increased number of fan coil units.

Primary Chilled Water: 2 pumps @ 190 gpm and 25 ft. head to replace 2 pumps @ 280 gpm and 25 ft. head.

Secondary Chilled Water: 2 pumps @ 460 gpm and 50 ft. head to replace 2 pumps @ 640 gpm and ft. head.

Boiler size remained approximately the same, and therefore the original boiler design shall remain the same.

See Appendix G for Pump Curve Data and Flow Schematics

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### **Underfloor Air Distribution System**

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The Outreach Innovation Building currently consists of an underfloor air distribution (UFAD) system in part of the building. After analysis, it was determined that this UFAD system will remain in the redesign, and be expanded into other areas that currently use overhead duct distribution systems. The large amount of data cables within the spaces and the large open office spaces make a UFAD system very attractive. The underfloor system will allow much more versatility in changing open office plans, and ease of access to data cables. Installation is often much easier with an underfloor system than with a conventional overhead ducted system. Initial cost is sometimes greater than a ducted system, but since the existing building already employs a UFAD system it was decided that the cost to expand this system to the remainder of the building would be minimal compared to the benefits.

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### Original Design Emissions Analysis and Results

Note: For calculation of lbm Pollutant / Ft<sup>2</sup> –year, conditioned space was used for value of floor area (also used in lighting W/Ft<sup>2</sup> value in previous section). This area was calculated at 90,310sq.ft. Listed Gross Square Foot of building is 97,000sq.ft. The difference is due to unconditioned space such as rooftop and other unconditioned spaces within the building. Principal building activity was assumed to be office use. Climatic Zone for the Outreach Innovation Building is Zone 2. Percent mix of each type of fuel was obtained from the Allegheny Power Company. Values for electric and natural gas use were obtained from HAP.

### Original Design

Fuel	% Mix U.S.	lbm Pollutant /kWh Allegheny Power Co.				
		Particulates	SO <sub>2</sub> /kWh	NO <sub>x</sub> /kWh	CO <sub>2</sub> /kWh	
Coal	65.7	7.22E-04	8.39E-03	4.87E-03	1.41E+00	
Oil	3.2	3.54E-05	4.96E-04	9.11E-05	6.79E-02	
Nat. Gas	21.9	0.00E+00	2.95E-06	5.55E-04	2.93E-01	
Nuclear	8.7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Hydro/Wind	0.5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
<b>Totals</b>	100.0	7.58E-04	8.89E-03	5.51E-03	1.77E+00	
Energy Use Yearly Bldg. Pollutant		3.30E+03	3.87E+04	2.40E+04	7.71E+06	lbs./Year
Natural Gas Use Yearly Pollutant		NA	NA	1.47E+04	1.57E+04	lbs./Year
Total Yearly Bldg. Pollutant		3.30E+03	3.87E+04	3.87E+04	7.73E+06	lbs./Year
<b>Total Bldg. Pollutant/Ft<sup>2</sup></b>		<b>3.65E-02</b>	<b>4.28E-01</b>	<b>4.28E-01</b>	<b>8.56E+01</b>	<b>lbs./Ft<sup>2</sup>-Year</b>
U.S. Averages						
50,001 to 100,000		9.16E-03	1.07E-01	6.33E-02	1.97E+01	lbs./Ft <sup>2</sup> -Year
Office		7.02E-02	1.19E-01	7.02E-02	2.18E+01	lbs./Ft <sup>2</sup> -Year
Zone 2		1.14E-02	1.34E-01	7.87E-02	2.45E+01	lbs./Ft <sup>2</sup> -Year

Total Mech. Energy	1360225.0	KWh/Year
Total Lighting Energy	2989490.0	KWh/Year
<b>Total Energy</b>	<b>4349715.0</b>	<b>KWh/Year</b>
Tot. Enrg.Ft <sup>2</sup> -year	164.38	MBH/Ft <sup>2</sup> -y
Floor Area (Ft <sup>2</sup> )	90,310	

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### Redesign Emissions Analysis and Results

#### DOAS Redesign

Fuel	% Mix U.S.	lbm Pollutant /kWh Allegheny Power Co.				
		Particulates	SO <sub>2</sub> /kWh	NO <sub>x</sub> /kWh	CO <sub>2</sub> /kWh	
Coal	65.7	7.22E-04	8.39E-03	4.87E-03	1.41E+00	
Oil	3.2	3.54E-05	4.96E-04	9.11E-05	6.79E-02	
Nat. Gas	21.9	0.00E+00	2.95E-06	5.55E-04	2.93E-01	
Nuclear	8.7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Hydro/Wind	0.5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
<b>Totals</b>	100.0	7.58E-04	8.89E-03	5.51E-03	1.77E+00	
Energy Use Yearly Bldg. Pollutant		2.77E+03	3.25E+04	2.02E+04	6.48E+06	lbs./Year
Natural Gas Use Yearly Pollutant		NA	NA	7.35E+03	7.85E+03	lbs./Year
Total Yearly Bldg. Pollutant		2.77E+03	3.25E+04	2.75E+04	6.49E+06	lbs./Year
<b>Total Bldg. Pollutant/Ft^2</b>		<b>3.07E-02</b>	<b>3.60E-01</b>	<b>3.05E-01</b>	<b>7.19E+01</b>	<b>lbs./Ft^2-Year</b>
U.S. Averages						
50,001 to 100,000		9.16E-03	1.07E-01	6.33E-02	1.97E+01	lbs./Ft^2-Year
Office		7.02E-02	1.19E-01	7.02E-02	2.18E+01	lbs./Ft^2-Year
Zone 2		1.14E-02	1.34E-01	7.87E-02	2.45E+01	lbs./Ft^2-Year

Total Mech. Energy	1213398.0	KWh/Year
Total Lighting Energy	2443685.0	KWh/Year
<b>Total Energy</b>	<b>3657083.0</b>	<b>KWh/Year</b>
Tot. Enrg.Ft^2-year	138.21	MBH/Ft^2-y
Floor Area (Ft^2)	90,310	

The total building pollutants per square foot for the Outreach Innovation Building are relatively close compared to the U.S. Averages based on Building Floor space, Principal Building Activity, and Climatic Zone.

Yearly Total Energy use was reduced by 692,632 KWh/Year. This is a 16% annual reduction in energy use.

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### Energy Sources and Rates

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The electricity rates for the Outreach Innovation Building were obtained from the Office of Physical Plant standard energy rates for The Pennsylvania State University.

#### Demand Charge

Monthly Demand Charge	7.76 \$/Kw
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#### Energy Charge

All kilowatt-hours	\$0.02383 per kilowatt-hour (Effective 1-1-04)
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#### Natural Gas

Price per therm	0.50 \$/therm
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#### Conversion:

$5.14 \text{ MCF} / 1.027 \times 10^6 \text{ BTU} * (100,000 \text{ BTU} / 1 \text{ therm}) = 0.05 \text{ $/therm}$

### Cost Analysis

---

Chiller size was reduced from 435 tons for the original design to 240 tons for the redesign. The size and number of air handling units was reduced drastically due to the implementation of a DOAS. Two-64 ton and two-81.2 ton air handling units were removed and a single 80 ton AHU with an energy recovery wheel was replaced to ventilate the building. 31 2-pipe fan coil units were needed in order to handle the remainder of the cooling and heating load within the building. Additional pipe and electrical wire will be needed in order to supply the chilled/hot water to each unit. The underfloor air distribution system was expanded to some sections within the building to replace the overhead duct system of the current design. See Appendix H for cost details.

Total new equipment cost = \$448,850

Total original equipment cost = \$388,650

Equipment cost different = \$60,200

### Payback Period

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Payback Period = Initial Cost Difference / Yearly Energy Savings

Payback Period = \$62,000 / \$43,623 = 1.38 years = 1 year 5 months



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### Mechanical Lost Rentable Space Breakdown

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Note: Does not include exterior penthouse space because this is not being considered "rentable space". Analysis includes 3<sup>rd</sup> floor mechanical room and vertical shaft space only.

#### Original Design

Mechanical Vertical Shaft Space:

Area per shaft \* # of shafts

81 sq.ft. \* 7 shafts = 567 sq.ft.

Mechanical Room Space:

6850 sq.ft.

Total Lost Rentable Space:

7417 sq.ft. = 8.7% of building floor area

#### Redesign

Mechanical Vertical Shaft Space:

290 sq.ft.

Mechanical Room Space:

4550 sq.ft.

Total Lost Rentable Space:

4840 sq.ft. = 5% of building floor area

This is a reduction of approximately 2600 sq.ft. or a savings of 3.7% of the building floor area.

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### Clean Agent Fire Suppression System Considerations

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Some spaces within the Outreach Innovation Building have electrical equipment which is expensive and can be damaged by water. Due to the high cost of clean agent systems, only critically important and sensitive areas should implement such systems. Such spaces include the main server room, video archive room, and the UPS/Dimmer room. After analyzing these spaces, it was decided that a clean agent fire suppression system could be designed and implemented. Such a system uses gases instead of water to extinguish a fire. The main benefit of such a system is in the event of a fire the clean agent system will not damage the delicate and expensive electrical equipment within the spaces as a typical wet pipe system would. The following describes the analysis and design of a clean agent fire suppression system.

Use Considerations for Clean Air Agent Systems (Fire Protection Handbook, 6-313)

1. They require a reasonably intact enclosure with the doors closed and external ventilation secured prior to discharge.
2. These agents provide virtually no cooling. This is an important consideration where large fires with long preburn times are expected.
3. Electrical power to wire/cable and equipment must be secured, or sufficiently high agent concentrations and hold times must be provided to ensure extinguishment at the expected electrical power density in the cable.
4. All elements of the detection, control, actuation, release, and distribution system must perform as designated. This places increased reliance on both acceptance testing and post-installation maintenance and test.

If the room geometry changes frequently the clean agent system may become inoperable or useless due to the sensitivity of the system to volume changes. This should not be a factor for the rooms being analyzed due to the use of these spaces. Fire suppression equipment failure should be anticipated where possible. Such anticipation includes the use of higher agent concentrations to account for volume or leakage changes. Early warning detectors should be implemented to permit human intervention prior to discharge.

Additional risk reduction may include the use of both a clean agent total flooding system and a standard wet-pipe automatic sprinkler system at a relatively low incremental cost. "For a typical 8-ft high compartment, the additional cost of providing a simple wet-pipe sprinkler system as a secondary system can be as low as 5% of the installed clean agent system cost" (Fire Protection Handbook,

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6-314). This cost is low when compared to the potential losses if the primary (clean agent) system should fail.

### Clean Agent System Chemical Selection

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There are many benefits and downsides to different agents that can be used in a clean agent system. For the design, it was decided a chemical that is acceptable for use in a normally occupied area would be best even though the areas being designed for are normally unoccupied. This was done in the event that personnel are in the space at time of discharge, and also in case of any agent leakage from the designed spaces to the rest of the building areas.

Another consideration was environmental effects. An agent that does not deplete ozone or contribute to global warming was desired.

It is also desirable to have an agent with a high NOAEL level. The NOAEL (No Observed Adverse Effect Level) is the highest concentration of an agent at which no "marked" or adverse effects occurred with exposure to the agent. "The use of halocarbon agents in occupied areas is generally subject to the constraint that the design concentration must be less than the NOAEL. In the 1996 edition of NFPA 2001, an exception allows the use of total flooding gases up to LOAEL (Lowest Observed Adverse Effect Level) for Class B hazards where a predischage alarm and time delay are provided and where acceptable to the Authority Having Jurisdiction. Based on the limitation that the design concentration must be below the NOAEL in most cases, it can be seen from Table 6-19I that three agents are acceptable for use in normally occupied areas for flame extinguishant purposes. These are HFC-227ea, HFC-23, and FC-3-1-10" (Fire Protection Handbook, 6-305).

HFC-227ea was chosen as the best agent for the desired results. "The US Army has done work to develop a new agent for the protection of the crew compartment in new models of armored combat vehicles to take on the role that is being filled by halon 1301 in current vehicles. The composition consists of 95% by weight HFC-227ea halocarbon agent together with 5% by weight sodium bicarbonate dry chemical. They have reported 26 that the sodium bicarbonate additive significantly reduces the generation of hydrogen fluoride normally found with the exposure of halocarbon agents to flames. They attribute this to the quick flame knockdown provided by the sodium bicarbonate. The Army has indicated that it has achieved a 40% increase in performance of the HFC-227ea with the addition of this small amount of sodium bicarbonate. The US EPA is reviewing this composition for addition to the SNAP list as an agent suitable for use in occupied areas." (Peripheral Manufacturing Inc.)

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### Clean Agent System Design

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The process of designing a total flooding gaseous extinguishing system is outlined below:

1. Determine the design concentration
2. Determine the total agent quantity
3. Establish the maximum discharge time
4. Select piping material and thickness consistent with pressure rating requirements
5. Design piping network and select nozzles to deliver required concentration at required discharge time to ensure mixing
6. Evaluate compartment over/under pressurization and provide venting if required
7. Establish minimum agent hold requirements and evaluate compartments for leakage

Other critical and integral parts of a clean agent system include the detection, alarm, and actuating systems. Also, the enclosure itself must be properly designed. This includes proper design of the space to prevent leakage during and after agent discharge to ensure proper hold time to adequately extinguish the fire. All openings such as doors and ventilation fans/openings must be secured prior to discharge.

1. Design Concentration of HFC-227ea from Table FP-1 Appendix I.

$$C = 8-10.8\%$$

2. Total Agent Quantity

$$w = V/S * (C/100-C)$$

$$S = k_1 + k_2 (T)$$

Where

w= specific weight of agent required

S= specific volume (cu ft/lb)

T= minimum ambient temp. of protected space

K1 and k2 are constants (Table FP-3 Appendix I)

V= net volume of protected space

C= design concentration

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Room 164: Server Room

$$S = k_1 + k_2 (T)$$

$$S = 1.885 F + 0.0046(65F)$$

$$S = 2.184$$

$$w = V/S * (C/100 - C)$$

$$w = 1600 \text{ cu.ft.} / 2.184 * (10.8/100 - 10.8)$$

$$w = \mathbf{88.7 \text{ lbs.}}$$

Required Storage Tank: Fike 70-041. Ceiling-hung inverted valve.

Room 165: UPS/Dimmer

$$S = k_1 + k_2 (T)$$

$$S = 1.885 F + 0.0046(65F)$$

$$S = 2.184$$

$$w = V/S * (C/100 - C)$$

$$w = 12000 \text{ cu.ft.} / 2.184 * (10.8/100 - 10.8)$$

$$w = \mathbf{665.25 \text{ lbs.}}$$

Required Storage Tank: Fike 70-157. Upright, floor mounted tank. 3" valve.

Room 169B: Video Storage

$$S = k_1 + k_2 (T)$$

$$S = 1.885 F + 0.0046(65F)$$

$$S = 2.184$$

$$w = V/S * (C/100 - C)$$

$$w = 9000 \text{ cu.ft.} / 2.184 * (10.8/100 - 10.8)$$

$$w = \mathbf{500 \text{ lbs.}}$$

Required Storage Tank: Fike 70-156. Upright floor mounted tank. 3" valve.

### 3. Discharge Time

Maximum discharge time allowed for clean agent systems is 10 seconds. This time limitation is to aid the following (Fire Protection Handbook, 6-318):

1. Provide high flow rates through nozzles to ensure adequate mixing of agent with air inside the enclosure
2. Provide sufficient velocity through pipes to ensure a homogeneous flow of liquid vapor
3. Limit the formation of agent thermal decomposition products

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4. Minimize direct and indirect fire damage, particularly in fast developing fire scenarios

### 4. Piping network

Room 164 UPS/Dimmer shall require no piping. Agent discharge tank will be mounted on ceiling with only 1 nozzle required to adequately suppress fire.

Server Room 165 shall have a 3" main gas line from tank. 1" branch lines shall supply 4-360 degree nozzles.

Video Storage Room 169B shall have a 3" main gas line from tank. 1" branch lines shall supply 4-360 degree nozzles.

### 5. Nozzle Selection

Each nozzle must properly distribute the agent in a uniform pattern and concentration. The nozzles are designed to discharge the agent in 10 seconds. See Appendix I for nozzle spray range.

### 6. Compartment Pressurization

"As the halocarbon agent is discharged into the space, it vaporizes rapidly, cooling the compartment and lowering the pressure. As the agent/air mixture gains heat from the walls or other objects in the space, the pressure recovers and, as additional agent is added, the pressure increases over ambient as mass is added to the compartment."(Fire Protection Handbook, 6-325)

Leakage of the agent is an area of concern. A simple solution is to install baffles on any opening or vent so that direct impingement by a nozzle jet on the opening is avoided. Another issue during discharge is the loss of agent due to delicate ceiling tiles being damaged. Such issues may be avoided by the use of deflector plates as seen in Appendix I.

### 7. Agent Hold Time and Leakage

Total flooding gas systems should maintain the minimum concentration within the room for a minimum of 10 minutes. This enables adequate time for emergency personnel to arrive, soak time for deep-seated fuels, and the prevention of re-flash due to hot surfaces. The calculated hold time is expected to be very conservative therefore the actual hold time can be expected to be much longer than the calculated hold time.

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### Clean Agent System Conclusion

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HFC-227ea was used at the clean system agent due to benefits such as no ozone depletion, high NOAEL level, and its ability to extinguish flame.

3 HFC-227ea agent storage tanks placed within their perspective rooms were selected for a total necessary agent specific weight of 1255 lbs.

Maximum discharge time is 10 seconds with a minimum agent holding time after discharge of 10 minutes.

Simple pipe and nozzle placement required a minimum amount of pipe to be used.

Proper detection and alarm systems must be installed in order to quickly detect a potential problem. Strobe and audio alarms must be used in order to give occupants time to evacuate the space. Manual override controls must be used in the event of improper detection. The manual overrides can be used to stop or start the discharge of the agent in the event that a problem is improperly detected.

If deemed necessary, the existing dry-pipe system can be installed as a backup to the clean agent system for as low as 5% of the installed clean agent system cost (Fire Protection Handbook, 6-314). This cost is small in comparison to potential losses if the primary clean agent system should fail. Also, the clean agent system is designed for quick extinguishing of a fire. If the fire continues to burn the clean agent system is not designed to handle such a problem. The backup dry-pipe system would then be useful in preventing damage to the rest of the building.

It has been determined that a clean agent system could be very beneficial in the server, video archive and UPS/Dimmer areas within the Outreach Innovation Building. Such a system could potentially save valuable data in the event of a fire within these spaces. The cost of the clean agent system could therefore be made up by the saving of expensive equipment and possibly irreplaceable information in the event of a fire.

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### Electrical Analysis Objective

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This is an analysis and comparison of the effects of the mechanical equipment of the redesign on the electrical system within the Outreach Innovation Building. Changes in the equipment that will be analyzed are the circuit breaker size, conductor size, and conduit size. Mechanical equipment changes include a new chiller, air handling unit, and primary and secondary pumps. An enthalpy wheel and 31 new fan coil units will be installed as part of the new design as well.

### Electrical Analysis Procedure

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The 2002 National Electric Code was used to perform the analysis. First the horsepower, voltage, phase, and power factors were found for each new piece of equipment. Then Table 430-150 of the NEC 2002 Code was used to establish full load current for 3-phase AC motors. The kVA was found for each piece of equipment. Circuit breakers were then sized to protect 250% of their actual load. This is to account for startup surge of the motors. Conductor size was multiplied by a safety factor of 125%. NEC Table 310.16 was then used to size the wire. THW Copper wire was used for all new equipment. All of the equipment is 3-phase 4 wire, so conduit size was obtained from table C-1 of the NEC 2002 Code.

The electrical documents have many extra panelboards for future expansion, but a load analysis was done to assure compliance with the new equipment. The kilo-Volt Amps were summed and a safety factor of 25% of the largest load's kVA was added. Panel schedules for the current design were incomplete, therefore it was assumed that all of the old equipment was on the same panelboard and all of the new equipment will be on the same panelboard. This is only for comparison purposes, in reality the equipment would be placed on different panelboards depending on the location throughout the building. The original panelboard would have to be 1000 Amps, while the panelboard with the new equipment would only require 300 Amps. (See Appendix J)



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### Summary and Recommendations

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#### Mechanical Redesign

The DOAS with fan coil units will provide proper ventilation with reduced energy consumption. The yearly energy consumption was reduced by 16% with the redesign for a cost savings of \$43,623 per year. Total lost rentable space is also reduced by 3.7% of the building floor area. Overall it is recommended that the DOAS fan coil system be implemented in the Outreach Innovation Building.

#### Clean Agent Fire Protection

The cost of losing valuable data and system downtime is small compared to the cost of the clean agent fire protection system. Using HFC-227ea as the chemical agent is an effective and environmentally friendly solution. It is recommended that the current dry pipe system still be installed in the event of the failure of the primary (clean agent) system. This can be done at a minimal cost due to the use of wet pipe systems throughout the building. A clean agent system using HFC-227ea should be used in the server room, video archive room, and UPS/Dimmer room.

#### Electrical Analysis

The redesigned mechanical equipment reduced the electrical demand on the building. Panelboard size was reduced. With the redesigned mechanical system there is more than adequate room for future electrical expansion.

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### **Credits / Acknowledgements**

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Joel Haight (The Pennsylvania State University Fire Protection Consultant)

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### Programs

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Carrier Hourly Analysis Program Version 4.2

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Appendix A	ASHRAE Std. 62-2001 Sample Equations
Appendix B	Air Handling Unit Data
Appendix C	Carrier Hourly Analysis Program v4.2 Data
Appendix D	Energy Wheel Data
Appendix E	Scroll Chiller Data
Appendix F	Fan Coil Unit Data
Appendix G	Pump Data and Schematics
Appendix H	Cost Analysis
Appendix I	Fire Protection Data
Appendix J	Electrical Data

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## **Appendix A**

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### **ASHRAE Standard 62-2001 Sample Equations**

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### Sample Equations

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$$V_{oz} = (P_z \cdot R_p + A_z \cdot R_a) / E_z$$

$$Z_p = V_{oz} / V_{pzm}$$

$$D = P_s / \sum P_z$$

$$V_{ou} = D \cdot \sum (R_p \cdot P_z) + (R_a \cdot \sum A_z)$$

$$X_s = V_{ou} / \sum V_{pz}$$

$$V_{ot} = V_{ou} / E_v$$

$A_z$  = Floor area of zone

$P_z$  = Zone population, largest number of people expected to occupy the zone

$R_p$  = Area outdoor air rate (Table 6.1)

$R_a$  = People outdoor air rate (Table 6.1)

$E_z$  = Zone air distribution effectiveness

$V_{oz}$  = Outdoor airflow to the zone corrected for zone air distribution effectiveness

$V_{pz}$  = Primary airflow to zone from air handler.

$V_{pzm}$  = Minimum value of the primary airflow to zone from air handler.

$Z_p$  = Primary outdoor air fraction

$P_s$  = System population, maximum simultaneous number of occupants of space served by system

$D$  = Occupant diversity, ratio of system peak occupancy to sum of space peak occupancies

$V_{ou}$  = Uncorrected outdoor air intake

$X_s$  = Mixing ratio at primary air handler of uncorrected outdoor air intake to system primary flow

Max  $Z_p$  = Maximum primary outdoor air fraction of all the zones

$E_v$  = System ventilation efficiency

$V_{ot}$  = Minimum outdoor air intake

$V_{oz}$  = Nominal outdoor air intake

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## **Appendix B**

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### **Air Handling Unit Data**

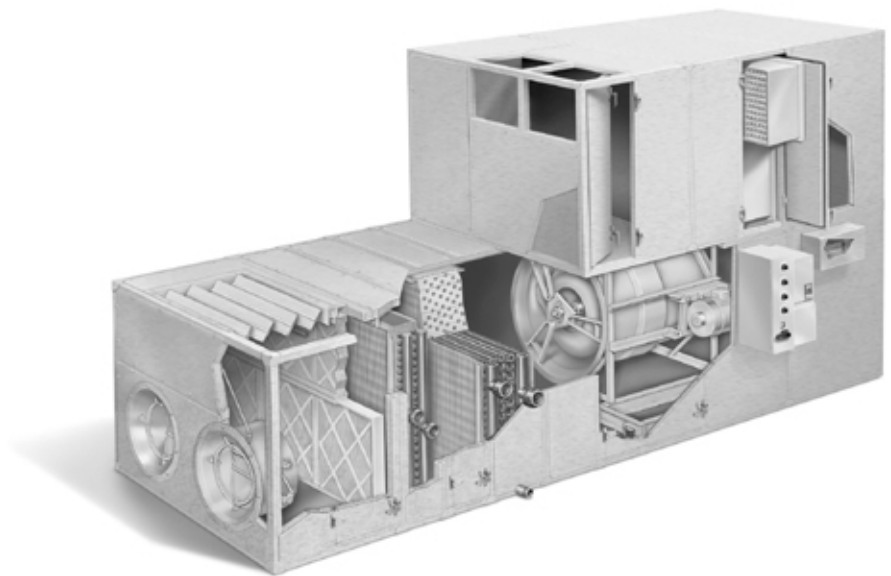




# Applied Central-Station Air Handlers

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## M-Series Climate Changer™ Air Handlers, Unit Sizes 3 to 120





# Feature Highlights

The M-Series Climate Changer™ air handler is a superior pre-engineered air handler with extensive flexibility to meet the specific needs of your engineered application. With its modular, “building-block” construction, the

M-Series air handler can also meet the needs of what have traditionally been custom air handler applications. The M-Series air handler, with all of its options, is used in a wide variety of applications in the industrial, institutional,

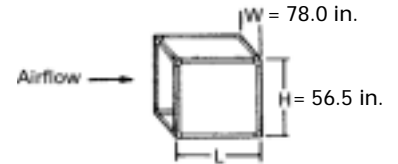
and commercial marketplaces. Trane continues to develop new options for this pre-engineered air handler, so that you remain firmly in control of performance and cost on every design project.

**Table 1. Summary of features and benefits**

Feature	Benefit
Flexible design	<ul style="list-style-type: none"><li>• Eases retrofit, renovation, and replacement</li><li>• Allows stacked units to reduce footprint</li><li>• Allows a wide variety of fans and coils</li><li>• Optimizes coil and fan performance</li><li>• Allows pre-engineered units to be used in custom applications</li><li>• Enables flexible module arrangement</li></ul>
Engineered construction and casing	<ul style="list-style-type: none"><li>• Provides sturdy unit construction for high performance and long life</li><li>• Provides strength to stack units with post-and-panel construction</li><li>• Enables flexible maintenance access to the unit interior</li></ul>
IAQ-ready unit	<ul style="list-style-type: none"><li>• Meets ASHRAE Standard 62.1 requirements</li><li>• Lowers installation, startup, and operating costs</li><li>• Controls ventilation airflow directly</li><li>• Removes airborne contaminants</li><li>• Inhibits microbial growth</li></ul>
Turnkey control options	<ul style="list-style-type: none"><li>• Enables single-source responsibility</li><li>• Reduces control-system installation costs</li><li>• Ensures reliable operation</li><li>• Provides an open protocol</li></ul>
Acoustics solutions	<ul style="list-style-type: none"><li>• Allows the unit to meet required NC (noise criteria) levels</li><li>• Minimizes sound source to reduce system first cost</li><li>• Provides accurate, ARI Standard 260-tested sound data</li></ul>
Energy-efficient solutions	<ul style="list-style-type: none"><li>• Recovers energy from the exhaust air stream</li><li>• Enables downsizing of the air-handling unit and other system components</li><li>• Reduces energy consumption of system components</li><li>• Increases operating efficiency with the low-flow, low-temperature EarthWise™ system</li></ul>

# General Data

## Unit Size 25



**Table 72. Module dimensions**

Module Type	Length (in.)	Weight (lb)	
		Single-Wall	Double-Wall
Intake	15.50	n/a	485
Mixing box			
With angled filters	40.00	498	577
Without angled filters	40.00	433	512
With Traq dampers	40.00	427	487
Air Blender® module	40.00	292	366
Filters			
2-in. or 4-in. angled	24.50	248	294
Cartridge (6-in. or 12-in. ) or short bag (18-in.)	24.50	250	295
2-in. or 4-in. flat	11.00	130	151
2-in. and 4-in. high-efficiency flat	15.50	203	232
2-in. or 4-in. flat open return	4.25	45	45
HEPA	L= 42.00, W= 82.00	256	338
Long bag (30-in. bag)	56.50	398	516
Access or blank			
Small horizontal	11.00	126	139
Medium horizontal	15.50	149	168
Extended-medium horizontal	19.00	171	193
Medium-large horizontal	24.50	210	238
Large horizontal or turning	40.00	297	344
Extra-large horizontal or turning	56.50	345	463
Face-and-bypass damper			
External	L=15.50 H=61.50	349	385
Internal	15.50	291	328
Face damper only	15.50	299	335
Coil <sup>1</sup>			
Small horizontal (with 2-row UW)	11.00	n/a	329
Medium horizontal (with 8-row UW)	15.50	n/a	678
Extended-medium horizontal (with 8-row UW)	19.00	n/a	709
Medium-large horizontal (with 10-row W)	24.50	n/a	1,168
Large horizontal or vertical (with 10-row W)	40.00	n/a	1,294
Electric heat <sup>2</sup>	40.00	685	758
Integral face-and-bypass (IFB) coil <sup>3</sup>	40.00	953	1,019
Multizone/double-duct	L=71.30 H=79.50	1,716	1,897
Humidifier	31.00	n/a	512
Moisture eliminator	11.00	n/a	446
Fan	56.50	See Table 76 for fan module weights	
Diffuser	15.50	225	262
Discharge plenum			
Horizontal	40.00	347	431
Vertical	L=56.50 H=40.00	298	428

1. Coil module weights include the coil noted with 144 aluminum fins per foot, standard tubes, and no water. Refer to the coil selection for exact coil weights.

2. Electric heat requires a large access or blank module downstream for blow-thru applications.

3. IFB coils require a medium access or blank module downstream.

# General Data

## Unit Size 25

**Table 73. Coil availability**

Module Type	½-Inch Coils	¾-Inch Coils
Small	2* rows	1 and 2* rows
Medium	2–4, 6*, and 8* rows	1–4 rows
Extended-medium	2–8 rows	1–6 rows
Medium-large	2–8 rows	1–10 rows
With access	2–6 rows	1–4 rows
Large horizontal	2–8 rows	1–10 rows
With access	2–8 rows	1–8 rows
Large vertical	2–8 rows	1–6 rows
Multizone (cold deck)	2–4, 6*, and 8* rows	1–4 rows

The drain pans for coils noted with \* are not extended.

**Table 74. Filter data**

Filter Type	Area (ft²)	Qty–Size (in.)
Flat (2 in., 4 in., or 2 in./4 in.) <i>Traq™ mixing boxes use flat filters</i>	24.00	6–24 × 24
Angled or mixing box (2 in. or 4 in.)	38.89	4–20 × 20 8–25 × 20
Bag or cartridge, 2-in. Prefilters	24.00	6–24 × 24
HEPA	24.00	6–24 × 24

2-inch filters available in permanent, throwaway, or pleated media  
4-inch filters available in pleated media, 65%, 85%, or 95% efficiency  
Bag or cartridge filters available in 65%, 85%, or 95% efficiency

**Table 75. Damper areas**

Module Type	Area (ft²)
Mixing box	
Back, bottom or top airfoil blade damper	10.26
Side airfoil blade damper	5.61
Traq damper	6.28
Internal face-and-bypass	
Face	18.87
Bypass	7.13
External face-and-bypass	
Face	24.74
Bypass	7.13
Face damper	24.74
Air Blender® module	10.40
Multizones	
Per deck	9.83
Maximum zones per deck	12

**Table 76. Fan module weights**

Casing Construction	Fan Module Weight (lb) <sup>1</sup>		
	FC Fans	AF Fans	Q Fans
Single-wall	949	1,082	1,415
Double-wall	1,068	1,201	1,533

1. Fan module weights include a high-efficiency, open and drip-proof (ODP) motor.

**Table 77. Fan data**

Fan Characteristic	Fan Application								
	Housed						Plenum	Vaneaxial	
	A	B	D	E	F	G	P	Q	R
Size/type	25 FC	22.38 FC	22 AF	22 AF	20 AF	20 AF	32.38 AF	27 Q	30 Q
Max rpm	811	1,273	1,850	2,300	2,200	2,450	1,611	2,160	1,940
ODP motor hp range	1–10	1–20	1–15	1–30	1–15	1–30	3–20	0.5–15	0.75–20
Outlet area (ft²)	6.70	5.16	5.50	5.50	4.38	4.38	n/a	4.54	5.60
Blast area (ft²)	3.69	2.78	3.42	3.42	2.60	2.60	n/a	n/a	n/a
Bearing size (in.)									
Drive side	1.6875	2.1875	1.5	2	1.5	1.6875	1.6875	1.4375	1.4375
Opposite drive side	1.6875	1.0000	1.5	2	1.5	1.6875	1.6875	1.4375	1.4375
Shaft size (in.)	1.6875	1.1875	1.5	2	1.5	1.6875	1.6875	1.4375	1.4375

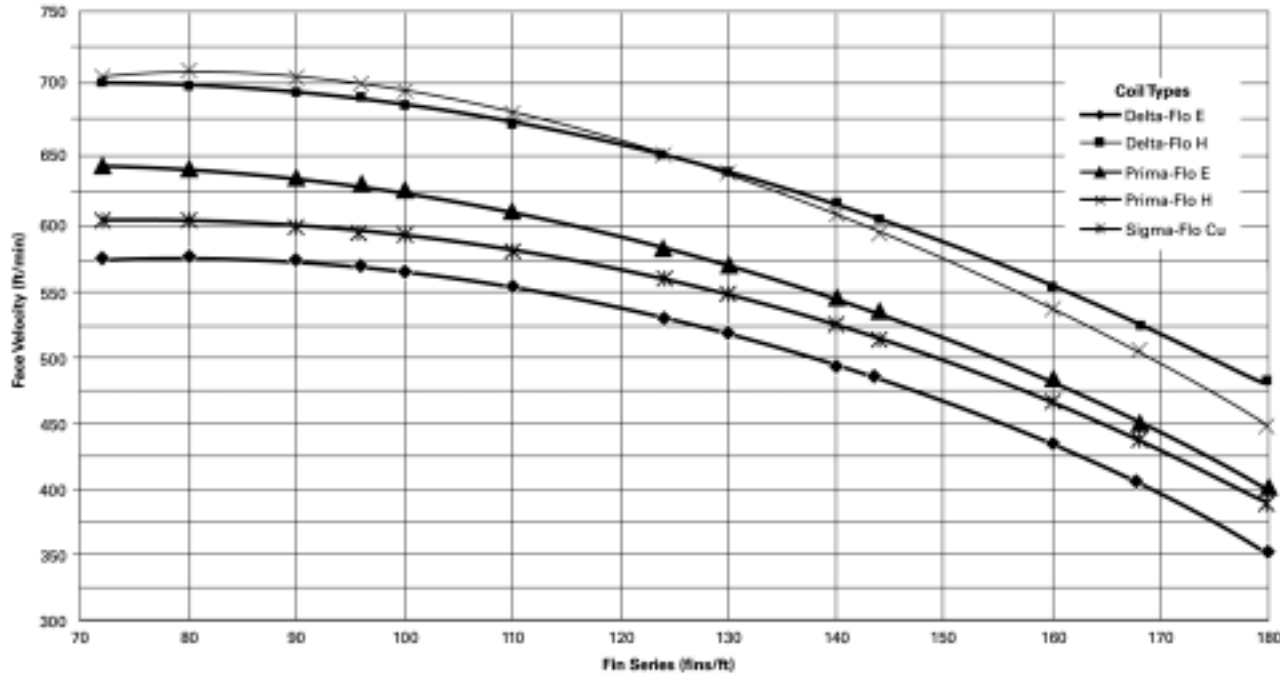
**Table 78. Coil data**

Coil Type	Rows	Fin Type	Area (ft²)	Qty–Size (in.)
½-inch unit coils (UW, UU, UF)	All available rows	Aluminum	24.38	1–51.25 × 68.5
¾-inch unit coils				
W	1	Alum. or Copper	22.67	2–24.00 × 68.0
W, WD, 5D	3 to 10	Aluminum	23.38	1–49.50 × 68.0
W, WD, K	2 to 8	Copper	22.67	1–48.00 × 68.0
W, WD, K	10	Copper	22.67	2–24.00 × 68.0
5W	All available rows	Alum. or Copper	22.67	1–48.00 × 68.0
K	2 to 10	Aluminum	22.67	1–48.00 × 68.0
WA, 5A, F, P2, P4, P8, D, DD, TT	All available rows	Alum. or Copper	22.67	2–24.00 × 68.0
1-inch unit coils (N, NS)	All available rows	Alum. or Copper	19.83	1–18.00 × 68.0 1–24.00 × 68.0
Modified coils (W, WD, 5W, WA, 5A, F, P2, P4, P8, K, D, DD, TT, N, NS)	All available rows	Alum. or Copper	17.00	2–18.00 × 68.0
Hot deck coils (W, 5W, WA, 5A, TT, N, NS)	1 and 2	Alum. or Copper	11.33	1–24.00 × 68.0



## Coil Data

Figure 49. Face velocity limits for moisture carryover with uncoated coils in unit sizes 21 to 30





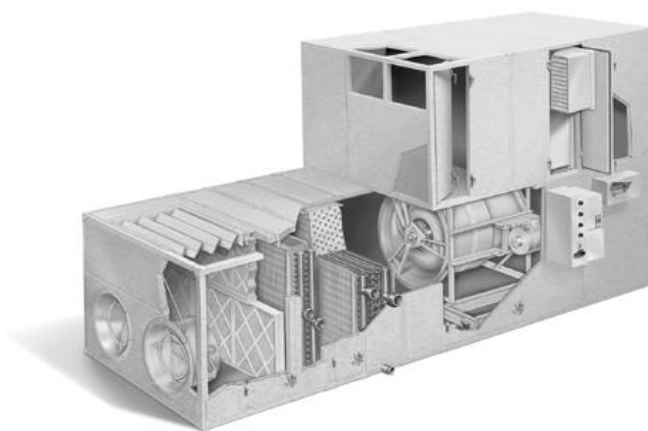
# M-Series Climate Changer™ Air Handler

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## Quick Select for Unit Sizes 3 to 120

### Selection Procedure

- 1 Size the air-handling unit based on airflow through the cooling coil (see Table 2). The unique fin design of Trane coils enables cooling coil selections at velocities in excess of 625 fpm with no moisture carryover. The coil moisture carryover curves from tested data are built into the Trane Official Product Selection System (the TOPSS™ program). Use this system to select coils.
- 2 Choose the coil module (see Table 3). Unit size, coil type, and coil rows determine the minimum coil module size required.
- 3 Select a filter type and check face velocities (see Table 4). The maximum recommended face velocity for pleated media, permanent, bag, and 12-inch cartridge filters is 625 fpm; for throwaway and HEPA filters, it is 500 fpm.
- 4 Design the basic air-handling system. Choose all required sections, including custom modules. Contact your local Trane sales office for more information on custom modules.
- 5 Estimate system static pressure requirements and select a fan (see Figure 5). Refer to M-Series air handler product catalog CLCH-PRC003-EN for pressure drops and catalog CLCH-PRC008-EN for fan curves.
- 6 Total the overall air-handling unit dimensions and weights. Use Table 1 for module dimensions and weights.
- 7 Select a control system. Factory-mounted, -wired, and -tested end devices, starters, VFDs, and direct-digital, interoperable controllers are available to minimize construction cycles and job-site coordination.
- 8 Contact your local Trane sales office to order an air-handling system or to ask questions.



# **Outreach Innovation Building**

Penn State Research Park  
State College, PA.

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## **Appendix C**

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Carrier Hourly Analysis Program v4.2 Data

## Air System Sizing Summary for AHU-1A&B

Project Name: Outreach\_Innovation\_Center14  
Prepared by: psuae

03/22/2005  
01:25PM

### Air System Information

Air System Name ..... **AHU-1A&B**  
Equipment Class ..... **CW AHU**  
Air System Type ..... **VAV**

Number of zones ..... **9**  
Floor Area ..... **3215.0** ft<sup>2</sup>  
Location ..... **Williamsport, Pennsylvania**

### Sizing Calculation Information

#### Zone and Space Sizing Method:

Zone CFM ..... **Peak zone sensible load**  
Space CFM ..... **Individual peak space loads**

Calculation Months ..... **Jan to Dec**  
Sizing Data ..... **Calculated**

### Central Cooling Coil Sizing Data

Total coil load ..... **17.4** Tons  
Total coil load ..... **208.6** MBH  
Sensible coil load ..... **130.0** MBH  
Coil CFM at Mar 1600 ..... **4093** CFM  
Max block CFM at Aug 1700 ..... **4374** CFM  
Sum of peak zone CFM ..... **4377** CFM  
Sensible heat ratio ..... **0.623**  
ft<sup>2</sup>/Ton ..... **185.0**  
BTU/(hr-ft<sup>2</sup>) ..... **64.9**  
Water flow @ 15.0 °F rise ..... **27.82** gpm

Load occurs at ..... **Mar 1600**  
OA DB / WB ..... **60.4 / 58.5** °F  
Entering DB / WB ..... **75.0 / 63.7** °F  
Leaving DB / WB ..... **45.0 / 44.4** °F  
Coil ADP ..... **41.7** °F  
Bypass Factor ..... **0.100**  
Resulting RH ..... **30** %  
Design supply temp. .... **48.3** °F  
Zone T-stat Check ..... **4 of 9** OK  
Max zone temperature deviation ..... **0.4** °F

### Central Heating Coil Sizing Data

**No central heating coil loads occurred during this calculation.**

### Preheat Coil Sizing Data

Max coil load ..... **133.4** MBH  
Coil CFM at Mar 0700 ..... **4202** CFM  
Max coil CFM ..... **4374** CFM  
Water flow @ 20.0 °F drop ..... **13.35** gpm

Load occurs at ..... **Mar 0700**  
Ent. DB / Lvg DB ..... **45.0 / 75.0** °F

### Humidifier Sizing Data

Max steam flow at Jan 0700 ..... **37.72** lb/hr  
Airflow Rate ..... **4089** CFM

Air mass flow ..... **18056.23** lb/hr  
Moisture gain ..... **.00209** lb/lb

### Supply Fan Sizing Data

Actual max CFM at Aug 1700 ..... **4374** CFM  
Standard CFM ..... **4291** CFM  
Actual max CFM/ft<sup>2</sup> ..... **1.36** CFM/ft<sup>2</sup>

Fan motor BHP ..... **5.93** BHP  
Fan motor kW ..... **4.42** kW  
Fan static ..... **4.65** in wg

### Outdoor Ventilation Air Data

Design airflow CFM ..... **350** CFM  
CFM/ft<sup>2</sup> ..... **0.11** CFM/ft<sup>2</sup>

CFM/person ..... **34.97** CFM/person



## Zone Sizing Summary for AHU-1A&B

Project Name: Outreach\_Innovation\_Center14  
Prepared by: psuae

03/22/2005  
01:25PM

### Air System Information

Air System Name ..... **AHU-1A&B**  
Equipment Class ..... **CW AHU**  
Air System Type ..... **VAV**

Number of zones ..... **9**  
Floor Area ..... **3215.0** ft<sup>2</sup>  
Location ..... **Williamsport, Pennsylvania**

### Sizing Calculation Information

**Zone and Space Sizing Method:**

Zone CFM ..... **Peak zone sensible load**  
Space CFM ..... **Individual peak space loads**

Calculation Months ..... **Jan to Dec**  
Sizing Data ..... **Calculated**

### Zone Sizing Data

Zone Name	Maximum Cooling Sensible (MBH)	Design Air Flow (CFM)	Minimum Air Flow (CFM)	Time of Peak Load	Maximum Heating Load (MBH)	Zone Floor Area (ft <sup>2</sup> )	Zone CFM/ft <sup>2</sup>
Zone 1	58.4	2063	21	Jan 1700	0.0	1200.0	1.72
Zone 2	10.2	359	4	Aug 1700	6.5	160.0	2.24
Zone 3	32.4	1144	11	Jan 1700	0.0	900.0	1.27
Zone 4	9.5	336	3	Jan 1700	0.0	375.0	0.90
Zone 5	2.5	87	1	Jan 1700	0.0	100.0	0.87
Zone 6	4.2	150	2	Jan 1700	0.0	180.0	0.83
Zone 7	2.3	82	1	Jan 1700	0.0	100.0	0.82
Zone 8	2.4	84	1	Jan 1700	0.0	100.0	0.84
Zone 9	2.0	72	1	Jul 1400	0.8	100.0	0.72

### Zone Terminal Sizing Data

Zone Name	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 20.0 °F	Zone Htg Coil Load (MBH)	Zone Htg Water gpm @ 20.0 °F	Mixing Box Fan Airflow (CFM)
Zone 1	0.0	0.00	0.0	0.00	0
Zone 2	6.5	0.65	0.0	0.00	0
Zone 3	0.0	0.00	0.0	0.00	0
Zone 4	0.0	0.00	0.0	0.00	0
Zone 5	0.0	0.00	0.0	0.00	0
Zone 6	0.0	0.00	0.0	0.00	0
Zone 7	0.0	0.00	0.0	0.00	0
Zone 8	0.0	0.00	0.0	0.00	0
Zone 9	0.8	0.08	0.0	0.00	0

### Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft <sup>2</sup> )	Space CFM/ft <sup>2</sup>
<b>Zone 1</b>							
164	1	58.4	Jan 1700	2063	0.0	1200.0	1.72
<b>Zone 2</b>							
165	1	10.2	Aug 1700	359	6.5	160.0	2.24
<b>Zone 3</b>							
169	1	32.4	Jan 1700	1144	0.0	900.0	1.27
<b>Zone 4</b>							
170	1	9.5	Jan 1700	336	0.0	375.0	0.90
<b>Zone 5</b>							
178	1	2.5	Jan 1700	87	0.0	100.0	0.87
<b>Zone 6</b>							
179	1	4.2	Jan 1700	150	0.0	180.0	0.83
<b>Zone 7</b>							

## Zone Sizing Summary for AHU-1A&B

Project Name: Outreach\_Innovation\_Center14  
Prepared by: psuae

03/22/2005  
01:25PM

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
105T	1	2.3	Jan 1700	82	0.0	100.0	0.82
<b>Zone 8</b>							
205T	1	2.4	Jan 1700	84	0.0	100.0	0.84
<b>Zone 9</b>							
305T	1	2.0	Jul 1400	72	0.8	100.0	0.72

## Air System Sizing Summary for AHU2A&B

Project Name: Outreach\_Innovation\_Center14  
Prepared by: psuae

03/22/2005  
01:23PM

### Air System Information

Air System Name ..... **AHU2A&B**  
Equipment Class ..... **CW AHU**  
Air System Type ..... **VAV**

Number of zones ..... **30**  
Floor Area ..... **19370.0** ft<sup>2</sup>  
Location ..... **Williamsport, Pennsylvania**

### Sizing Calculation Information

#### Zone and Space Sizing Method:

Zone CFM ..... **Peak zone sensible load**  
Space CFM ..... **Individual peak space loads**

Calculation Months ..... **Jan to Dec**  
Sizing Data ..... **Calculated**

### Central Cooling Coil Sizing Data

Total coil load ..... **105.5** Tons  
Total coil load ..... **1265.9** MBH  
Sensible coil load ..... **723.6** MBH  
Coil CFM at Jul 1600 ..... **16349** CFM  
Max block CFM at Jul 1700 ..... **17636** CFM  
Sum of peak zone CFM ..... **17636** CFM  
Sensible heat ratio ..... **0.572**  
ft<sup>2</sup>/Ton ..... **183.6**  
BTU/(hr-ft<sup>2</sup>) ..... **65.4**  
Water flow @ 15.0 °F rise ..... **168.88** gpm

Load occurs at ..... **Jul 1600**  
OA DB / WB ..... **89.4 / 72.8** °F  
Entering DB / WB ..... **89.4 / 72.8** °F  
Leaving DB / WB ..... **47.6 / 46.9** °F  
Coil ADP ..... **43.0** °F  
Bypass Factor ..... **0.100**  
Resulting RH ..... **35** %  
Design supply temp. .... **50.9** °F  
Zone T-stat Check ..... **18 of 30** OK  
Max zone temperature deviation ..... **3.7** °F

### Central Heating Coil Sizing Data

**No central heating coil loads occurred during this calculation.**

### Preheat Coil Sizing Data

Max coil load ..... **379.6** MBH  
Coil CFM at Feb 0800 ..... **8519** CFM  
Max coil CFM ..... **17636** CFM  
Water flow @ 20.0 °F drop ..... **37.98** gpm

Load occurs at ..... **Feb 0800**  
Ent. DB / Lvg DB ..... **32.9 / 75.0** °F

### Humidifier Sizing Data

Max steam flow at Jan 0600 ..... **81.32** lb/hr  
Airflow Rate ..... **6084** CFM

Air mass flow ..... **26862.36** lb/hr  
Moisture gain ..... **.00303** lb/lb

### Supply Fan Sizing Data

Actual max CFM at Jul 1700 ..... **17636** CFM  
Standard CFM ..... **17304** CFM  
Actual max CFM/ft<sup>2</sup> ..... **0.91** CFM/ft<sup>2</sup>

Fan motor BHP ..... **23.89** BHP  
Fan motor kW ..... **17.82** kW  
Fan static ..... **4.65** in wg

### Outdoor Ventilation Air Data

Design airflow CFM ..... **17636** CFM  
CFM/ft<sup>2</sup> ..... **0.91** CFM/ft<sup>2</sup>

CFM/person ..... **95.74** CFM/person

## Zone Sizing Summary for AHU2A&B

Project Name: Outreach\_Innovation\_Center14  
Prepared by: psuae

03/22/2005  
01:23PM

### Air System Information

Air System Name ..... **AHU2A&B**  
Equipment Class ..... **CW AHU**  
Air System Type ..... **VAV**

Number of zones ..... **30**  
Floor Area ..... **19370.0** ft<sup>2</sup>  
Location ..... **Williamsport, Pennsylvania**

### Sizing Calculation Information

**Zone and Space Sizing Method:**

Zone CFM ..... **Peak zone sensible load**  
Space CFM ..... **Individual peak space loads**

Calculation Months ..... **Jan to Dec**  
Sizing Data ..... **Calculated**

### Zone Sizing Data

Zone Name	Maximum Cooling Sensible (MBH)	Design Air Flow (CFM)	Minimum Air Flow (CFM)	Time of Peak Load	Maximum Heating Load (MBH)	Zone Floor Area (ft <sup>2</sup> )	Zone CFM/ft <sup>2</sup>
Zone 1	4.4	173	2	Jan 1700	0.0	200.0	0.87
Zone 2	8.6	338	3	Jan 1700	0.0	400.0	0.85
Zone 3	5.3	207	2	Aug 1600	1.8	200.0	1.04
Zone 4	2.2	86	1	Jan 1700	0.0	100.0	0.86
Zone 5	4.4	173	2	Jan 1700	0.0	200.0	0.87
Zone 6	11.1	436	4	Jan 1700	0.0	550.0	0.79
Zone 7	66.1	2587	26	Jan 1700	0.0	2900.0	0.89
Zone 8	6.4	322	3	Jan 1700	0.0	600.0	0.54
Zone 9	8.0	312	3	Sep 1100	4.5	90.0	3.46
Zone 10	18.3	719	7	Aug 1200	17.3	520.0	1.38
Zone 11	56.1	2211	22	Aug 1500	43.1	1420.0	1.56
Zone 12	2.0	78	1	Jan 1700	0.0	100.0	0.78
Zone 13	5.2	203	2	Jan 1700	0.0	325.0	0.63
Zone 14	8.0	312	3	Jan 1700	0.0	500.0	0.62
Zone 15	1.8	72	1	Aug 1900	1.8	90.0	0.80
Zone 16	15.9	622	6	Aug 1900	13.0	860.0	0.72
Zone 17	12.3	483	5	Jul 1700	9.6	400.0	1.21
Zone 18	22.5	881	9	Jun 1700	15.3	600.0	1.47
Zone 19	30.0	1177	12	Jun 1700	19.5	660.0	1.78
Zone 20	1.8	70	1	Jul 2000	2.8	90.0	0.78
Zone 21	0.5	21	0	Jan 1700	0.0	90.0	0.24
Zone 22	25.3	1350	14	Jan 1700	0.0	1500.0	0.90
Zone 23	4.1	161	2	Jan 1700	0.0	360.0	0.45
Zone 24	13.9	544	5	Sep 1100	9.8	400.0	1.36
Zone 25	0.8	60	1	Jan 2300	0.0	1000.0	0.06
Zone 26	6.7	263	3	Jun 1700	4.0	100.0	2.63
Zone 27	4.5	177	2	Sep 1100	3.0	200.0	0.89
Zone 28	3.3	129	1	Aug 1700	5.5	175.0	0.74
Zone 29	1.1	60	1	Jan 2300	0.0	600.0	0.10
Zone 30	86.4	3409	34	Jun 1700	54.6	4140.0	0.82

### Zone Terminal Sizing Data

Zone Name	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 20.0 °F	Zone Htg Coil Load (MBH)	Zone Htg Water gpm @ 20.0 °F	Mixing Box Fan Airflow (CFM)
Zone 1	0.0	0.00	0.0	0.00	0
Zone 2	0.0	0.00	0.0	0.00	0
Zone 3	1.8	0.18	0.0	0.00	0
Zone 4	0.0	0.00	0.0	0.00	0
Zone 5	0.0	0.00	0.0	0.00	0
Zone 6	0.0	0.00	0.0	0.00	0

## Zone Sizing Summary for AHU2A&B

Project Name: Outreach\_Innovation\_Center14  
Prepared by: psuae

03/22/2005  
01:23PM

Zone Name	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 20.0 °F	Zone Htg Coil Load (MBH)	Zone Htg Water gpm @ 20.0 °F	Mixing Box Fan Airflow (CFM)
Zone 7	0.0	0.00	0.0	0.00	0
Zone 8	0.0	0.00	0.0	0.00	0
Zone 9	4.5	0.45	0.0	0.00	0
Zone 10	17.3	1.73	0.0	0.00	0
Zone 11	43.1	4.31	0.0	0.00	0
Zone 12	0.0	0.00	0.0	0.00	0
Zone 13	0.0	0.00	0.0	0.00	0
Zone 14	0.0	0.00	0.0	0.00	0
Zone 15	1.8	0.18	0.0	0.00	0
Zone 16	13.0	1.30	0.0	0.00	0
Zone 17	9.6	0.96	0.0	0.00	0
Zone 18	15.3	1.53	0.0	0.00	0
Zone 19	19.5	1.95	0.0	0.00	0
Zone 20	2.8	0.28	0.0	0.00	0
Zone 21	0.0	0.00	0.0	0.00	0
Zone 22	0.0	0.00	0.0	0.00	0
Zone 23	0.0	0.00	0.0	0.00	0
Zone 24	9.8	0.98	0.0	0.00	0
Zone 25	0.0	0.00	0.0	0.00	0
Zone 26	4.0	0.40	0.0	0.00	0
Zone 27	3.0	0.30	0.0	0.00	0
Zone 28	5.5	0.55	0.0	0.00	0
Zone 29	0.0	0.00	0.0	0.00	0
Zone 30	54.6	5.46	0.0	0.00	0

### Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
<b>Zone 1</b>							
135	1	4.4	Jan 1700	173	0.0	200.0	0.87
<b>Zone 2</b>							
136	1	8.6	Jan 1700	338	0.0	400.0	0.85
<b>Zone 3</b>							
137	1	5.3	Aug 1600	207	1.8	200.0	1.04
<b>Zone 4</b>							
138	1	2.2	Jan 1700	86	0.0	100.0	0.86
<b>Zone 5</b>							
139	1	4.4	Jan 1700	173	0.0	200.0	0.87
<b>Zone 6</b>							
140	1	11.1	Jan 1700	436	0.0	550.0	0.79
<b>Zone 7</b>							
141	1	66.1	Jan 1700	2587	0.0	2900.0	0.89
<b>Zone 8</b>							
143	2	1.7	Jan 1700	66	0.0	130.0	0.50
144	1	0.9	Jan 1700	60	0.0	80.0	0.75
145	1	1.0	Jan 1700	60	0.0	100.0	0.60
146	1	0.9	Jan 1700	60	0.0	80.0	0.75
R145A	1	0.3	Jan 2300	11	0.0	80.0	0.13
<b>Zone 9</b>							
148	1	8.0	Sep 1100	312	4.5	90.0	3.46
<b>Zone 10</b>							
149	1	16.7	Aug 1200	654	17.3	420.0	1.56
150	1	1.7	Jan 1700	65	0.0	100.0	0.65
<b>Zone 11</b>							

## Zone Sizing Summary for AHU2A&B

Project Name: Outreach\_Innovation\_Center14  
Prepared by: psuae

03/22/2005  
01:23PM

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
151	1	52.8	Sep 1500	2067	41.2	1170.0	1.77
152	1	3.7	Aug 1700	144	1.8	250.0	0.58
<b>Zone 12</b>							
153	1	2.0	Jan 1700	78	0.0	100.0	0.78
<b>Zone 13</b>							
154	1	5.2	Jan 1700	203	0.0	325.0	0.63
<b>Zone 14</b>							
155	1	8.0	Jan 1700	312	0.0	500.0	0.62
<b>Zone 15</b>							
156	1	1.8	Aug 1900	72	1.8	90.0	0.80
<b>Zone 16</b>							
162	1	3.0	Aug 1900	116	4.6	260.0	0.45
161	1	1.9	Aug 1900	76	2.3	200.0	0.38
163	1	11.0	Aug 1900	430	6.1	400.0	1.08
<b>Zone 17</b>							
167	1	7.8	Jun 1700	306	6.0	240.0	1.27
166T	1	4.5	Jul 1700	178	3.6	160.0	1.11
<b>Zone 18</b>							
168	1	6.5	Jun 1700	255	4.4	150.0	1.70
171	1	16.0	Jun 1700	626	10.9	450.0	1.39
<b>Zone 19</b>							
172	1	6.8	Jun 1700	264	4.9	160.0	1.65
174	1	23.3	Jun 1700	912	14.6	500.0	1.82
<b>Zone 20</b>							
175	1	1.8	Jul 2000	70	2.8	90.0	0.78
<b>Zone 21</b>							
176	1	0.5	Jan 1700	21	0.0	90.0	0.24
<b>Zone 22</b>							
101F	1	25.3	Jan 1700	1350	0.0	1500.0	0.90
<b>Zone 23</b>							
151A	1	1.4	Jan 1700	54	0.0	120.0	0.45
151B	1	1.4	Jan 1700	54	0.0	120.0	0.45
151C	1	1.4	Jan 1700	54	0.0	120.0	0.45
<b>Zone 24</b>							
151D	1	13.9	Sep 1100	544	9.8	400.0	1.36
<b>Zone 25</b>							
159A	1	0.8	Jan 2300	60	0.0	1000.0	0.06
<b>Zone 26</b>							
102F	1	6.7	Jun 1700	263	4.0	100.0	2.63
<b>Zone 27</b>							
103F	1	4.5	Sep 1100	177	3.0	200.0	0.89
<b>Zone 28</b>							
157X	1	3.3	Aug 1700	129	5.5	175.0	0.74
<b>Zone 29</b>							
Corridor1_2	1	1.1	Jan 2300	60	0.0	600.0	0.10
<b>Zone 30</b>							
222A	1	15.1	Jan 1700	592	0.0	1500.0	0.39
222B,J	1	43.5	Jun 1700	1703	36.3	1260.0	1.35
222K	1	10.0	Jun 1700	391	11.1	200.0	1.95
222L	1	3.1	Jun 1400	121	2.4	140.0	0.87
222M	1	5.1	Jun 0800	201	4.8	150.0	1.34
222N	1	1.2	Jan 1700	46	0.0	100.0	0.46
222P	1	2.3	Jan 1700	91	0.0	200.0	0.46
222Q	1	1.1	Jan 1700	50	0.0	100.0	0.50
222S	1	3.9	Jan 1700	153	0.0	350.0	0.44
222U	1	1.6	Jan 1700	61	0.0	140.0	0.44

## Air System Sizing Summary for AHU3A&B

Project Name: Outreach\_Innovation\_Center14  
Prepared by: psuae

03/22/2005  
04:09PM

### Air System Information

Air System Name ..... **AHU3A&B**  
Equipment Class ..... **CW AHU**  
Air System Type ..... **VAV**

Number of zones ..... **33**  
Floor Area ..... **42420.0** ft<sup>2</sup>  
Location ..... **Williamsport, Pennsylvania**

### Sizing Calculation Information

#### Zone and Space Sizing Method:

Zone CFM ..... **Peak zone sensible load**  
Space CFM ..... **Individual peak space loads**

Calculation Months ..... **Jan to Dec**  
Sizing Data ..... **Calculated**

### Central Cooling Coil Sizing Data

Total coil load ..... **195.9** Tons  
Total coil load ..... **2350.8** MBH  
Sensible coil load ..... **1360.2** MBH  
Coil CFM at Aug 1500 ..... **31465** CFM  
Max block CFM at Aug 1600 ..... **33734** CFM  
Sum of peak zone CFM ..... **33734** CFM  
Sensible heat ratio ..... **0.579**  
ft<sup>2</sup>/Ton ..... **216.5**  
BTU/(hr-ft<sup>2</sup>) ..... **55.4**  
Water flow @ 10.0 °F rise ..... **470.41** gpm

Load occurs at ..... **Aug 1500**  
OA DB / WB ..... **90.0 / 73.0** °F  
Entering DB / WB ..... **90.0 / 73.0** °F  
Leaving DB / WB ..... **49.2 / 48.3** °F  
Coil ADP ..... **44.7** °F  
Bypass Factor ..... **0.100**  
Resulting RH ..... **36** %  
Design supply temp. .... **52.8** °F  
Zone T-stat Check ..... **17 of 33** OK  
Max zone temperature deviation ..... **5.1** °F

### Central Heating Coil Sizing Data

**No central heating coil loads occurred during this calculation.**

### Preheat Coil Sizing Data

Max coil load ..... **665.4** MBH  
Coil CFM at Mar 0700 ..... **19098** CFM  
Max coil CFM ..... **33734** CFM  
Water flow @ 20.0 °F drop ..... **66.58** gpm

Load occurs at ..... **Mar 0700**  
Ent. DB / Lvg DB ..... **42.1 / 75.0** °F

### Humidifier Sizing Data

Max steam flow at Feb 0700 ..... **84.36** lb/hr  
Airflow Rate ..... **12569** CFM

Air mass flow ..... **55494.11** lb/hr  
Moisture gain ..... **.00152** lb/lb

### Supply Fan Sizing Data

Actual max CFM at Aug 1600 ..... **33734** CFM  
Standard CFM ..... **33099** CFM  
Actual max CFM/ft<sup>2</sup> ..... **0.80** CFM/ft<sup>2</sup>

Fan motor BHP ..... **50.13** BHP  
Fan motor kW ..... **37.38** kW  
Fan static ..... **5.10** in wg

### Outdoor Ventilation Air Data

Design airflow CFM ..... **33734** CFM  
CFM/ft<sup>2</sup> ..... **0.80** CFM/ft<sup>2</sup>

CFM/person ..... **141.38** CFM/person

## Zone Sizing Summary for AHU3A&B

Project Name: Outreach\_Innovation\_Center14  
Prepared by: psuae

03/22/2005  
04:09PM

### Air System Information

Air System Name ..... **AHU3A&B**  
Equipment Class ..... **CW AHU**  
Air System Type ..... **VAV**

Number of zones ..... **33**  
Floor Area ..... **42420.0** ft<sup>2</sup>  
Location ..... **Williamsport, Pennsylvania**

### Sizing Calculation Information

**Zone and Space Sizing Method:**

Zone CFM ..... **Peak zone sensible load**  
Space CFM ..... **Individual peak space loads**

Calculation Months ..... **Jan to Dec**  
Sizing Data ..... **Calculated**

### Zone Sizing Data

Zone Name	Maximum Cooling Sensible (MBH)	Design Air Flow (CFM)	Minimum Air Flow (CFM)	Time of Peak Load	Maximum Heating Load (MBH)	Zone Floor Area (ft <sup>2</sup> )	Zone CFM/ft <sup>2</sup>
Zone 1	20.8	883	9	Jun 1700	11.1	950.0	0.93
Zone 2	11.7	497	5	Jun 1700	5.3	630.0	0.79
Zone 3	1.3	57	1	Jan 1700	0.0	160.0	0.35
Zone 4	2.5	105	1	Jan 1700	0.0	160.0	0.66
Zone 5	1.7	90	1	Jan 2300	0.0	600.0	0.15
Zone 6	100.9	4495	45	Sep 1300	54.8	5325.0	0.84
Zone 7	0.9	39	0	Jan 1700	0.0	275.0	0.14
Zone 8	0.9	39	0	Jan 1700	0.0	275.0	0.14
Zone 9	38.3	1628	16	Jul 1700	29.4	2725.0	0.60
Zone 10	19.5	828	8	Jun 1700	15.9	530.0	1.56
Zone 11	2.3	99	1	Jan 1700	0.0	175.0	0.57
Zone 12	1.7	74	1	Jan 1700	0.0	175.0	0.42
Zone 13	1.4	61	1	Jan 1700	0.0	140.0	0.43
Zone 14	1.6	66	1	Jan 1700	0.0	160.0	0.41
Zone 15	3.6	151	2	Jan 1700	0.0	275.0	0.55
Zone 16	2.5	106	1	Jul 1700	3.2	150.0	0.71
Zone 17	1.6	69	1	Jul 1800	2.9	275.0	0.25
Zone 18	9.6	406	4	Aug 1700	12.1	200.0	2.03
Zone 19	1.9	81	1	Jul 1400	1.1	140.0	0.58
Zone 20	1.9	81	1	Jul 1400	1.1	140.0	0.58
Zone 21	6.3	269	3	Jul 1700	11.6	290.0	0.93
Zone 22	1.9	83	1	Jul 1400	0.7	90.0	0.92
Zone 23	3.3	142	1	Jul 1300	2.3	275.0	0.51
Zone 24	3.3	142	1	Jul 1300	2.3	275.0	0.51
Zone 25	0.3	14	0	Jul 1300	0.8	100.0	0.14
Zone 26	18.4	782	8	Aug 1600	18.2	900.0	0.87
Zone 27	3.6	152	2	Jul 1400	5.2	275.0	0.55
Zone 28	3.6	153	2	Aug 1700	5.2	275.0	0.56
Zone 29	134.5	5880	59	Sep 1300	78.3	5060.0	1.16
Zone 30	341.4	15703	157	Jul 1700	217.6	15820.0	0.99
Zone 31	1.3	70	1	Jan 2300	0.0	700.0	0.10
Zone 32	6.3	350	4	Jan 2300	0.0	3500.0	0.10
Zone 33	2.5	140	1	Jan 2300	0.0	1400.0	0.10

### Zone Terminal Sizing Data

Zone Name	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 20.0 °F	Zone Htg Coil Load (MBH)	Zone Htg Water gpm @ 20.0 °F	Mixing Box Fan Airflow (CFM)
Zone 1	11.1	1.11	0.0	0.00	0
Zone 2	5.3	0.53	0.0	0.00	0
Zone 3	0.0	0.00	0.0	0.00	0



## Zone Sizing Summary for AHU3A&B

Project Name: Outreach\_Innovation\_Center14  
Prepared by: psuae

03/22/2005  
04:09PM

Zone Name	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 20.0 °F	Zone Htg Coil Load (MBH)	Zone Htg Water gpm @ 20.0 °F	Mixing Box Fan Airflow (CFM)
Zone 4	0.0	0.00	0.0	0.00	0
Zone 5	0.0	0.00	0.0	0.00	0
Zone 6	54.8	5.48	0.0	0.00	0
Zone 7	0.0	0.00	0.0	0.00	0
Zone 8	0.0	0.00	0.0	0.00	0
Zone 9	29.4	2.95	0.0	0.00	0
Zone 10	15.9	1.59	0.0	0.00	0
Zone 11	0.0	0.00	0.0	0.00	0
Zone 12	0.0	0.00	0.0	0.00	0
Zone 13	0.0	0.00	0.0	0.00	0
Zone 14	0.0	0.00	0.0	0.00	0
Zone 15	0.0	0.00	0.0	0.00	0
Zone 16	3.2	0.32	0.0	0.00	0
Zone 17	2.9	0.29	0.0	0.00	0
Zone 18	12.1	1.21	0.0	0.00	0
Zone 19	1.1	0.11	0.0	0.00	0
Zone 20	1.1	0.11	0.0	0.00	0
Zone 21	11.6	1.16	0.0	0.00	0
Zone 22	0.7	0.07	0.0	0.00	0
Zone 23	2.3	0.23	0.0	0.00	0
Zone 24	2.3	0.23	0.0	0.00	0
Zone 25	0.8	0.08	0.0	0.00	0
Zone 26	18.2	1.83	0.0	0.00	0
Zone 27	5.2	0.52	0.0	0.00	0
Zone 28	5.2	0.52	0.0	0.00	0
Zone 29	78.3	7.84	0.0	0.00	0
Zone 30	217.6	21.77	0.0	0.00	0
Zone 31	0.0	0.00	0.0	0.00	0
Zone 32	0.0	0.00	0.0	0.00	0
Zone 33	0.0	0.00	0.0	0.00	0

### Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
<b>Zone 1</b>							
119	1	20.8	Jun 1700	883	11.1	950.0	0.93
<b>Zone 2</b>							
120	1	11.7	Jun 1700	497	5.3	630.0	0.79
<b>Zone 3</b>							
122	1	1.3	Jan 1700	57	0.0	160.0	0.35
<b>Zone 4</b>							
124	1	2.5	Jan 1700	105	0.0	160.0	0.66
<b>Zone 5</b>							
125	1	1.7	Jan 2300	90	0.0	600.0	0.15
<b>Zone 6</b>							
128	1	31.9	Jun 1400	1356	10.3	3000.0	0.45
128A	1	2.0	Jan 1700	84	0.0	225.0	0.37
128B	1	1.4	Jan 1700	61	0.0	150.0	0.40
128C	1	4.3	Jan 1700	183	0.0	450.0	0.41
128E-N	1	66.1	Sep 1200	2812	44.5	1500.0	1.87
<b>Zone 7</b>							
106R	1	0.9	Jan 1700	39	0.0	275.0	0.14
<b>Zone 8</b>							
107R	1	0.9	Jan 1700	39	0.0	275.0	0.14

## Zone Sizing Summary for AHU3A&B

Project Name: Outreach\_Innovation\_Center14  
Prepared by: psuae

03/22/2005  
04:09PM

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
<b>Zone 9</b>							
121,121F	1	38.3	Jul 1700	1628	29.4	2725.0	0.60
<b>Zone 10</b>							
121B-E	1	19.5	Jun 1700	828	15.9	530.0	1.56
<b>Zone 11</b>							
121G	1	2.3	Jan 1700	99	0.0	175.0	0.57
<b>Zone 12</b>							
121H	1	1.7	Jan 1700	74	0.0	175.0	0.42
<b>Zone 13</b>							
121I	1	1.4	Jan 1700	61	0.0	140.0	0.43
<b>Zone 14</b>							
126M	1	1.6	Jan 1700	66	0.0	160.0	0.41
<b>Zone 15</b>							
127P	1	3.6	Jan 1700	151	0.0	275.0	0.55
<b>Zone 16</b>							
123K	1	2.5	Jul 1700	106	3.2	150.0	0.71
<b>Zone 17</b>							
113Z	1	1.6	Jul 1800	69	2.9	275.0	0.25
<b>Zone 18</b>							
315	1	9.6	Aug 1700	406	12.1	200.0	2.03
<b>Zone 19</b>							
322	1	1.9	Jul 1400	81	1.1	140.0	0.58
<b>Zone 20</b>							
323	1	1.9	Jul 1400	81	1.1	140.0	0.58
<b>Zone 21</b>							
316,317	1	6.3	Jul 1700	269	11.6	290.0	0.93
<b>Zone 22</b>							
304P	1	1.9	Jul 1400	83	0.7	90.0	0.92
<b>Zone 23</b>							
306R	1	3.3	Jul 1300	142	2.3	275.0	0.51
<b>Zone 24</b>							
307R	1	3.3	Jul 1300	142	2.3	275.0	0.51
<b>Zone 25</b>							
309J	1	0.3	Jul 1300	14	0.8	100.0	0.14
<b>Zone 26</b>							
301F	1	18.4	Aug 1600	782	18.2	900.0	0.87
<b>Zone 27</b>							
313Z	1	3.6	Jul 1400	152	5.2	275.0	0.55
<b>Zone 28</b>							
314Z	1	3.6	Aug 1700	153	5.2	275.0	0.56
<b>Zone 29</b>							
224A	1	0.4	Jan 2300	23	0.0	150.0	0.15
224B	1	0.9	Jan 1700	36	0.0	100.0	0.36
224C	1	1.2	Jan 1700	50	0.0	150.0	0.34
225,225H	1	113.6	Sep 1200	4829	69.7	3300.0	1.46
225A	1	12.3	Sep 1500	522	8.6	160.0	3.26
225B	1	1.2	Jan 1700	50	0.0	150.0	0.34
225D	1	2.0	Jan 1700	87	0.0	340.0	0.26
225C	1	1.4	Jan 1700	59	0.0	140.0	0.42
225E	1	1.7	Jan 1700	74	0.0	190.0	0.39
225F	1	1.7	Jan 1700	74	0.0	190.0	0.39
225G	1	1.7	Jan 1700	74	0.0	190.0	0.39
<b>Zone 30</b>							
215	1	0.1	Jan 2300	15	0.0	100.0	0.15
223	1	13.5	Jul 1500	574	6.5	1000.0	0.57
229	1	1.9	Jan 1700	79	0.0	170.0	0.46
230	1	1.8	Jan 1700	77	0.0	165.0	0.47

## Zone Sizing Summary for AHU3A&B

Project Name: Outreach\_Innovation\_Center14  
Prepared by: psuae

03/22/2005  
04:09PM

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
231	1	1.8	Jan 1700	78	0.0	165.0	0.47
233	1	1.3	Jan 1700	57	0.0	140.0	0.41
234	1	1.3	Jan 1700	57	0.0	140.0	0.41
235	1	0.5	Jan 1700	20	0.0	50.0	0.41
236	1	2.2	Jan 1700	96	0.0	235.0	0.41
237	1	26.1	Aug 1600	1108	18.6	1100.0	1.01
238	1	5.6	Jan 1700	238	0.0	450.0	0.53
239	1	22.0	Jun 1700	937	19.8	720.0	1.30
240	1	27.7	Jun 1700	1176	25.3	1000.0	1.18
241	1	23.2	Jun 1700	984	13.6	600.0	1.64
204P	1	1.6	Jan 1700	68	0.0	100.0	0.68
206R	1	3.1	Jan 1700	132	0.0	275.0	0.48
207R	1	3.1	Jan 1700	132	0.0	275.0	0.48
209J	1	0.1	Jan 2300	3	0.0	100.0	0.03
223A	1	3.9	Jan 1700	164	0.0	350.0	0.47
223B	1	0.3	Jan 2300	15	0.0	100.0	0.15
223F	1	3.2	Jul 1400	137	3.5	100.0	1.37
224,224D	1	14.6	Jun 1400	620	10.2	775.0	0.80
225I	1	1.4	Jan 1700	61	0.0	150.0	0.40
225K	1	1.4	Jan 1700	61	0.0	150.0	0.40
227A	1	5.5	Jan 1700	234	0.0	500.0	0.47
227B	1	0.7	Jan 1700	28	0.0	70.0	0.40
227C	1	0.7	Jan 1700	28	0.0	70.0	0.40
227D	1	1.5	Jan 1700	65	0.0	130.0	0.50
227F	1	0.9	Jan 1700	38	0.0	70.0	0.54
227G	1	0.9	Jan 1700	38	0.0	70.0	0.54
227H,228	1	132.1	Sep 1100	5615	71.1	4320.0	1.30
237A	1	0.1	Jan 2300	19	0.0	125.0	0.15
238A	1	3.1	Jan 1700	132	0.0	235.0	0.56
238C,E,F	1	26.7	Sep 1600	1134	20.1	600.0	1.89
238H	1	12.8	Jul 1700	543	13.7	250.0	2.17
238I,K	1	16.1	Jun 1700	685	15.2	450.0	1.52
239A	1	1.6	Jan 1700	67	0.0	140.0	0.48
239B	1	1.6	Jan 1700	67	0.0	140.0	0.48
239C	1	1.6	Jan 1700	67	0.0	140.0	0.48
239D	1	1.3	Jan 1700	55	0.0	100.0	0.55
<b>Zone 31</b>							
Corridor1_3	1	1.3	Jan 2300	70	0.0	700.0	0.10
<b>Zone 32</b>							
Corridor2_3	1	6.3	Jan 2300	350	0.0	3500.0	0.10
<b>Zone 33</b>							
Corridor3_3	1	2.5	Jan 2300	140	0.0	1400.0	0.10

## Air System Sizing Summary for DOAS-2

Project Name: Outreach\_Innovation\_Center\_DOAS2  
Prepared by: psuae

03/22/2005  
01:31PM

### Air System Information

Air System Name ..... **DOAS-2**  
Equipment Class ..... **TERM**  
Air System Type ..... **2P-FC**

Number of zones ..... **33**  
Floor Area ..... **22075.0** ft<sup>2</sup>  
Location ..... **Williamsport, Pennsylvania**

### Sizing Calculation Information

#### Zone and Space Sizing Method:

Zone CFM ..... **Sum of space airflow rates**  
Space CFM ..... **Individual peak space loads**

Calculation Months ..... **Jan to Dec**  
Sizing Data ..... **Calculated**

### Cooling Coil Sizing Data

Total coil load ..... **24.4** Tons  
Total coil load ..... **293.3** MBH  
Sensible coil load ..... **168.1** MBH  
Coil CFM at Jul 1500 ..... **3667** CFM  
Max coil CFM ..... **3667** CFM  
Sensible heat ratio ..... **0.573**  
Water flow @ 10.0 °F rise ..... **58.70** gpm

Load occurs at ..... **Jul 1500**  
OA DB / WB ..... **90.0 / 73.0** °F  
Entering DB / WB ..... **90.0 / 73.0** °F  
Leaving DB / WB ..... **46.7 / 46.0** °F  
Bypass Factor ..... **0.100**

### Heating Coil Sizing Data

Max coil load ..... **136.0** MBH  
Coil CFM at Jan 0600 ..... **3667** CFM  
Max coil CFM ..... **3667** CFM  
Water flow @ 20.0 °F drop ..... **13.61** gpm

Load occurs at ..... **Jan 0600**  
Ent. DB / Lvg DB ..... **46.7 / 81.7** °F

### Ventilation Fan Sizing Data

Actual max CFM ..... **3667** CFM  
Standard CFM ..... **3598** CFM  
Actual max CFM/ft<sup>2</sup> ..... **0.17** CFM/ft<sup>2</sup>

Fan motor BHP ..... **4.97** BHP  
Fan motor kW ..... **3.70** kW  
Fan static ..... **4.65** in wg

### Exhaust Fan Sizing Data

Actual max CFM ..... **3667** CFM  
Standard CFM ..... **3598** CFM  
Actual max CFM/ft<sup>2</sup> ..... **0.17** CFM/ft<sup>2</sup>

Fan motor BHP ..... **2.40** BHP  
Fan motor kW ..... **1.79** kW  
Fan static ..... **2.25** in wg

### Outdoor Ventilation Air Data

Design airflow CFM ..... **3667** CFM  
CFM/ft<sup>2</sup> ..... **0.17** CFM/ft<sup>2</sup>

CFM/person ..... **22.53** CFM/person

## Zone Sizing Summary for DOAS-2

Project Name: Outreach\_Innovation\_Center\_DOAS2  
Prepared by: psuae

03/22/2005  
01:31PM

### Air System Information

Air System Name ..... **DOAS-2**  
Equipment Class ..... **TERM**  
Air System Type ..... **2P-FC**

Number of zones ..... **33**  
Floor Area ..... **22075.0** ft<sup>2</sup>  
Location ..... **Williamsport, Pennsylvania**

### Sizing Calculation Information

**Zone and Space Sizing Method:**

Zone CFM ..... **Sum of space airflow rates**  
Space CFM ..... **Individual peak space loads**

Calculation Months ..... **Jan to Dec**  
Sizing Data ..... **Calculated**

### Zone Sizing Data

Zone Name	Maximum Cooling Sensible (MBH)	Design Air Flow (CFM)	Minimum Air Flow (CFM)	Time of Peak Load	Maximum Heating Load (MBH)	Zone Floor Area (ft <sup>2</sup> )	Zone CFM/ft <sup>2</sup>
Zone 1	4.4	245	245	Jan 1700	0.0	200.0	1.23
Zone 2	8.6	480	480	Jan 1700	0.0	400.0	1.20
Zone 3	5.3	294	294	Aug 1600	1.8	200.0	1.47
Zone 4	2.2	121	121	Jan 1700	0.0	100.0	1.21
Zone 5	4.4	245	245	Jan 1700	0.0	200.0	1.23
Zone 6	11.1	618	618	Jan 1700	0.0	550.0	1.12
Zone 7	66.1	3667	3667	Jan 1700	0.0	2900.0	1.26
Zone 8	4.7	288	262	Jan 1700	0.0	470.0	0.61
Zone 9	8.0	442	442	Sep 1100	4.5	90.0	4.91
Zone 10	18.3	1019	1019	Aug 1200	17.3	520.0	1.96
Zone 11	56.1	3134	3134	Aug 1500	43.1	1420.0	2.21
Zone 12	2.0	111	111	Jan 1700	0.0	100.0	1.11
Zone 13	5.2	288	288	Jan 1700	0.0	325.0	0.89
Zone 14	8.0	442	442	Jan 1700	0.0	500.0	0.88
Zone 15	1.8	102	102	Aug 1900	1.8	90.0	1.13
Zone 16	15.9	882	882	Aug 1900	13.0	860.0	1.03
Zone 17	12.3	685	685	Jul 1700	9.6	400.0	1.71
Zone 18	22.5	1248	1248	Jun 1700	15.3	600.0	2.08
Zone 19	30.0	1668	1668	Jun 1700	19.5	660.0	2.53
Zone 20	1.8	99	99	Jul 2000	2.8	90.0	1.10
Zone 21	0.5	30	30	Jan 1700	0.0	90.0	0.33
Zone 22	25.3	1407	1407	Jan 1700	0.0	1500.0	0.94
Zone 23	4.1	228	228	Jan 1700	0.0	360.0	0.63
Zone 24	13.9	771	771	Sep 1100	9.8	400.0	1.93
Zone 25	0.8	60	43	Jan 2300	0.0	1000.0	0.06
Zone 26	6.7	372	372	Jun 1700	4.0	100.0	3.72
Zone 27	4.5	251	251	Sep 1100	3.0	200.0	1.25
Zone 28	2.4	132	132	Aug 1900	2.9	275.0	0.48
Zone 29	3.3	183	183	Aug 1700	5.5	175.0	1.05
Zone 30	118.7	6587	6587	Sep 1100	101.8	1100.0	5.99
Zone 31	2.3	130	130	Jan 2300	0.0	1300.0	0.10
Zone 32	6.3	351	351	Jan 2300	0.0	3500.0	0.10
Zone 33	2.5	140	140	Jan 2300	0.0	1400.0	0.10

### Terminal Unit Sizing Data - Cooling

Zone Name	Total Coil Load (MBH)	Sens Coil Load (MBH)	Coil Entering DB / WB (°F)	Coil Leaving DB / WB (°F)	Water Flow @ 10.0 °F (gpm)	Time of Peak Load
Zone 1	5.9	5.9	80.7 / 64.6	58.0 / 56.5	1.19	Sep 0700
Zone 2	11.8	11.4	80.5 / 64.8	58.0 / 56.5	2.36	Jul 0700
Zone 3	6.5	6.5	79.5 / 64.6	58.5 / 57.1	1.31	Jul 0700
Zone 4	3.0	3.0	81.1 / 56.6	58.0 / 46.8	0.59	Jan 0700

## Zone Sizing Summary for DOAS-2

Project Name: Outreach\_Innovation\_Center\_DOAS2  
Prepared by: psuae

03/22/2005  
01:31PM

Zone Name	Total Coil Load (MBH)	Sens Coil Load (MBH)	Coil Entering DB / WB (°F)	Coil Leaving DB / WB (°F)	Water Flow @ 10.0 °F (gpm)	Time of Peak Load
Zone 5	5.9	5.9	80.7 / 64.6	58.0 / 56.5	1.19	Sep 0700
Zone 6	15.2	14.9	80.8 / 64.8	58.0 / 56.5	3.05	Sep 0700
Zone 7	89.6	88.0	80.6 / 64.7	58.0 / 56.5	17.93	Sep 0700
Zone 8	8.6	8.6	86.1 / 55.9	58.0 / 43.5	1.72	Jan 0600
Zone 9	8.9	8.9	79.1 / 62.2	60.1 / 55.2	1.78	Sep 1100
Zone 10	22.6	22.6	79.3 / 62.4	58.4 / 54.6	4.52	Aug 1100
Zone 11	66.5	66.5	79.0 / 63.3	59.0 / 56.0	13.30	Aug 1500
Zone 12	2.8	2.8	81.5 / 56.7	58.0 / 46.8	0.55	Jan 0700
Zone 13	7.2	7.2	81.7 / 58.3	58.0 / 48.6	1.45	Jan 0700
Zone 14	11.1	11.1	81.7 / 58.4	58.0 / 48.7	2.22	Jan 0700
Zone 15	2.1	2.0	78.7 / 66.0	60.5 / 59.3	0.42	Aug 1700
Zone 16	19.8	19.8	79.7 / 61.1	58.6 / 53.0	3.96	Aug 0600
Zone 17	14.7	14.7	79.4 / 62.3	59.2 / 54.8	2.93	Jun 1700
Zone 18	25.7	25.7	79.3 / 62.8	59.9 / 55.6	5.14	Jul 1700
Zone 19	33.8	33.8	79.3 / 63.2	60.2 / 56.2	6.76	Jun 1700
Zone 20	2.1	2.1	80.1 / 62.3	59.9 / 54.9	0.42	Jul 0700
Zone 21	0.9	0.8	82.7 / 66.6	58.0 / 56.5	0.19	Mar 0700
Zone 22	41.6	41.6	85.9 / 56.1	58.0 / 43.9	8.33	Jan 0700
Zone 23	5.9	5.9	82.3 / 57.2	58.0 / 46.9	1.18	Jan 0700
Zone 24	16.9	16.9	79.3 / 63.0	58.7 / 55.4	3.38	Sep 1100
Zone 25	1.8	1.8	86.1 / 55.9	58.0 / 43.5	0.36	Jan 0600
Zone 26	7.2	7.0	79.0 / 66.2	61.3 / 60.0	1.43	Jun 1700
Zone 27	5.9	5.6	79.2 / 64.6	58.0 / 56.6	1.19	Sep 1100
Zone 28	3.4	3.0	79.4 / 65.3	58.0 / 56.7	0.68	Aug 0700
Zone 29	3.9	3.6	78.6 / 65.6	59.9 / 58.6	0.78	Aug 1500
Zone 30	129.5	129.5	78.8 / 62.6	60.3 / 55.8	25.91	Sep 1100
Zone 31	3.9	3.9	86.1 / 55.9	58.0 / 43.5	0.78	Jan 0600
Zone 32	10.5	10.5	86.1 / 55.9	58.0 / 43.5	2.09	Jan 0600
Zone 33	4.2	4.2	86.1 / 55.9	58.0 / 43.5	0.84	Jan 0600

### Terminal Unit Sizing Data - Heating, Fan, Ventilation

## Zone Sizing Summary for DOAS-2

Project Name: Outreach\_Innovation\_Center\_DOAS2  
Prepared by: psuae

03/22/2005  
01:31PM

Zone Name	HEATING COIL SIZING DATA			FAN SIZING DATA			VENT
	Coil Load (MBH)	Coil Ent/Lvg DB (°F)	Water Flow @20.0 °F (gpm)	Design Airflow (CFM)	Fan Motor (BHP)	Fan Motor (kW)	Design Airflow (CFM)
Zone 1	0.0	0.0 / 0.0	0.00	245	0.116	0.086	20
Zone 2	0.0	0.0 / 0.0	0.00	480	0.226	0.169	20
Zone 3	1.1	71.9 / 75.4	0.11	294	0.139	0.103	20
Zone 4	0.0	0.0 / 0.0	0.00	121	0.057	0.043	20
Zone 5	0.0	0.0 / 0.0	0.00	245	0.116	0.086	20
Zone 6	0.0	0.0 / 0.0	0.00	618	0.292	0.217	40
Zone 7	0.0	0.0 / 0.0	0.00	3667	1.731	1.291	200
Zone 8	0.0	0.0 / 0.0	0.00	288	0.136	0.101	288
Zone 9	3.5	70.8 / 78.4	0.35	442	0.209	0.156	20
Zone 10	14.4	71.7 / 85.1	1.44	1019	0.481	0.359	92
Zone 11	34.9	71.0 / 81.5	3.49	3134	1.479	1.103	164
Zone 12	0.0	0.0 / 0.0	0.00	111	0.052	0.039	20
Zone 13	0.0	0.0 / 0.0	0.00	288	0.136	0.101	40
Zone 14	0.0	0.0 / 0.0	0.00	442	0.209	0.156	60
Zone 15	1.7	69.9 / 85.5	0.17	102	0.048	0.036	0
Zone 16	10.3	72.0 / 82.9	1.03	882	0.416	0.311	95
Zone 17	7.7	72.0 / 82.6	0.77	685	0.323	0.241	65
Zone 18	12.4	71.6 / 81.0	1.24	1248	0.589	0.439	83
Zone 19	15.5	70.9 / 79.6	1.55	1668	0.787	0.587	80
Zone 20	2.2	72.5 / 93.8	0.22	99	0.047	0.035	20
Zone 21	0.0	0.0 / 0.0	0.00	30	0.014	0.011	0
Zone 22	0.0	0.0 / 0.0	0.00	1407	0.664	0.495	1350
Zone 23	0.0	0.0 / 0.0	0.00	228	0.108	0.080	60
Zone 24	8.0	71.8 / 81.6	0.80	771	0.364	0.271	56
Zone 25	0.0	0.0 / 0.0	0.00	60	0.028	0.021	60
Zone 26	3.5	70.4 / 79.3	0.35	372	0.176	0.131	0
Zone 27	2.7	70.5 / 80.5	0.27	251	0.118	0.088	0
Zone 28	2.7	69.7 / 88.9	0.27	132	0.063	0.047	0
Zone 29	5.2	69.2 / 95.8	0.52	183	0.087	0.065	0
Zone 30	88.4	70.1 / 82.7	8.84	6587	3.109	2.318	154
Zone 31	0.0	0.0 / 0.0	0.00	130	0.062	0.046	130
Zone 32	0.0	0.0 / 0.0	0.00	351	0.166	0.123	350
Zone 33	0.0	0.0 / 0.0	0.00	140	0.066	0.049	140

### Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
<b>Zone 1</b>							
135	1	4.4	Jan 1700	245	0.0	200.0	1.23
<b>Zone 2</b>							
136	1	8.6	Jan 1700	480	0.0	400.0	1.20
<b>Zone 3</b>							
137	1	5.3	Aug 1600	294	1.8	200.0	1.47
<b>Zone 4</b>							
138	1	2.2	Jan 1700	121	0.0	100.0	1.21
<b>Zone 5</b>							
139	1	4.4	Jan 1700	245	0.0	200.0	1.23
<b>Zone 6</b>							
140	1	11.1	Jan 1700	618	0.0	550.0	1.12
<b>Zone 7</b>							
141	1	66.1	Jan 1700	3667	0.0	2900.0	1.26
<b>Zone 8</b>							
143	1	1.7	Jan 1700	93	0.0	130.0	0.72
144	1	0.9	Jan 1700	60	0.0	80.0	0.75

## Zone Sizing Summary for DOAS-2

Project Name: Outreach\_Innovation\_Center\_DOAS2  
Prepared by: psuae

03/22/2005  
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Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
145	1	1.0	Jan 1700	60	0.0	100.0	0.60
146	1	0.9	Jan 1700	60	0.0	80.0	0.75
R145A	1	0.3	Jan 2300	15	0.0	80.0	0.19
<b>Zone 9</b>							
148	1	8.0	Sep 1100	442	4.5	90.0	4.91
<b>Zone 10</b>							
149	1	16.7	Aug 1200	927	17.3	420.0	2.21
150	1	1.7	Jan 1700	92	0.0	100.0	0.92
<b>Zone 11</b>							
151	1	52.8	Sep 1500	2930	41.2	1170.0	2.50
152	1	3.7	Aug 1700	204	1.8	250.0	0.82
<b>Zone 12</b>							
153	1	2.0	Jan 1700	111	0.0	100.0	1.11
<b>Zone 13</b>							
154	1	5.2	Jan 1700	288	0.0	325.0	0.89
<b>Zone 14</b>							
155	1	8.0	Jan 1700	442	0.0	500.0	0.88
<b>Zone 15</b>							
156	1	1.8	Aug 1900	102	1.8	90.0	1.13
<b>Zone 16</b>							
161	1	1.9	Aug 1900	108	2.3	200.0	0.54
162	1	3.0	Aug 1900	164	4.6	260.0	0.63
163	1	11.0	Aug 1900	610	6.1	400.0	1.52
<b>Zone 17</b>							
167	1	7.8	Jun 1700	434	6.0	240.0	1.81
166T	1	4.5	Jul 1700	252	3.6	160.0	1.57
<b>Zone 18</b>							
168	1	6.5	Jun 1700	361	4.4	150.0	2.41
171	1	16.0	Jun 1700	887	10.9	450.0	1.97
<b>Zone 19</b>							
172	1	6.8	Jun 1700	375	4.9	160.0	2.34
174	1	23.3	Jun 1700	1293	14.6	500.0	2.59
<b>Zone 20</b>							
175	1	1.8	Jul 2000	99	2.8	90.0	1.10
<b>Zone 21</b>							
176	1	0.5	Jan 1700	30	0.0	90.0	0.33
<b>Zone 22</b>							
101F	1	25.3	Jan 1700	1407	0.0	1500.0	0.94
<b>Zone 23</b>							
151A	1	1.4	Jan 1700	76	0.0	120.0	0.63
151B	1	1.4	Jan 1700	76	0.0	120.0	0.63
151C	1	1.4	Jan 1700	76	0.0	120.0	0.63
<b>Zone 24</b>							
151D	1	13.9	Sep 1100	771	9.8	400.0	1.93
<b>Zone 25</b>							
159A	1	0.8	Jan 2300	60	0.0	1000.0	0.06
<b>Zone 26</b>							
102F	1	6.7	Jun 1700	372	4.0	100.0	3.72
<b>Zone 27</b>							
103F	1	4.5	Sep 1100	251	3.0	200.0	1.25
<b>Zone 28</b>							
114Z	1	2.4	Aug 1900	132	2.9	275.0	0.48
<b>Zone 29</b>							
157X	1	3.3	Aug 1700	183	5.5	175.0	1.05
<b>Zone 30</b>							
324	1	118.7	Sep 1100	6587	101.8	1100.0	5.99
<b>Zone 31</b>							



## Zone Sizing Summary for DOAS-2

Project Name: Outreach\_Innovation\_Center\_DOAS2  
Prepared by: psuae

03/22/2005  
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Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
Corridor1_2	1	1.1	Jan 2300	60	0.0	600.0	0.10
Corridor1_3	1	1.3	Jan 2300	70	0.0	700.0	0.10
<b>Zone 32</b>							
Corridor2_3	1	6.3	Jan 2300	351	0.0	3500.0	0.10
<b>Zone 33</b>							
Corridor3_3	1	2.5	Jan 2300	140	0.0	1400.0	0.10

## Air System Sizing Summary for DOAS-3

Project Name: Outreach\_Innovation\_Center\_DOAS5  
Prepared by: psuae

03/22/2005  
10:00PM

### Air System Information

Air System Name ..... **DOAS-3**  
Equipment Class ..... **TERM**  
Air System Type ..... **2P-FC**

Number of zones ..... **34**  
Floor Area ..... **57610.0** ft<sup>2</sup>  
Location ..... **Williamsport, Pennsylvania**

### Sizing Calculation Information

#### Zone and Space Sizing Method:

Zone CFM ..... **Sum of space airflow rates**  
Space CFM ..... **Individual peak space loads**

Calculation Months ..... **Jan to Dec**  
Sizing Data ..... **Calculated**

### Cooling Coil Sizing Data

Total coil load ..... **52.7** Tons  
Total coil load ..... **632.9** MBH  
Sensible coil load ..... **362.7** MBH  
Coil CFM at Jul 1500 ..... **7913** CFM  
Max coil CFM ..... **7913** CFM  
Sensible heat ratio ..... **0.573**  
Water flow @ 10.0 °F rise ..... **126.65** gpm

Load occurs at ..... **Jul 1500**  
OA DB / WB ..... **90.0 / 73.0** °F  
Entering DB / WB ..... **90.0 / 73.0** °F  
Leaving DB / WB ..... **46.7 / 46.0** °F  
Bypass Factor ..... **0.100**

### Heating Coil Sizing Data

Max coil load ..... **293.5** MBH  
Coil CFM at Jan 0600 ..... **7913** CFM  
Max coil CFM ..... **7913** CFM  
Water flow @ 20.0 °F drop ..... **29.36** gpm

Load occurs at ..... **Jan 0600**  
Ent. DB / Lvg DB ..... **46.7 / 81.7** °F

### Ventilation Fan Sizing Data

Actual max CFM ..... **7913** CFM  
Standard CFM ..... **7764** CFM  
Actual max CFM/ft<sup>2</sup> ..... **0.14** CFM/ft<sup>2</sup>

Fan motor BHP ..... **10.72** BHP  
Fan motor kW ..... **7.99** kW  
Fan static ..... **4.65** in wg

### Exhaust Fan Sizing Data

Actual max CFM ..... **7913** CFM  
Standard CFM ..... **7764** CFM  
Actual max CFM/ft<sup>2</sup> ..... **0.14** CFM/ft<sup>2</sup>

Fan motor BHP ..... **5.19** BHP  
Fan motor kW ..... **3.87** kW  
Fan static ..... **2.25** in wg

### Outdoor Ventilation Air Data

Design airflow CFM ..... **7913** CFM  
CFM/ft<sup>2</sup> ..... **0.14** CFM/ft<sup>2</sup>

CFM/person ..... **20.79** CFM/person

## Zone Sizing Summary for DOAS-3

Project Name: Outreach\_Innovation\_Center\_DOAS2  
Prepared by: psuae

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### Air System Information

Air System Name ..... **DOAS-3**  
Equipment Class ..... **TERM**  
Air System Type ..... **2P-FC**

Number of zones ..... **34**  
Floor Area ..... **57610.0** ft<sup>2</sup>  
Location ..... **Williamsport, Pennsylvania**

### Sizing Calculation Information

**Zone and Space Sizing Method:**

Zone CFM ..... **Sum of space airflow rates**  
Space CFM ..... **Individual peak space loads**

Calculation Months ..... **Jan to Dec**  
Sizing Data ..... **Calculated**

### Zone Sizing Data

Zone Name	Maximum Cooling Sensible (MBH)	Design Air Flow (CFM)	Minimum Air Flow (CFM)	Time of Peak Load	Maximum Heating Load (MBH)	Zone Floor Area (ft <sup>2</sup> )	Zone CFM/ft <sup>2</sup>
Zone 1	20.8	1154	1154	Jun 1700	11.1	950.0	1.21
Zone 2	11.7	649	649	Jun 1700	5.3	630.0	1.03
Zone 3	1.3	74	74	Jan 1700	0.0	160.0	0.46
Zone 4	2.5	137	137	Jan 1700	0.0	160.0	0.86
Zone 5	1.7	95	95	Jan 2300	0.0	600.0	0.16
Zone 6	31.9	1771	1771	Jun 1400	10.3	3000.0	0.59
Zone 7	0.9	51	51	Jan 1700	0.0	275.0	0.18
Zone 8	0.9	51	51	Jan 1700	0.0	275.0	0.18
Zone 9	38.3	2126	2126	Jul 1700	29.4	2725.0	0.78
Zone 10	19.5	1081	1081	Jun 1700	15.9	530.0	2.04
Zone 11	2.3	130	130	Jan 1700	0.0	175.0	0.74
Zone 12	1.7	97	97	Jan 1700	0.0	175.0	0.55
Zone 13	1.4	79	79	Jan 1700	0.0	140.0	0.57
Zone 14	1.6	86	86	Jan 1700	0.0	160.0	0.54
Zone 15	3.6	197	197	Jan 1700	0.0	275.0	0.72
Zone 16	100.9	5870	5870	Sep 1300	54.8	5325.0	1.10
Zone 17	2.5	138	138	Jul 1700	3.2	150.0	0.92
Zone 18	1.6	90	90	Jul 1800	2.9	275.0	0.33
Zone 19	428.5	25371	25346	Jul 1700	272.2	19910.0	1.27
Zone 20	135.9	7752	7752	Sep 1300	78.3	5210.0	1.49
Zone 21	2.8	154	154	Jul 1700	2.9	275.0	0.56
Zone 22	3.8	208	208	Aug 1900	2.9	275.0	0.76
Zone 23	9.6	531	531	Aug 1700	12.1	200.0	2.65
Zone 24	1.9	105	105	Jul 1400	1.1	140.0	0.75
Zone 25	1.9	105	105	Jul 1400	1.1	140.0	0.75
Zone 26	6.3	351	351	Jul 1700	11.6	290.0	1.21
Zone 27	274.1	15218	15218	Aug 1300	241.5	13000.0	1.17
Zone 28	1.9	108	108	Jul 1400	0.7	90.0	1.20
Zone 29	3.3	185	185	Jul 1300	2.3	275.0	0.67
Zone 30	3.3	185	185	Jul 1300	2.3	275.0	0.67
Zone 31	0.3	19	19	Jul 1300	0.8	100.0	0.19
Zone 32	18.4	1022	1022	Aug 1600	18.2	900.0	1.14
Zone 33	3.6	198	198	Jul 1400	5.2	275.0	0.72
Zone 34	3.6	200	200	Aug 1700	5.2	275.0	0.73

### Terminal Unit Sizing Data - Cooling

Zone Name	Total Coil Load (MBH)	Sens Coil Load (MBH)	Coil Entering DB / WB (°F)	Coil Leaving DB / WB (°F)	Water Flow @ 10.0 °F (gpm)	Time of Peak Load
Zone 1	25.0	25.0	79.5 / 62.5	59.0 / 55.0	5.01	Jul 1700
Zone 2	14.7	14.7	79.9 / 63.1	58.4 / 55.2	2.95	Jul 0700
Zone 3	2.0	2.0	83.7 / 58.1	58.0 / 47.5	0.40	Jan 0700

## Zone Sizing Summary for DOAS-3

Project Name: Outreach\_Innovation\_Center\_DOAS2  
Prepared by: psuae

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Zone Name	Total Coil Load (MBH)	Sens Coil Load (MBH)	Coil Entering DB / WB (°F)	Coil Leaving DB / WB (°F)	Water Flow @ 10.0 °F (gpm)	Time of Peak Load
Zone 4	3.8	3.8	84.0 / 55.8	58.0 / 44.4	0.76	Jan 0700
Zone 5	2.8	2.8	86.1 / 55.9	58.0 / 43.6	0.56	Jan 0600
Zone 6	47.0	47.0	83.0 / 63.8	58.0 / 54.7	9.41	Jun 0700
Zone 7	1.8	1.4	84.3 / 68.0	58.0 / 56.5	0.36	Nov 0700
Zone 8	1.8	1.4	84.3 / 68.0	58.0 / 56.5	0.36	Nov 0700
Zone 9	53.0	53.0	81.5 / 63.5	58.0 / 54.9	10.61	Jul 0700
Zone 10	21.5	21.5	79.2 / 62.4	60.5 / 55.5	4.30	Jun 1700
Zone 11	3.3	3.3	81.8 / 65.0	58.0 / 56.4	0.66	Sep 0700
Zone 12	2.5	2.5	82.8 / 58.3	58.0 / 48.1	0.51	Jan 0700
Zone 13	2.1	2.1	83.0 / 57.6	58.0 / 47.1	0.42	Jan 0700
Zone 14	2.4	2.2	81.9 / 65.8	58.0 / 56.5	0.48	Feb 0700
Zone 15	5.2	4.8	81.1 / 65.3	58.0 / 56.5	1.04	Jan 0800
Zone 16	137.7	137.7	80.1 / 62.5	58.0 / 54.2	27.55	Sep 1100
Zone 17	3.2	3.1	79.3 / 64.5	58.2 / 56.8	0.64	Jul 1300
Zone 18	2.4	2.2	81.2 / 65.3	58.0 / 56.5	0.47	Jul 0700
Zone 19	727.5	727.5	86.1 / 62.1	59.1 / 51.8	145.59	Jul 1700
Zone 20	208.3	208.3	83.6 / 61.3	58.3 / 51.5	41.68	Sep 1300
Zone 21	3.7	3.3	79.0 / 65.3	58.7 / 57.4	0.74	Jul 1200
Zone 22	5.2	4.8	79.8 / 64.9	58.0 / 56.6	1.04	Aug 0700
Zone 23	10.4	10.4	78.7 / 63.0	60.2 / 56.2	2.08	Aug 1600
Zone 24	2.5	2.5	80.8 / 63.2	58.0 / 54.8	0.51	Jul 0700
Zone 25	2.5	2.5	80.8 / 63.2	58.0 / 54.8	0.51	Jul 0700
Zone 26	7.3	7.3	79.5 / 62.5	59.9 / 55.3	1.45	Jul 1700
Zone 27	351.6	351.6	79.8 / 62.7	58.0 / 54.6	70.35	Aug 1100
Zone 28	2.8	2.8	82.1 / 61.7	58.0 / 52.5	0.55	Jul 0700
Zone 29	4.5	4.1	79.1 / 64.8	58.0 / 56.7	0.90	Jul 0900
Zone 30	4.5	4.1	79.1 / 64.8	58.0 / 56.7	0.90	Jul 0900
Zone 31	0.5	0.3	78.4 / 68.7	62.1 / 61.2	0.09	Jul 1300
Zone 32	22.6	22.6	80.4 / 61.4	59.5 / 53.5	4.52	Aug 1500
Zone 33	4.8	4.4	79.1 / 64.8	58.0 / 56.7	0.96	Jul 1200
Zone 34	4.9	4.5	79.3 / 64.8	58.0 / 56.6	0.97	Jul 0700

### Terminal Unit Sizing Data - Heating, Fan, Ventilation

## Zone Sizing Summary for DOAS-3

Project Name: Outreach\_Innovation\_Center\_DOAS2  
Prepared by: psuae

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Zone Name	HEATING COIL SIZING DATA			FAN SIZING DATA			VENT
	Coil Load (MBH)	Coil Ent/Lvg DB (°F)	Water Flow @20.0 °F (gpm)	Design Airflow (CFM)	Fan Motor (BHP)	Fan Motor (kW)	Design Airflow (CFM)
Zone 1	7.5	72.4 / 78.5	0.75	1154	0.545	0.406	133
Zone 2	3.1	72.8 / 77.3	0.31	649	0.306	0.229	88
Zone 3	0.0	0.0 / 0.0	0.00	74	0.035	0.026	20
Zone 4	0.0	0.0 / 0.0	0.00	137	0.065	0.048	80
Zone 5	0.0	0.0 / 0.0	0.00	95	0.045	0.033	90
Zone 6	1.3	74.5 / 75.2	0.13	1771	0.836	0.623	420
Zone 7	0.0	0.0 / 0.0	0.00	51	0.024	0.018	0
Zone 8	0.0	0.0 / 0.0	0.00	51	0.024	0.018	0
Zone 9	19.8	73.1 / 81.8	1.98	2126	1.004	0.748	381
Zone 10	12.6	71.0 / 82.0	1.26	1081	0.510	0.381	74
Zone 11	0.0	0.0 / 0.0	0.00	130	0.061	0.046	15
Zone 12	0.0	0.0 / 0.0	0.00	97	0.046	0.034	20
Zone 13	0.0	0.0 / 0.0	0.00	79	0.038	0.028	20
Zone 14	0.0	0.0 / 0.0	0.00	86	0.041	0.030	0
Zone 15	0.0	0.0 / 0.0	0.00	197	0.093	0.069	0
Zone 16	35.2	73.0 / 78.6	3.53	5870	2.771	2.066	854
Zone 17	2.9	70.8 / 90.5	0.29	138	0.065	0.049	8
Zone 18	2.5	71.8 / 97.7	0.25	90	0.042	0.032	14
Zone 19	0.0	0.0 / 0.0	0.00	25371	11.975	8.929	25371
Zone 20	0.0	0.0 / 0.0	0.00	7752	3.659	2.728	5111
Zone 21	2.7	69.9 / 86.2	0.27	154	0.073	0.054	0
Zone 22	2.5	70.1 / 81.6	0.25	208	0.098	0.073	0
Zone 23	11.0	70.4 / 89.9	1.10	531	0.250	0.187	20
Zone 24	0.6	73.3 / 79.0	0.06	105	0.050	0.037	20
Zone 25	0.6	73.3 / 79.0	0.06	105	0.050	0.037	20
Zone 26	10.1	71.1 / 98.3	1.01	351	0.166	0.124	41
Zone 27	184.8	71.9 / 83.4	18.49	15218	7.183	5.356	1818
Zone 28	0.0	0.0 / 0.0	0.00	108	0.051	0.038	45
Zone 29	1.9	70.2 / 79.9	0.19	185	0.087	0.065	0
Zone 30	1.9	70.2 / 79.9	0.19	185	0.087	0.065	0
Zone 31	0.8	68.5 / 105.8	0.08	19	0.009	0.007	0
Zone 32	13.1	73.6 / 85.7	1.31	1022	0.482	0.360	225
Zone 33	4.7	69.3 / 91.7	0.47	198	0.094	0.070	0
Zone 34	4.9	69.6 / 92.7	0.49	200	0.094	0.070	0

### Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
<b>Zone 1</b>							
119	1	20.8	Jun 1700	1154	11.1	950.0	1.21
<b>Zone 2</b>							
120	1	11.7	Jun 1700	649	5.3	630.0	1.03
<b>Zone 3</b>							
122	1	1.3	Jan 1700	74	0.0	160.0	0.46
<b>Zone 4</b>							
124	1	2.5	Jan 1700	137	0.0	160.0	0.86
<b>Zone 5</b>							
125	1	1.7	Jan 2300	95	0.0	600.0	0.16
<b>Zone 6</b>							
128	1	31.9	Jun 1400	1771	10.3	3000.0	0.59
<b>Zone 7</b>							
106R	1	0.9	Jan 1700	51	0.0	275.0	0.18
<b>Zone 8</b>							
107R	1	0.9	Jan 1700	51	0.0	275.0	0.18

## Zone Sizing Summary for DOAS-3

Project Name: Outreach\_Innovation\_Center\_DOAS2  
Prepared by: psuae

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Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
<b>Zone 9</b>							
121,121F	1	38.3	Jul 1700	2126	29.4	2725.0	0.78
<b>Zone 10</b>							
121B-E	1	19.5	Jun 1700	1081	15.9	530.0	2.04
<b>Zone 11</b>							
121G	1	2.3	Jan 1700	130	0.0	175.0	0.74
<b>Zone 12</b>							
121H	1	1.7	Jan 1700	97	0.0	175.0	0.55
<b>Zone 13</b>							
121I	1	1.4	Jan 1700	79	0.0	140.0	0.57
<b>Zone 14</b>							
126M	1	1.6	Jan 1700	86	0.0	160.0	0.54
<b>Zone 15</b>							
127P	1	3.6	Jan 1700	197	0.0	275.0	0.72
<b>Zone 16</b>							
128	1	31.9	Jun 1400	1771	10.3	3000.0	0.59
128A	1	2.0	Jan 1700	109	0.0	225.0	0.49
128B	1	1.4	Jan 1700	79	0.0	150.0	0.53
128C	1	4.3	Jan 1700	239	0.0	450.0	0.53
128E-N	1	66.1	Sep 1200	3672	44.5	1500.0	2.45
<b>Zone 17</b>							
123K	1	2.5	Jul 1700	138	3.2	150.0	0.92
<b>Zone 18</b>							
113Z	1	1.6	Jul 1800	90	2.9	275.0	0.33
<b>Zone 19</b>							
215	1	0.1	Jan 2300	15	0.0	100.0	0.15
223	1	13.5	Jul 1500	749	6.5	1000.0	0.75
229	1	1.9	Jan 1700	103	0.0	170.0	0.61
230	1	1.8	Jan 1700	100	0.0	165.0	0.61
231	1	1.8	Jan 1700	102	0.0	165.0	0.62
233	1	1.3	Jan 1700	75	0.0	140.0	0.53
234	1	1.3	Jan 1700	75	0.0	140.0	0.53
235	1	0.5	Jan 1700	27	0.0	50.0	0.53
236	1	2.2	Jan 1700	125	0.0	235.0	0.53
237	1	26.1	Aug 1600	1448	18.6	1100.0	1.32
238	1	5.6	Jan 1700	311	0.0	450.0	0.69
239	1	22.0	Jun 1700	1223	19.8	720.0	1.70
240	1	27.7	Jun 1700	1535	25.3	1000.0	1.54
241	1	23.2	Jun 1700	1285	13.6	600.0	2.14
204P	1	1.6	Jan 1700	89	0.0	100.0	0.89
205T	1	2.4	Jan 1700	133	0.0	100.0	1.33
206R	1	3.1	Jan 1700	172	0.0	275.0	0.63
207R	1	3.1	Jan 1700	172	0.0	275.0	0.63
209J	1	0.1	Jan 2300	4	0.0	100.0	0.04
222A	1	15.1	Jan 1700	839	0.0	1500.0	0.56
222B,J	1	43.5	Jun 1700	2415	36.3	1260.0	1.92
222K	1	10.0	Jun 1700	554	11.1	200.0	2.77
222L	1	3.1	Jun 1400	172	2.4	140.0	1.23
222M	1	5.1	Jun 0800	284	4.8	150.0	1.90
222N	1	1.2	Jan 1700	65	0.0	100.0	0.65
222P	1	2.3	Jan 1700	130	0.0	200.0	0.65
222Q	1	1.1	Jan 1700	62	0.0	100.0	0.62
222S	1	3.9	Jan 1700	217	0.0	350.0	0.62
222U	1	1.6	Jan 1700	87	0.0	140.0	0.62
223A	1	3.9	Jan 1700	214	0.0	350.0	0.61
223B	1	0.3	Jan 2300	16	0.0	100.0	0.16
223F	1	3.2	Jul 1400	179	3.5	100.0	1.79

## Zone Sizing Summary for DOAS-3

Project Name: Outreach\_Innovation\_Center\_DOAS2  
Prepared by: psuae

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Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
224,224D	1	14.6	Jun 1400	810	10.2	775.0	1.04
225K	1	1.4	Jan 1700	79	0.0	150.0	0.53
227A	1	5.5	Jan 1700	306	0.0	500.0	0.61
227B	1	0.7	Jan 1700	37	0.0	70.0	0.52
227C	1	0.7	Jan 1700	37	0.0	70.0	0.52
227D	1	1.5	Jan 1700	85	0.0	130.0	0.66
227F	1	0.9	Jan 1700	49	0.0	70.0	0.70
227G	1	0.9	Jan 1700	49	0.0	70.0	0.70
227H,228	1	132.1	Sep 1100	7333	71.1	4320.0	1.70
237A	1	0.1	Jan 2300	19	0.0	125.0	0.15
238A	1	3.1	Jan 1700	173	0.0	235.0	0.74
238C,E,F	1	26.7	Sep 1600	1480	20.1	600.0	2.47
238H	1	12.8	Jul 1700	709	13.7	250.0	2.84
238I,K	1	16.1	Jun 1700	895	15.2	450.0	1.99
239A	1	1.6	Jan 1700	87	0.0	140.0	0.62
239B	1	1.6	Jan 1700	87	0.0	140.0	0.62
239C	1	1.6	Jan 1700	87	0.0	140.0	0.62
239D	1	1.3	Jan 1700	72	0.0	100.0	0.72
<b>Zone 20</b>							
224A	1	0.4	Jan 2300	24	0.0	150.0	0.16
224B	1	0.9	Jan 1700	48	0.0	100.0	0.48
224C	1	1.2	Jan 1700	66	0.0	150.0	0.44
225,225H	1	113.6	Sep 1200	6306	69.7	3300.0	1.91
225A	1	12.3	Sep 1500	682	8.6	160.0	4.26
225B	1	1.2	Jan 1700	66	0.0	150.0	0.44
225C	1	1.4	Jan 1700	77	0.0	140.0	0.55
225D	1	2.0	Jan 1700	114	0.0	340.0	0.33
225E	1	1.7	Jan 1700	97	0.0	190.0	0.51
225F	1	1.7	Jan 1700	97	0.0	190.0	0.51
225G	1	1.7	Jan 1700	97	0.0	190.0	0.51
225I	1	1.4	Jan 1700	79	0.0	150.0	0.53
<b>Zone 21</b>							
213Z	1	2.8	Jul 1700	154	2.9	275.0	0.56
<b>Zone 22</b>							
214Z	1	3.8	Aug 1900	208	2.9	275.0	0.76
<b>Zone 23</b>							
315	1	9.6	Aug 1700	531	12.1	200.0	2.65
<b>Zone 24</b>							
322	1	1.9	Jul 1400	105	1.1	140.0	0.75
<b>Zone 25</b>							
323	1	1.9	Jul 1400	105	1.1	140.0	0.75
<b>Zone 26</b>							
316,317	1	6.3	Jul 1700	351	11.6	290.0	1.21
<b>Zone 27</b>							
320,321	1	274.1	Aug 1300	15218	241.5	13000.0	1.17
<b>Zone 28</b>							
304P	1	1.9	Jul 1400	108	0.7	90.0	1.20
<b>Zone 29</b>							
306R	1	3.3	Jul 1300	185	2.3	275.0	0.67
<b>Zone 30</b>							
307R	1	3.3	Jul 1300	185	2.3	275.0	0.67
<b>Zone 31</b>							
309J	1	0.3	Jul 1300	19	0.8	100.0	0.19
<b>Zone 32</b>							
301F	1	18.4	Aug 1600	1022	18.2	900.0	1.14
<b>Zone 33</b>							
313Z	1	3.6	Jul 1400	198	5.2	275.0	0.72

### Zone Sizing Summary for DOAS-3

Project Name: Outreach\_Innovation\_Center\_DOAS2  
Prepared by: psuae

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Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
<b>Zone 34</b>							
314Z	1	3.6	Aug 1700	200	5.2	275.0	0.73



## Annual Cost Summary

Outreach\_Innovation\_Center14  
psuae

03/22/2005  
04:10PM

**Table 1. Annual Costs**

Component	Sample Building (\$)
Air System Fans	10,026
Cooling	22,367
Heating	53,805
Pumps	1,966
Cooling Tower Fans	0
<b>HVAC Sub-Total</b>	<b>88,164</b>
Lights	30,114
Electric Equipment	45,402
Misc. Electric	0
Misc. Fuel Use	0
<b>Non-HVAC Sub-Total</b>	<b>75,516</b>
<b>Grand Total</b>	<b>163,680</b>

**Table 2. Annual Cost per Unit Floor Area**

Component	Sample Building (\$/ft²)
Air System Fans	0.115
Cooling	0.255
Heating	0.614
Pumps	0.022
Cooling Tower Fans	0.000
<b>HVAC Sub-Total</b>	<b>1.007</b>
Lights	0.344
Electric Equipment	0.518
Misc. Electric	0.000
Misc. Fuel Use	0.000
<b>Non-HVAC Sub-Total</b>	<b>0.862</b>
<b>Grand Total</b>	<b>1.869</b>
Gross Floor Area (ft²)	87590.0
Conditioned Floor Area (ft²)	87590.0

Note: Values in this table are calculated using the Gross Floor Area.

**Table 3. Component Cost as a Percentage of Total Cost**

Component	Sample Building (%)
Air System Fans	6.1
Cooling	13.7
Heating	32.9
Pumps	1.2
Cooling Tower Fans	0.0
<b>HVAC Sub-Total</b>	<b>53.9</b>
Lights	18.4
Electric Equipment	27.7
Misc. Electric	0.0
Misc. Fuel Use	0.0
<b>Non-HVAC Sub-Total</b>	<b>46.1</b>
<b>Grand Total</b>	<b>100.0</b>

## Annual Cost Summary

Outreach\_Innovation\_Center\_DOAS3  
psuae

03/22/2005  
02:57PM

**Table 1. Annual Costs**

Component	Sample Building (\$)
Air System Fans	20,697
Cooling	9,954
Heating	27,678
Pumps	0
Cooling Tower Fans	0
<b>HVAC Sub-Total</b>	<b>58,329</b>
Lights	26,786
Electric Equipment	34,942
Misc. Electric	0
Misc. Fuel Use	0
<b>Non-HVAC Sub-Total</b>	<b>61,728</b>
<b>Grand Total</b>	<b>120,057</b>

**Table 2. Annual Cost per Unit Floor Area**

Component	Sample Building (\$/ft²)
Air System Fans	0.250
Cooling	0.120
Heating	0.334
Pumps	0.000
Cooling Tower Fans	0.000
<b>HVAC Sub-Total</b>	<b>0.704</b>
Lights	0.323
Electric Equipment	0.422
Misc. Electric	0.000
Misc. Fuel Use	0.000
<b>Non-HVAC Sub-Total</b>	<b>0.745</b>
<b>Grand Total</b>	<b>1.448</b>
Gross Floor Area (ft²)	82900.0
Conditioned Floor Area (ft²)	82900.0

Note: Values in this table are calculated using the Gross Floor Area.

**Table 3. Component Cost as a Percentage of Total Cost**

Component	Sample Building (%)
Air System Fans	17.2
Cooling	8.3
Heating	23.1
Pumps	0.0
Cooling Tower Fans	0.0
<b>HVAC Sub-Total</b>	<b>48.6</b>
Lights	22.3
Electric Equipment	29.1
Misc. Electric	0.0
Misc. Fuel Use	0.0
<b>Non-HVAC Sub-Total</b>	<b>51.4</b>
<b>Grand Total</b>	<b>100.0</b>

## Cooling Plant Sizing Summary for Cooling Plant

Outreach\_Innovation\_Center14  
psuae

03/29/2005  
09:11PM

### 1. Plant Information:

Plant Name ..... **Cooling Plant**  
Plant Type ..... **Chiller Plant**  
Design Weather ..... **Williamsport, Pennsylvania**

### 2. Cooling Plant Sizing Data:

Maximum Plant Load ..... **434.1** Tons  
Load occurs at ..... **Jul 1500**  
ft<sup>2</sup>/Ton ..... **201.8** ft<sup>2</sup>/Ton  
Floor area served by plant ..... **87590.0** ft<sup>2</sup>

### 3. Coincident Air System Cooling Loads for Jul 1500

Air System Name	Mult.	System Cooling Coil Load ( Tons )
AHU-1A&B	2	14.9
AHU2A&B	2	104.8
AHU3A&B	1	194.7

System loads are for coils whose cooling source is ' Chilled Water ' .

## Cooling Plant Sizing Summary for DOAS Cooling(2)

Outreach\_Innovation\_Center\_DOAS6  
psuae

03/29/2005  
09:00PM

### 1. Plant Information:

Plant Name ..... DOAS Cooling(2)  
Plant Type ..... Chiller Plant  
Design Weather ..... Williamsport, Pennsylvania

### 2. Cooling Plant Sizing Data:

Maximum Plant Load ..... 238.4 Tons  
Load occurs at ..... Jul 1500  
ft<sup>2</sup>/Ton ..... 334.2 ft<sup>2</sup>/Ton  
Floor area served by plant ..... 79685.0 ft<sup>2</sup>

### 3. Coincident Air System Cooling Loads for Jul 1500

Air System Name	Mult.	System Cooling Coil Load ( Tons )
DOAS-2	1	68.8
DOAS-3	1	169.6

System loads are for coils whose cooling source is ' Chilled Water ' .

# **Outreach Innovation Building**

Penn State Research Park  
State College, PA.

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## **Appendix D**

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### **Energy Wheel Data**



# Type A Energy Wheels

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**for Modular and T-Series  
Climate Changer™ Air Handlers**

# Application Considerations

## Electrical Power

Separate single or three-phase power must be run to the energy wheel module (see Table 1). The energy wheel motor is provided with thermal protection.

The MCC energy wheel module is provided with an external 4" x 4" junction box for field power connection. A starting contactor must be supplied and installed.

Power is connected to the T-Series energy wheel section through the high voltage electrical penetration in the exhaust fan section.

## Temperature Limits

- 150°F (66°C) maximum
- -20°F (-29°C) minimum

Colder ambient temperatures can be tolerated, provided the module/section is oriented so the drive motor is in a warmer air stream.

## Cross Leakage and Purge

All energy wheels have some cross leakage and purge, so do not use energy wheels in application involving toxic or hazardous air streams. The percentage of cross leakage

depends on the pressure differentials across the wheel section. With Trane energy wheels the exhaust air transfer ratios are typically low (<3%).

Fan placement can affect the pressurization of the two air streams, which controls the direction that the seal-related leakage moves. Therefore, fan placement can be used to direct that leakage. Table 2 describes the ways in which fans can be arranged to direct the cross leakage. *Remember that exhaust and supply air fans must be arranged to provide counterflow airflow through the energy wheel.*

**Table 1. Type A energy wheel electrical requirements, standard motor data<sup>1</sup>**

Wheel Size (nominal cfm)	Motor hp	Motor voltage/phase	Motor Hz	Motor Amperage
1,500	1/6 hp	200-208/240 volt, single-phase	50/60	1.1
3,000	1/2 hp	200-208/240 volt, single-phase	50/60	2.7
	1/6 hp	200-230/460 volt, three-phase	50/60	1.04/0.52
4,000, 5,000	1/2 hp	200-208/240 volt, single-phase	50/60	2.7
	1/6 hp	200-230/460 volt, three-phase	50/60	0.84/0.38
6,000–25,000	1/4 hp	200-230/460 volt, three-phase	60	1.6/0.8

1. Optional voltages, which differ from the above, are available for the 3-5K wheel.

**Table 2. Fan arrangement comparison**

Arrangement	Cross Leakage Path	Comments
Draw-thru supply and exhaust and blow-thru supply and exhaust	Either direction depending on the static pressures in the supply and exhaust air chambers	Provides lower leakage as designed. There is little control over seal-related leakage over the life of the equipment as filters clog and air streams go out of balance.

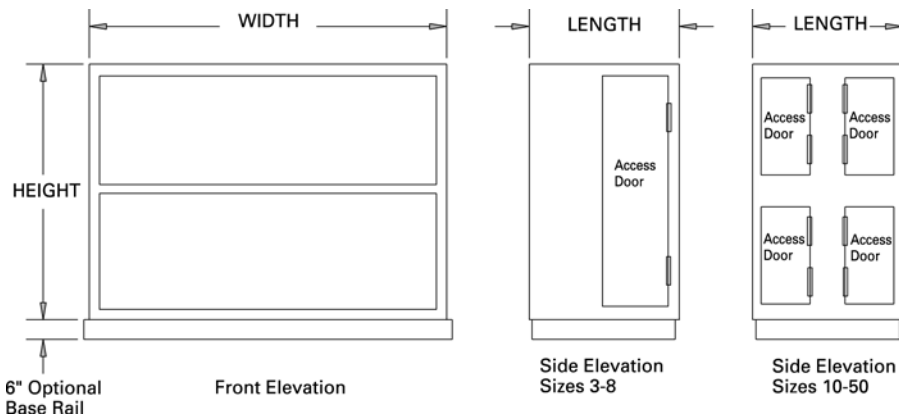
# MCC Dimensions and Weights

The two configurations detailed below are the more common arrangements for

MCC energy wheel units. To obtain dimensions and weights for more unique configura-

tions, contact Lexington marketing at 800-228-1666, extension 2615.

**Figure 7. MCC dimensional data**



**Table 6. MCC module dimensions and weights: 100% outside air<sup>1</sup> (no dampers)**

Unit Size	Access Door	Module Length	Module Width	Module Height	Weight (lb.)
3	24 x 52	36	38	49 <sup>3</sup> / <sub>4</sub>	503
6	24 x 52	36	44	54 <sup>3</sup> / <sub>4</sub>	683
8	24 x 52	36	52	62 <sup>1</sup> / <sub>4</sub>	707
10	11 <sup>1</sup> / <sub>2</sub> x 30	43 <sup>3</sup> / <sub>4</sub>	64	68 <sup>1</sup> / <sub>4</sub>	916
12	11 <sup>1</sup> / <sub>2</sub> x 34	43 <sup>3</sup> / <sub>4</sub>	68	76 <sup>1</sup> / <sub>4</sub>	1161
14	13 <sup>1</sup> / <sub>2</sub> x 36	47 <sup>3</sup> / <sub>4</sub>	72	80 <sup>1</sup> / <sub>4</sub>	1215
17	13 <sup>1</sup> / <sub>2</sub> x 40	47 <sup>3</sup> / <sub>4</sub>	78	88 <sup>1</sup> / <sub>4</sub>	1319
21	17 <sup>1</sup> / <sub>2</sub> x 44 <sup>1</sup> / <sub>2</sub>	55 <sup>3</sup> / <sub>4</sub>	80	97 <sup>1</sup> / <sub>4</sub>	1585
25	21 x 50 <sup>3</sup> / <sub>4</sub>	62 <sup>3</sup> / <sub>4</sub>	90	109 <sup>3</sup> / <sub>4</sub>	1732
30	21 <sup>3</sup> / <sub>8</sub> x 50 <sup>3</sup> / <sub>4</sub>	62 <sup>3</sup> / <sub>4</sub>	95	109 <sup>3</sup> / <sub>4</sub>	2076
35	20 <sup>1</sup> / <sub>2</sub> x 57	62 <sup>3</sup> / <sub>4</sub>	100	124 <sup>1</sup> / <sub>4</sub>	2141
40	20 <sup>1</sup> / <sub>2</sub> x 57	62 <sup>3</sup> / <sub>4</sub>	113	124 <sup>1</sup> / <sub>4</sub>	2369
50	20 <sup>1</sup> / <sub>2</sub> x 69	62 <sup>3</sup> / <sub>4</sub>	120	148 <sup>1</sup> / <sub>4</sub>	2680

1. Module dimensions and weights are subject to change without notice. Refer to the Trane submittals for current dimensions and weights.



# **Outreach Innovation Building**

Penn State Research Park  
State College, PA.

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## **Appendix E**

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### **Scroll Chiller Data**



# Air-Cooled Condensers

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20 to 120Tons





# Model Number Description

## 20To 60Ton Model Nomenclature

**C** **A** **U** **C** **C20** **4** **1** **\*** **0** **3** **H** **0'**  
1 2 3 4 5,6,7 8 9 10 11 12 13 14

### **Digit 1 – Unit Type**

C = Condenser

### **Digit 2 – Condenser**

A = Air-Cooled

### **Digit 3 – Airflow**

U = Upflow

### **Digit 4 – Development Sequence**

C = Third

### **Digit s 5,6,7 – Nominal Capacity**

C20 = 20Tons C40 = 40Tons

C25 = 25Tons C50 = 50Tons

C30 = 30Tons C60 = 60Tons

### **Digit 8 – Power Supply**

G = 200/230/60/3 XL

4 = 460/60/3 XL

5 = 575/60/3 XL

### **Digit 9 – Condenser Circuit**

1 = Single (20-30 Ton)

2 = Dual (40-60 Ton)

### **Digit 10 – Design Sequence**

\* = Factory Assigned

### **Digit 11 – Ambient Control**

0 = Standard

1 = 0 F

### **Digit 12 – Agency Approval**

0 = None

3 = UL/CSA

### **Digits 13, 14 – Miscellaneous**

H = Copper Fins

1 = Spring Isolators

2 = Rubber Isolators

## 80To 120Ton Model Nomenclature

**C** **A** **U** **C** **C80** **4** **2** **A** **0** **3** **H** **0'**  
1 2 3 4 5,6,7 8 9 10 11 12 13 14

### **Digit 1 – Unit Type**

C = Condenser

### **Digit 2 – Condenser**

A = Air-Cooled

### **Digit 3 – Airflow**

U = Upflow

### **Digit 4 – Development Sequence**

C = Third

### **Digits 5,6,7 – Nominal Capacity**

C80 = 80 Tons

D10 = 100 Tons

D12 = 120 Tons

### **Digit 8 – Power Supply**

F = 230/60/3

4 = 460/60/3

5 = 575/60/3

E = 200/60/3

### **Digit 9 – Condenser Circuit**

2 = Dual Circuit

### **Digit 10 – Design Sequence**

A = First

### **Digit 11 – Ambient Control**

0 = Standard

1 = 0 F

### **Digit 12 – Agency Approval**

0 = None

2 = CSA

3 = UL/CSA

### **Digits 13, 14 – Miscellaneous**

H = Copper Fins

1 = Spring Isolators

1. The service digit for each model number contains 14 digits; all 14 digits must be referenced.

# General Data

**Table GD-1 – General Data**

	20Ton	25Ton	30Ton	40Ton	50Ton	60Ton	80Ton	100Ton	120Ton
<b>Model Number</b>	CAUC-C20	CAUC-C25	CAUC-C30	CAUC-C40	CAUC-C50	CAUC-C60	CAUC-C80	CAUC-D10	CAUC-D12
Gross Heat Rejection (MBh) <sup>1</sup>	301	373	455	614	712	888	1244	1425	1819
<b>Condenser Fan Data</b>									
Number/Size/Type	2/26"/Prop	3/26"/Prop	3/26"/Prop	4/26"/Prop	6/26"/Prop	6/26"/Prop	8/26"/Prop	12/26"/Prop	12/26"/Prop
Fan Drive	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Direct
No. of Motors/Hp (Each)	2/1.0	3/1.0	3/1.0	4/1.0	6/1.0	6/1.0	8/1.0	12/1.0	12/1.0
Nominal Cfm	12,400	16,700	19,000	24,800	33,400	38,000	49,600	66,800	76,000
<b>Condenser Coil Data</b>									
No./Size (In.)	1/63x71	1/71x71	1/45x71 1/49x71	2/65x70	2/51x96	2/66x90	4/65x70	4/51x96	4/66x90
Face Area (Sq. Ft.)	31.0	35.0	46.1	63.2	67.1	88.0	126.4	136.0	165.0
Rows/Fins Per Ft.	3/168	3/156	3/168	3/168	3/156	3/168	3/168	3/156	3/168
<b>General Data</b>									
No. Refrigerant Circuits	1	1	1	2	2	2	2	2	2
Operating Charge <sup>2</sup> (Lbs of R-22)	25	28	37	52	56	74	104	112	148
Condenser Storage Capacity <sup>3</sup>	67	76	96	136	142	184	272	284	368
<b>Ambient Temperature Operating Range</b>									
Standard Ambient (F)	40-115	40-115	40-115	40-115	40-115	40-115	40-115	40-115	40-115
Low Ambient Option (F)	0-115	0-115	0-115	0-115	0-115	0-115	0-115	0-115	0-115

**Notes:**

1. Gross Heat Rejection is at a 30 F ITD (Initial Temperature Difference) between condensing temperature and ambient air entering condenser (includes the effect of subcooling).
2. Operating charge is for entire unit.
3. At conditions of 95 F ambient, condenser is 95 percent full.



# Electrical Data

**Table ED-1 — Electrical Data**

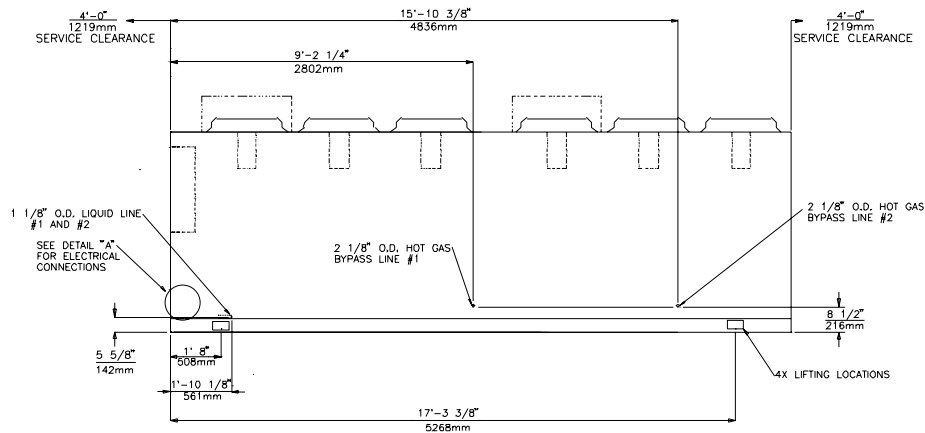
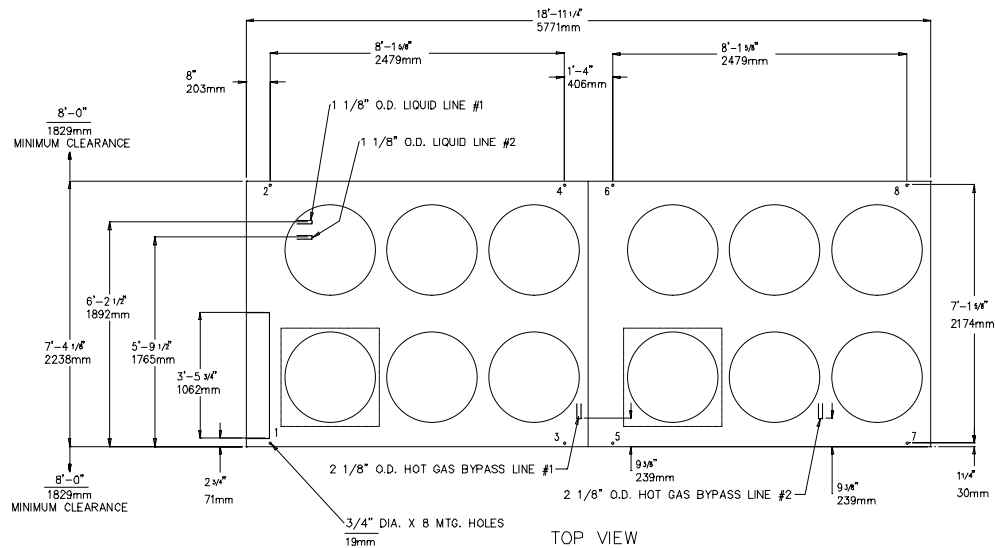
Nominal Tons	Model No.	Unit Characteristics				Condenser Fan Motor			
		Electrical Characteristics	Allowable Voltage Range	Minimum Circuit Ampacity (3),(5)	Maximum Fuse Size (2),(5)	No./HP (1)	FLA (Ea.) (1)	LRA (Ea.) (1)	KW (Ea.) (1),(4)
20	CAUC-C20G	200-230/60/3	180-220/208-254	9.2	15	2/1.0	4.1	20.7	0.9
	CAUC-C204	460/60/3	416-508	4.1	15	2/1.0	1.8	9.0	0.9
	CAUC-C205	575/60/3	520-635	3.2	15	2/1.0	1.4	7.2	0.9
25	CAUC-C25G	200-230/60/3	180-220/208-254	13.3	20	3/1.0	4.1	20.7	0.9
	CAUC-C254	460/60/3	416-508	5.9	15	3/1.0	1.8	9.0	0.9
	CAUC-C255	575/60/3	520-635	4.6	15	3/1.0	1.4	7.2	0.9
30	CAUC-C30G	200-230/60/3	180-220/208-254	13.3	20	3/1.0	4.1	20.7	0.9
	CAUC-C304	460/60/3	416-508	5.9	15	3/1.0	1.8	9.0	0.9
	CAUC-C305	575/60/3	520-635	4.6	15	3/1.0	1.4	7.2	0.9
40	CAUC-C40G	200-230/60/3	180-220/208-254	17.4	20	4/1.0	4.1	20.7	0.9
	CAUC-C404	460/60/3	416-508	7.7	15	4/1.0	1.8	9.0	0.9
	CAUC-C405	575/60/3	520-635	6.0	15	4/1.0	1.4	7.2	0.9
50	CAUC-C50G	200-230/60/3	180-220/208-254	25.6	30	6/1.0	4.1	20.7	0.9
	CAUC-C504	460/60/3	416-508	11.3	15	6/1.0	1.8	9.0	0.9
	CAUC-C505	575/60/3	520-635	8.8	15	6/1.0	1.4	7.2	0.9
60	CAUC-C60G	200-230/60/3	180-220/208-254	25.6	30	6/1.0	4.1	20.7	0.9
	CAUC-C604	460/60/3	416-508	11.3	15	6/1.0	1.8	9.0	0.9
	CAUC-C605	575/60/3	520-635	8.8	15	6/1.0	1.4	7.2	0.9
80	CAUC-C80E	200/60/3	180-220	34	40	8/1.0	4.1	20.7	0.9
	CAUC-C80F	230/60/3	208-254	34	40	8/1.0	4.1	20.7	0.9
	CAUC-C804	460/60/3	416-508	15	20	8/1.0	1.8	9.0	0.9
	CAUC-C805	575/60/3	520-635	12	15	8/1.0	1.4	7.2	0.9
100	CAUC-D10E	200/60/3	180-220	50	60	12/1.0	4.1	20.7	0.9
	CAUC-D10F	230/60/3	208-254	50	60	12/1.0	4.1	20.7	0.9
	CAUC-D104	460/60/3	416-508	22	25	12/1.0	1.8	9.0	0.9
	CAUC-D105	575/60/3	520-635	17	20	12/1.0	1.4	7.2	0.9
120	CAUC-D12E	200/60/3	180-220	50	60	12/1.0	4.1	20.7	0.9
	CAUC-D12F	230/60/3	208-254	50	60	12/1.01	4.1	20.7	0.9
	CAUC-D124	460/60/3	416-508	22	25	12/1.0	1.8	9.0	0.9
	CAUC-D125	575/60/3	520-635	17	20	12/1.0	1.4	7.2	0.9

**Notes:**

1. Electric information is for each individual motor.
2. Maximum fuse size is permitted by NEC 440-22 is 300 percent of one motor RLA plus the RLA of the remaining motors.
3. Minimum circuit ampacity equals 125 percent of the RLA of one motor plus the RLA of the remaining motors.
4. All Kw values taken at conditions of 45 F saturated suction temperature at the compressor and 95 F ambient.
5. Local codes may take precedence.

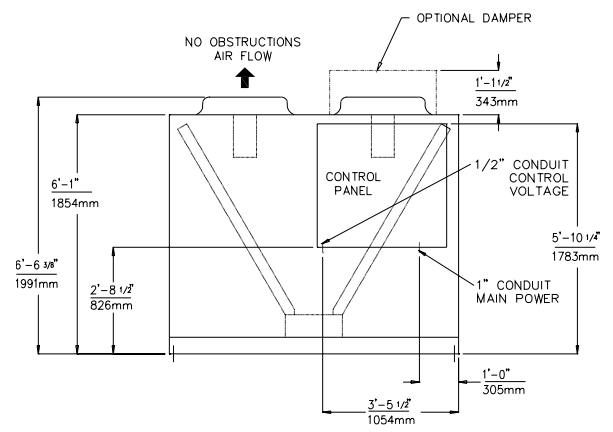
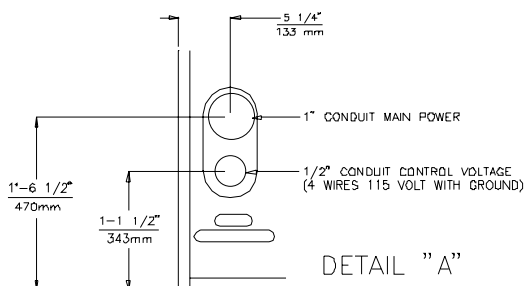
# Dimensional Data (120Ton)

Figure DD-10 – CAUC-C120 Unit Dimensions, Recommended Clearances, Mounting Locations, Electric and Refrigerant Connection Sizes and Locations



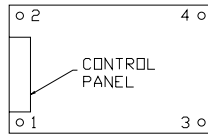
## NOTES:

- HOT GAS DISCHARGE AND LIQUID LINE CONNECTION LOCATIONS SHOWN IN THE FRONT VIEW DO NOT REPRESENT HOLES IN THE UNIT PANEL. ACCESS TO THESE CONNECTIONS ARE PROVIDED BY THE CUSTOMERS.
- DIMENSIONAL TOLERANCE  $\pm 1/8"$ .

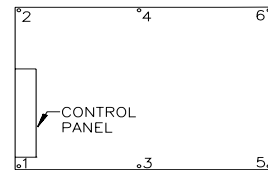


# Weights

**Figure W-1 – 20-30 Tons**



**Figure W-2 – 40-60 Tons**

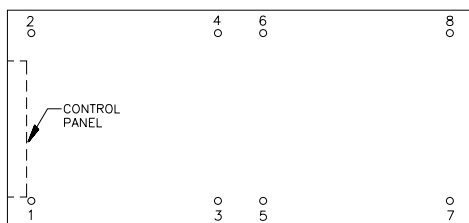


**Top View (Mounting Locations)**

**Table W-1 – 20 to 60 Ton Weights (Lbs./Kg.)**

Nominal Tons	Model Number	Operating Weight		Weight On Isolator At Mounting Locations											
		AL	CU	Loc. 1		Loc. 2		Loc. 3		Loc. 4		Loc. 5		Loc. 6	
20	CAUC-C20	Lb.	1146	1348	320	371	326	365	248	306	252	301	—	—	—
		Kg.	519.8	611.5	145.2	168.3	147.9	165.6	112.5	138.8	114.3	136.5	—	—	—
25	CAUC-C25	Lb.	1190	1394	329	378	337	381	259	315	265	319	—	—	—
		Kg.	539.8	632.3	149.2	171.5	152.9	172.8	117.5	142.9	120.2	144.7	—	—	—
30	CAUC-C30	Lb.	1302	1585	353	414	371	444	282	355	296	381	—	—	—
		Kg.	590.6	719.0	160.1	187.8	168.3	201.4	127.9	161.0	134.3	172.8	—	—	—
40	CAUC-C40	Lb.	2048	2366	363	406	347	392	349	404	334	389	335	401	320
		Kg.	929.0	1073.2	164.7	184.2	157.4	177.8	158.3	183.3	151.5	176.5	152.0	181.9	145.2
50	CAUC-C50	Lb.	2280	2664	407	464	392	449	387	453	373	438	367	441	354
		Kg.	1034.2	1208.4	184.6	210.5	177.8	203.7	175.5	205.5	169.2	198.7	166.5	200.0	160.6
60	CAUC-C60	Lb.	2465	3010	433	515	420	505	417	511	405	501	401	507	389
		Kg.	1118.1	1365.3	196.4	233.6	190.5	229.1	189.2	231.8	183.7	227.3	181.9	230.0	176.5

**Figure W-3 – 80-120 Tons**



**Top View (Mounting Locations)**

**Table W-2 – 80 to 120 Ton Weights (Lbs./Kg.)**

Nominal Tons	Model Number	Coil Fin	Operating Weight	Weight On Isolator At Mounting Points							
				Loc. 1	Loc. 2	Loc. 3	Loc. 4	Loc. 5	Loc. 6	Loc. 7	Loc. 8
80	CAUC-C80	AL	Lb.	4036	514	478	522	485	524	487	532
		CU	Lb.	1830.7	233.2	216.8	236.8	220.0	237.7	220.9	241.3
		AL	Kg.	4542	603	571	600	569	600	568	597
		CU	Kg.	2060.3	273.5	259.0	272.2	258.1	272.2	257.6	270.8
100	CAUC-D10	AL	Lb.	4911	631	600	630	598	629	598	628
		CU	Lb.	2227.6	286.2	272.2	285.8	271.3	285.3	271.3	284.9
		AL	Kg.	5371	586	549	597	560	600	562	611
		CU	Kg.	2436.3	265.8	249.0	270.8	254.0	272.2	254.9	277.1
120	CAUC-D12	AL	Lb.	5472	698	666	700	668	700	668	702
		CU	Lb.	2482.1	316.6	302.1	317.5	303.0	317.5	303.0	318.4
		AL	Kg.	5971	774	742	779	747	780	748	786
		CU	Kg.	2708.4	351.1	336.6	353.4	338.8	353.8	339.3	356.5

# **Outreach Innovation Building**

Penn State Research Park  
State College, PA.

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## **Appendix F**

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### **Fan Coil Unit Data**



# Outreach Innovation Building

Penn State Research Park  
State College, PA.

## Fan Coil Zone Schedule

Fan Coil	Zones	Coil	MBH	Coil Ton	Coil Type	
1	1	5.9				
	2	11.8				
	3	6.5				
	4	3				
	5	5.9				
	6	15.2	48.3	<b>4.03</b>	12-2	
2	7	89.6	89.6	<b>7.47</b>	12-4	
3	8	8.6	8.6	<b>0.72</b>	12-2	
4	9	8.9				
	10	22.6				
	24	16.9	48.4	<b>4.03</b>	12-2	
5	11	66.5				
	23	5.9	72.4	<b>6.03</b>	12-4	
6	12	2.8				
	13	7.2				
	14	11.1				
	25	1.8	22.9	<b>1.91</b>	12-2	
7	15	2.1				
	16	19.8				
	29	3.9	25.8	<b>2.15</b>	12-2	
8	17	14.7				
	18	25.7	40.4	<b>3.37</b>	12-2	
9	19	33.8				
	20	2.1				
	21	0.9	36.8	<b>3.07</b>	12-2	
10	22	41.6	41.6	<b>3.47</b>	12-2	
11	1	25				
	2	14.7	39.7	<b>3.31</b>	12-2	
12	3	2				
	11	3.3				
	12	2.5				
	13	2.1	9.9	<b>0.83</b>	12-2	
13	9	53	53	<b>4.42</b>	12-2	
14	10	21.5	21.5	<b>1.79</b>	12-2	
15	14	2.4				
	15	5.2	7.6	<b>0.63</b>	12-2	
16	16	137.7	68.5	<b>5.71</b>	12-4	*2
17	222b,j	3.2	3.2	<b>0.27</b>	12-2	
18	19	727	120	<b>10.00</b>	12-6	*6
19	20	208	104	<b>8.67</b>	12-6	*2
20	24	2.5				
	25	2.5				
	27	351	117	<b>9.75</b>	12-6	*3
21	29	4.5				
	30	4.5	9	<b>0.75</b>	12-2	
22	23	10.4				
	28	2.8	13.2	<b>1.10</b>	12-2	

## Outreach Innovation Building

Penn State Research Park  
State College, PA.

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Coil Type	Quantity
12-2	16
12-4	4
12-6	11
Total	31



# Blower Coil Air Handler

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Air Terminal Devices  
400 to 3000 cfm





# Application Considerations

## Application Flexibility

The Trane blower coil air handler offers a wide range of application flexibility between the fan-coil unit and the packaged climate changer.

Units are available in seven nominal capacities ranging from 1.0 to 7.5 tons cooling and 400 to 3000 cfm airflow. The basic unit is available in horizontal (model BCHC) as well as a vertical (model BCVC) configuration.

The single-zone, constant volume applications that we will discuss in this section are:

- two-pipe hydronic
- two-pipe hydronic with electric heat
- four-pipe hydronic
- economizer

Other applications of the BCHC/BCVC are:

- DX cooling
- two-pipe hydronic with steam heating

### Two-Pipe Units

The standard BCHC/BCVC unit is equipped with a hydronic coil. The unit can perform cooling only, heating and cooling (changeover system) or heating only. In a changeover system the unit cools during the spring, summer, and fall seasons (summer mode) and heats during the winter season (winter mode).

Use the Trane Official Product Selection System™ (TOPSS) program for specific design criteria such as flow rate, temperature rise/drop, pressure drop, glycol mixtures, and capacity.

When selecting two-pipe changeover units, note that TOPSS will only provide output that meets both the cooling and heating capacity requirements. Because cooling and heating capacity requirements for a given unit may differ significantly, a given coil may be optimally sized for one load and over/under sized for the other load.

### Two-Pipe Units With Electric Heat

With the addition of electric heat, the two-pipe system can heat or cool. In the non-changeover system the main coil is always used for cooling and the electric heater is always used for heating. In the changeover system, during the summer mode (spring, summer and fall), the main coil is used for cooling and electric heater is used for heating. During the winter

mode, the main coil is used for heating and the electric heater is disabled.

Two-pipe systems with electric heat are an economical solution to the intermediate season (spring and fall) comfort problems associated with straight two-pipe systems. In moderate climates, or where electric rates are low, non-changeover systems are typically used. In climates with significant heating loads and/or high electric rates, a changeover system, to allow hydronic heating, is typically used.

### Changeover in Two-Pipe Systems

Changing between cooling and heating modes in a two-pipe system requires energy to heat or cool the mass of water in the piping system at switchover.

ASHRAE Standard 90.1-2001 defines specific requirements for minimizing the energy impact of this switchover:

- The system must allow a deadband, between changeover from one mode to the other, of at least 15°F (8°C) outdoor-air temperature.
- The system must include controls that allow the system to operate in one mode for at least four hours before changing to the other mode.
- Reset controls must be provided to allow heating and cooling supply-water temperatures, at the changeover point, to be no more than 30°F (17°C) apart.

### Four-Pipe Units

The addition of a one-row or two-row heating coil to the basic BCHC/BCVC unit makes it compatible for a four-pipe cooling and heating system. The heating coil is available factory installed in either the preheat or reheat position.

Four-pipe systems solve the intermediate season (spring and fall) comfort problems associated with straight two-pipe systems because they only either cool or heat year-round. However, they do require chiller and boiler operation to be available to operate year-round.

When making the choice between a two or four-pipe system, also consider:

- cooling/heating loads in perimeter zones of the building
- the importance of temperature and humidity control for the zone
- first cost

TOPSS allows independent selection of

the cooling and heating coils for flexibility in flow rates, pressure drops, temperature rise/drop, and fluid type.

### DX Cooling Units

A BCHC/BCVC unit with a DX cooling coil will often be connected to an air-cooled condensing unit. Some condensing units have two, independent refrigeration circuits, while the DX coil in the BCHC/BCVC unit is single-circuited. **Do not manifold two, independent refrigeration circuits into a single-circuited DX (evaporator) coil.**

### Dehumidification

The BCHC/BCVC has two methods for improving the dehumidification performance of the constant-volume unit.

### Automatic Fan Speed Adjustment

When equipped with a Tracer ZN520 controller, the BCHC/BCVC unit can be operated in the AUTO fan speed setting that operates the fan at the lowest speed possible, while maintaining space temperature setpoint. As the cooling load decreases, the first control step is to switch the fan to operate at low speed. Upon a further drop in cooling load, the control valve modulates to further reduce the unit's cooling capacity. This results in improved dehumidification performance because less air passes through the coil and, therefore, leaves the coil at a cooler, drier condition.

To provide the proper amount of outdoor air to the space at all fan speeds, the Tracer ZN520 controller automatically adjusts the position of the economizer damper when the fan switches speeds. Fan-speed adjustment has an added acoustical advantage in that operating the fan at low speed results in quieter operation.

### Four-Pipe Unit with Reheat

BCHC/BCVC units equipped with a Tracer ZN520 controller and a hydronic heating coil in the reheat position will provide direct control of space humidity. If the space humidity level does not exceed the desired upper limit, the unit responds to reduced cooling load by modulating the control valve and, if in AUTO mode, switching between fan speeds. However, if the space humidity level rises above the upper limit, the capacity of the cooling coil is increased, overcooling the air to maintain the space humidity below the

# Application Considerations

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upper limit. Then, the capacity of the heating coil modulates, adding a small amount of heat to temper the air and avoid overcooling the space.

The Tracer ZN520 controller responds to a signal from a humidity sensor installed in the space or a signal from a building automation system, and independently modulates the cooling and heating coils to directly control both temperature and humidity in the space. While this configuration can directly control indoor humidity levels, it does require the boiler (or other source of heat) to be available year-round.

## Impact of Chilled-Water Reset

In many constant-flow pumping systems, the leaving chilled-water temperature setpoint is reset based on either outdoor dry-bulb temperature or some indication of cooling load. Use caution when implementing a chilled-water reset strategy because space humidity control can be compromised if the water gets too warm.

A BCHC/BCVC unit equipped with a Tracer ZN520 can accept an input signal from a humidity sensor in the space. A building automation system will continually poll the humidity level in all spaces, or in a single representative space, to limit the amount of chilled-water reset and maintain space humidity levels.

## Airside Economizer

Adding a mixing box with a damper actuator allows economizer or free cooling applications. When using blower coils for these applications, Trane highly recommends using a freeze protection device to protect the coil(s). If the unit has a Tracer ZN520 controller, you must have an outside air temperature signal from either a hardwired outside air sensor or from the building automation system, such as Tracer Summit™.

## Location and Installation

Avoid locating the unit directly above spaces where sound levels may be critical, such as areas near the occupied space. Install horizontal units over false ceilings in service areas such as corridors or storage rooms. Install vertical units in closets or mechanical rooms.

Horizontal units are installed by suspend-

ing the corners of the unit with threaded rods. Use suitable vibration isolators and take the following precautions to comply with generally accepted installation practices.

- Use flexible duct connectors or supply and return sides (if ducted).
- Use acoustic lining on the inside of main supply duct for noise control.
- Do not attach ceiling suspension wires to unit or through ducts.
- Locate return air grilles as far as possible from the unit to avoid noise transmission.
- Design and install ductwork as per ASHRAE guides, SMACNA, and local code requirements.

## Acoustics

Controlling outdoor and equipment noise within the occupied space is increasingly important to system designers and building occupants/owners. Therefore, give proper consideration to this subject in the application of the BCHC/BCVC unit.

Selecting fan and coil combinations is inherently flexible for sound-sensitive applications. In such instances, a fan running at low speed with a high capacity coil normally yields satisfactory results. It also may be desirable to select a larger nominal capacity unit and operate it at less than nominal airflow for further acoustic benefit.

BCHC/BCVC sound power, Lw, data for ducted discharge, inlet + casing, and casing radiated components is available from TOPSS. This sound power data is useful in estimating the sound levels in the occupied space for a given application.

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**Note: All sound power data is based on three-phase motors. Trane recommends three-phase motors for sound sensitive applications to avoid potential single-phase motor hum.**

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## Operating Limitations

Reference the General Data section for minimum and maximum operating limits. Units must not operate above maximum fan rpm or unit airflow. Unit operation above the maximum fan rpm will drastically reduce bearing life and may result in catastrophic failure. Operating the unit above the maximum airflow in

the cooling mode may result in unsatisfactory operation due to water carryover from the coil. In addition, it is often uneconomical to operate a unit at its maximum rpm due to greater motor power requirements.

The unit may not perform at an optimal acoustical performance level if it operates in the fan's traditional stall region.

Do not operate units with electric heat below the minimum airflow limit to prevent excessive leaving air temperatures and electric heat limit trips.

Do not operate hydronic and electric heat simultaneously to prevent excessive leaving air temperatures and limit trips. Electric heat units have a lockout switch to disable the electric heater if the temperature off the hydronic coil is greater than 95°F.

Do not operate units with a leaving air temperature above 130°F, unless fitted with special higher insulation class motors.

Do not operate coils above the water flow limits to prevent erosion and noise. A minimum or "self-venting" water flow rate is also listed in the General Data Section. If the coil is set to operate below this flow rate, periodically vent it by flushing at a higher flow rate.

Do not operate piping packages and water valves above the water flow limit to prevent erosion and noise. Water valves supplied with the BCHC/BCVC units as accessories are intended for use in "treated" closed loop chilled or hot water systems. Do not use valves with open or potable water systems. Such applications may cause scaling and particulate collection interference with the valve function and reduce the life and effectiveness of the valve.

# Performance Data

# Cooling Capacities

**Table PD-13. Chilled Water Coil Cooling Capacity, EDB = 80°F, EWB = 67°F, EWT = 45°F**

Unit Size		rows of coil		airflow		Water Temperature Rise, ΔT																											
						6°F							8°F							10°F							12°F						
						tc	sc	ldb	lwb	gpm	wpd	tc	sc	ldb	lwb	gpm	wpd	tc	sc	ldb	lwb	gpm	wpd	tc	sc	ldb	lwb	gpm	wpd				
12	2	300	4.8	4.8	65.6	62.2	1.6	0.27	4.0	4.0	67.9	63.0	1.0	0.11	3.7	3.7	68.9	63.3	0.7	0.06	3.4	3.4	69.8	63.6	0.6	0.04							
		400	6.0	6.0	66.3	62.5	2.0	0.42	4.5	4.5	69.8	63.7	1.1	0.14	4.1	4.1	70.7	64.0	0.8	0.08	3.8	3.8	71.5	64.2	0.6	0.05							
		500	7.1	7.1	67.2	62.8	2.4	0.57	4.9	4.9	71.2	64.1	1.2	0.16	4.4	4.4	72.0	64.4	0.9	0.09	4.0	4.0	72.7	64.6	0.7	0.05							
	4	300	11.6	8.3	54.9	54.5	3.9	2.08	9.6	7.5	57.3	56.9	2.4	0.86	7.4	6.7	59.8	59.4	1.5	0.35	7.3	7.3	63.5	61.5	1.2	0.25							
		400	14.3	10.5	56.2	55.6	4.8	3.04	11.9	9.6	58.2	57.6	3.0	1.29	9.5	8.7	60.3	59.7	1.9	0.56	8.6	8.6	64.3	61.8	1.4	0.34							
		500	16.5	12.5	57.3	56.5	5.5	3.98	13.9	11.5	59.1	58.3	3.5	1.71	11.3	10.5	60.9	60.0	2.3	0.77	8.6	8.6	64.3	61.8	1.4	0.34							
	6	300	14.9	9.8	50.4	50.3	5.0	4.27	13.5	9.2	52.2	52.1	3.4	2.10	11.8	8.5	54.3	54.2	2.4	1.10	9.9	7.8	56.6	56.5	1.7	0.58							
		400	18.7	12.6	51.5	51.4	6.2	6.49	16.9	11.8	53.2	53.1	4.2	3.18	14.9	11.0	55.1	55.0	3.0	1.68	12.8	10.1	57.0	56.9	2.1	0.91							
		500	22.1	15.1	52.6	52.4	7.4	8.80	20.0	14.2	54.2	54.0	5.0	4.29	17.7	13.3	55.9	55.7	3.5	2.28	15.2	12.3	57.6	57.4	2.5	1.25							
18	2	450	8.6	8.0	63.9	61.2	2.9	0.87	5.7	5.7	68.5	63.2	1.4	0.24	4.9	4.9	70.1	63.7	1.0	0.12	4.5	4.5	70.9	64.0	0.8	0.07							
		600	10.3	9.9	65.0	61.8	3.4	1.23	7.4	7.4	68.8	63.3	1.9	0.39	5.5	5.5	71.8	64.3	1.1	0.14	5.0	5.0	72.5	64.6	0.8	0.09							
		750	11.6	11.6	66.0	62.3	3.9	1.55	8.8	8.8	69.4	63.5	2.2	0.53	5.8	5.8	73.0	64.7	1.2	0.16	5.3	5.3	73.6	64.9	0.9	0.10							
	4	450	17.7	12.5	54.8	54.3	5.9	4.90	15.4	11.6	56.6	56.1	3.9	2.23	12.9	10.6	58.6	58.0	2.6	1.07	10.2	9.6	60.6	60.0	1.7	0.50							
		600	21.4	15.7	56.3	55.6	7.1	6.96	18.7	14.6	57.9	57.2	4.7	3.19	16.0	13.6	59.5	58.7	3.2	1.58	13.1	12.5	61.1	60.3	2.2	0.78							
		750	24.5	18.5	57.7	56.7	8.2	8.95	21.5	17.3	59.1	58.0	5.4	4.11	18.5	16.2	60.4	59.4	3.7	2.06	15.5	15.1	61.8	60.7	2.6	1.06							
	6	450	22.3	14.7	50.4	50.3	7.4	9.76	20.6	14.0	51.9	51.8	5.2	4.98	18.7	13.1	53.5	53.4	3.7	2.77	16.5	12.3	55.3	55.2	2.8	1.59							
		600	27.8	18.7	51.8	51.6	9.3	14.62	25.6	17.7	53.2	53.0	6.4	7.38	23.2	16.8	54.7	54.5	4.6	4.10	20.7	15.7	56.2	56.0	3.4	2.38							
		750	32.6	22.4	53.0	52.7	10.9	19.58	29.8	21.2	54.4	54.1	7.5	9.77	27.0	20.1	55.7	55.4	5.4	5.42	24.2	19.0	57.1	56.8	4.0	3.17							
24	2	600	12.2	11.1	63.2	60.8	4.1	0.72	8.2	8.2	67.6	62.9	2.0	0.20	7.5	7.5	68.6	63.3	1.5	0.11	6.9	6.9	69.5	63.6	1.2	0.07							
		800	14.9	14.0	64.1	61.3	5.0	1.05	10.2	10.2	68.5	63.2	2.5	0.30	8.4	8.4	70.5	63.9	1.7	0.14	7.7	7.7	71.2	64.1	1.3	0.08							
		1000	17.1	16.5	65.0	61.8	5.7	1.37	12.4	12.4	68.8	63.3	3.1	0.43	9.1	9.1	71.8	64.3	1.8	0.16	8.3	8.3	72.5	64.6	1.4	0.09							
	4	600	25.1	17.4	53.7	53.3	8.4	3.94	21.7	16.0	55.8	55.4	5.4	1.78	18.0	14.6	58.0	57.6	3.6	0.83	13.6	12.9	60.5	60.0	2.3	0.35							
		800	30.8	22.0	55.1	54.6	10.3	5.78	26.9	20.4	56.9	56.3	6.7	2.63	22.7	18.8	58.7	58.1	4.5	1.26	18.1	17.1	60.7	60.0	3.0	0.60							
		1000	35.6	26.1	56.3	55.6	11.9	7.59	31.2	24.4	57.9	57.2	7.8	3.46	26.6	22.6	59.5	58.7	5.3	1.70	21.8	20.8	61.1	60.3	3.6	0.84							
	6	600	31.0	20.1	49.6	49.5	10.3	7.48	28.7	19.1	51.1	51.0	7.2	3.83	26.0	18.0	52.9	52.8	5.2	2.12	22.8	16.7	54.8	54.7	3.8	1.20							
		800	39.1	25.9	50.7	50.6	13.0	11.47	36.1	24.6	52.2	52.1	9.0	5.82	32.8	23.1	53.8	53.6	6.6	3.23	29.0	21.6	55.5	55.4	4.8	1.85							
		1000	46.3	31.1	51.8	51.6	15.4	15.69	42.6	29.6	53.2	53.0	10.6	7.88	38.7	27.9	54.7	54.5	7.7	4.37	34.4	26.2	56.2	56.0	5.7	2.53							
36	2	900	24.7	19.2	60.6	58.4	8.2	3.16	19.8	17.4	62.5	60.2	5.0	1.21	13.9	13.9	66.0	62.4	2.8	0.41	10.8	10.8	69.1	63.4	1.8	0.18							
		1200	29.4	23.7	62.1	59.4	9.8	4.38	24.3	21.8	63.5	60.8	6.1	1.77	18.3	18.3	66.2	62.4	3.7	0.69	12.1	12.1	70.9	64.0	2.0	0.23							
		1500	33.2	27.7	63.2	60.2	11.1	5.50	27.9	25.8	64.4	61.4	7.0	2.29	21.9	21.9	66.8	62.6	4.4	0.96	15.4	15.4	70.7	64.0	2.6	0.35							
	4	900	41.6	27.8	52.0	51.7	13.9	12.13	38.2	26.4	53.4	53.1	9.6	6.09	34.5	24.8	55.0	54.6	6.9	3.34	30.3	23.2	56.7	56.3	5.1	1.88							
		1200	51.4	35.2	53.4	53.0	17.1	17.96	47.0	33.3	54.8	54.3	11.8	8.92	42.6	31.5	56.2	55.6	8.5	4.92	37.9	29.7	57.6	57.0	6.3	2.83							
		1500	59.8	41.9	54.7	54.0	19.9	23.84	54.5	39.7	56.0	55.3	13.6	11.74	49.4	37.7	57.2	56.5	9.9	6.46	44.2	35.6	58.5	57.7	7.4	3.76							
	6	900	49.1	31.4	48.4	48.3	16.4	21.43	46.7	30.3	49.5	49.4	11.7	11.54	44.0	29.1	50.7	50.6	8.8	6.88	40.9	27.7	52.1	52.0	6.8	4.31							
		1200	62.4	40.4	49.4	49.3	20.8	33.30	59.0	38.9	50.6	50.5	14.8	17.69	55.4	37.4	51.8	51.7	11.1	10.44	51.4	35.7	53.0	52.9	8.6	6.53							
		1500	74.4	48.9	50.5	50.3	24.8	46.05	70.0	47.0	51.6	51.5	17.5	24.19	65.4	45.0	52.8	52.6	13.1	14.15	60.6	43.0	54.0	53.8	10.1	8.82							

EDB = entering dry-bulb temperature

EWB = wet-bulb temperature

EWT = entering water temperature

tc = total capacity (MBh)

sc = sensible capacity (MBh)

ldb = leaving dry-bulb temperature

lwb = leaving wet-bulb temperature

gpm = water flow rate, gallons per minute

wpd = water pressure drop @ average water density (ft H<sub>2</sub>O)

## Notes:

1. Some of the volumetric flow rates are less than those required for self-venting. See Table GD-1 on page 14.

2. Values lightly shaded means the gpm is below the minimum (<1.5 fps venting velocity) or above the maximum (>10 ft wg) recommended for most applications.

3. Values darkly shaded means the gpm is below the ARI limits (1.0 fps tubeside velocity).

4. Capacities calculated with 0.00000 tube-side fouling factor.

# Performance Data

# Cooling Capacities

**Table PD-15. Chilled Water High-Capacity Cooling Coil Data, EAT = 80°F DB / 67°F WB and EWT = 40°F**

Unit Size		Rows of Coil airflow		Water Temperature Rise, ΔT																															
				6°F								10°F								16°F								20°F							
				tc	sc	ldb	lwb	gpm	wpd	tc	sc	ldb	lwb	gpm	wpd	tc	sc	ldb	lwb	gpm	wpd	tc	sc	ldb	lwb	gpm	wpd								
12	2	300	9.3	6.8	59.5	57.2	3.1	2.25	5.0	5.0	65.0	62.0	1.0	0.28	3.9	3.9	68.2	63.1	0.5	0.08	3.4	3.4	69.7	63.6	0.3	0.04									
		400	11.0	8.3	61.2	58.5	3.7	3.05	6.3	6.3	65.6	62.2	1.3	0.43	4.4	4.4	70.1	63.8	0.5	0.09	3.8	3.8	71.5	64.2	0.4	0.05									
		500	12.3	9.6	62.6	59.4	4.1	3.77	7.5	7.5	66.4	62.5	1.5	0.58	4.7	4.7	71.5	64.2	0.6	0.10	4.0	4.0	72.7	64.6	0.4	0.06									
	4	300	16.1	10.3	49.0	48.6	5.4	9.70	13.4	9.0	52.7	52.3	2.7	2.71	8.2	7.0	59.0	58.5	1.0	0.48	6.6	6.4	60.7	60.2	0.7	0.22									
		400	19.9	12.9	50.8	50.3	6.6	14.19	16.4	11.4	54.2	53.6	3.3	3.91	10.5	9.1	59.5	58.8	1.3	0.75	7.4	7.4	63.1	61.3	0.7	0.27									
		500	23.0	15.2	52.4	51.7	7.7	18.65	18.9	13.5	55.6	54.8	3.8	5.07	12.4	11.0	60.1	59.3	1.6	1.01	8.2	8.2	65.1	62.0	0.8	0.32									
	6	300	19.2	11.8	44.4	44.3	6.4	17.91	17.2	10.9	47.2	47.1	3.4	5.87	13.4	9.1	52.4	52.3	1.7	1.59	10.0	7.8	56.5	56.4	1.0	0.64									
		400	24.3	15.1	45.8	45.7	8.1	27.58	21.6	13.9	48.6	48.5	4.3	8.82	16.8	11.7	53.4	53.2	2.1	2.39	13.0	10.2	56.8	56.7	1.3	1.01									
		500	28.9	18.2	47.1	46.9	9.6	37.84	25.5	16.6	49.9	49.8	5.1	11.86	19.8	14.1	54.4	54.2	2.5	3.20	15.5	12.5	57.4	57.2	1.6	1.39									
18	2	450	14.1	10.1	59.6	57.1	4.7	5.24	9.6	8.4	63.1	60.5	1.9	1.00	5.3	5.3	69.4	63.5	0.7	0.14	4.5	4.5	70.8	64.0	0.5	0.07									
		600	16.4	12.2	61.6	58.5	5.5	6.93	11.5	10.3	64.4	61.2	2.3	1.39	5.8	5.8	71.3	64.1	0.7	0.17	5.0	5.0	72.5	64.6	0.5	0.08									
		750	18.1	14.0	63.1	59.5	6.0	8.41	13.0	12.0	65.4	61.8	2.6	1.74	6.2	6.2	72.5	64.6	0.8	0.19	5.3	5.3	73.6	64.9	0.5	0.09									
	4	450	23.8	15.2	49.4	49.0	7.9	21.65	20.3	13.6	52.5	52.0	4.1	6.38	14.4	11.2	57.4	56.9	1.8	1.46	9.7	9.4	61.0	60.4	1.0	0.48									
		600	29.0	18.9	51.4	50.8	9.7	31.19	24.6	17.0	54.4	53.7	4.9	8.98	17.7	14.2	58.5	57.7	2.2	2.11	12.7	12.4	61.3	60.5	1.3	0.78									
		750	33.4	22.2	53.2	52.3	11.1	40.42	28.1	19.9	55.9	55.0	5.6	11.44	20.4	16.9	59.5	58.5	2.6	2.72	15.2	15.0	61.9	60.8	1.5	1.06									
	6	450	28.4	17.5	44.8	44.7	9.5	40.39	25.8	16.3	47.3	47.2	5.2	13.43	21.1	14.1	51.5	51.4	2.6	3.98	17.1	12.5	54.8	54.7	1.7	1.85									
		600	35.7	22.3	46.3	46.2	11.9	61.41	32.1	20.6	48.9	48.8	6.4	19.90	26.0	17.9	52.9	52.7	3.3	5.81	21.4	16.0	55.8	55.6	2.1	2.74									
		750	42.2	26.6	47.8	47.6	14.1	83.21	37.6	24.5	50.4	50.1	7.5	26.44	30.2	21.4	54.2	53.9	3.8	7.60	25.0	19.3	56.7	56.4	2.5	3.62									
24	2	600	21.2	14.7	57.8	55.7	7.1	5.51	15.1	12.2	61.5	59.2	3.0	1.13	8.2	8.2	67.6	62.9	1.0	0.16	7.2	7.2	69.2	63.4	0.7	0.08									
		800	25.1	17.9	59.7	57.1	8.4	7.51	18.2	15.2	62.8	60.0	3.6	1.59	9.2	9.2	69.6	63.6	1.1	0.19	7.9	7.9	71.0	64.1	0.8	0.10									
		1000	28.2	20.7	61.2	58.2	9.4	9.33	20.6	17.8	63.9	60.7	4.1	2.01	9.9	9.9	71.0	64.1	1.2	0.22	8.5	8.5	72.3	64.5	0.9	0.11									
	4	600	33.9	21.3	47.8	47.5	11.3	20.30	29.6	19.3	50.8	50.4	5.9	6.19	21.7	16.0	55.8	55.4	2.7	1.50	15.3	13.5	59.6	59.1	1.5	0.53									
		800	42.0	26.8	49.6	49.1	14.0	30.09	36.3	24.3	52.5	52.0	7.3	8.96	26.9	20.4	56.9	56.3	3.4	2.21	19.9	17.7	59.9	59.3	2.0	0.86									
		1000	49.0	31.8	51.2	50.5	16.3	39.93	41.9	28.7	54.0	53.3	8.4	11.67	31.3	24.4	57.9	57.1	3.9	2.90	23.8	21.6	60.5	59.6	2.4	1.18									
	6	600	39.4	24.1	43.6	43.5	13.1	35.79	36.3	22.6	45.9	45.8	7.3	12.22	30.4	19.8	50.0	49.9	3.8	3.78	25.2	17.6	53.4	53.3	2.5	1.81									
		800	50.2	31.0	44.9	44.8	16.7	55.72	45.8	28.9	47.3	47.2	9.2	18.56	38.0	25.4	51.3	51.1	4.8	5.64	31.8	22.7	54.2	54.1	3.2	2.73									
		1000	60.0	37.4	46.1	46.0	20.0	77.13	54.2	34.7	48.6	48.4	10.8	25.19	44.6	30.4	52.4	52.3	5.6	7.52	37.5	27.5	55.1	54.9	3.7	3.67									
36	2	900	36.0	23.9	56.0	54.0	12.0	17.67	29.4	21.1	58.8	56.6	5.9	4.71	18.1	16.7	63.2	60.9	2.3	0.81	11.2	11.2	68.8	63.3	1.1	0.23									
		1200	42.9	29.2	58.0	55.6	14.3	24.46	34.8	25.9	60.5	57.9	7.0	6.42	22.8	21.3	63.9	61.2	2.9	1.24	12.4	12.4	70.6	63.9	1.2	0.27									
		1500	48.5	33.8	59.6	56.8	16.2	30.74	39.2	30.0	61.9	58.9	7.8	7.97	26.6	25.3	64.7	61.6	3.3	1.63	16.4	16.4	70.1	63.7	1.6	0.45									
	4	900	53.6	33.3	46.5	46.2	17.9	58.72	48.6	30.9	48.8	48.5	9.7	19.26	39.9	27.1	52.7	52.4	5.0	5.71	33.0	24.2	55.6	55.2	3.3	2.71									
		1200	67.0	42.1	48.2	47.8	22.3	88.17	60.0	38.9	50.6	50.1	12.0	28.25	48.9	34.1	54.2	53.7	6.1	8.23	40.9	30.9	56.7	56.1	4.1	3.98									
		1500	78.6	50.1	49.8	49.2	26.2	118.26	69.9	46.1	52.1	51.5	14.0	37.21	56.5	40.5	55.5	54.9	7.1	10.68	47.6	36.9	57.7	57.0	4.8	5.21									
	6	900	60.7	36.9	42.8	42.7	20.2	100.36	57.3	35.3	44.5	44.4	11.5	35.78	50.5	32.0	47.7	47.6	6.3	12.18	44.7	29.4	50.4	50.3	4.5	6.53									
		1200	77.9	47.7	44.0	43.9	26.0	157.96	72.8	45.3	45.8	45.7	14.6	55.06	63.3	40.8	49.1	49.0	7.9	18.21	55.9	37.6	51.6	51.5	5.6	9.71									
		1500	93.6	57.8	45.1	45.0	31.2	220.74	86.7	54.5	47.1	46.9	17.3	75.56	74.6	49.0	50.4	50.3	9.3	24.45	65.6	45.1	52.8	52.6	6.6	12.92									

EDB = entering dry-bulb temperature  
 EWB = wet-bulb temperature  
 EWT = entering water temperature  
 tc = total capacity (MBh)  
 sc = sensible capacity (MBh)  
 ldb = leaving dry-bulb temperature  
 lwb = leaving wet-bulb temperature  
 gpm = water flow rate, gallons per minute  
 wpd = water pressure drop @ average water density (ft H<sub>2</sub>O)

**Notes:**

- Some of the volumetric flow rates are less than those required for self-venting. See Table GD-1 on page 14.
- Values lightly shaded means the gpm is below the minimum (<1.5 fps venting velocity) or above the maximum (>10 ft wg) recommended for most applications.
- Values darkly shaded means the gpm is below the ARI limits (1.0 fps tubeside velocity).
- Capacities calculated with 0.00000 tube-side fouling factor.
- High Capacity coils applicable where higher water pressure differentials are acceptable and are also recommended for Earthwise™ applications (See Note 6).
- Earthwise™ is a trademark of the Trane to identify equipment designed for applications requiring greater water temperature rises, lower entering water temperatures (EWT) and lower air supply temperatures (ldb).

high-capacity cooling coil, EWT = 40°F



# Performance Data

# Heating Capacities

**Table PD-21. One-Row Hot Water Heating Coil, EAT = 60°F and EWT= 180°F**

Unit Size		Water Temperature Drop, ΔT																							
		10°F				15°F				20°F				25°F				30°F				40°F			
		airflow	tc	lat	gpm	wpd	tc	lat	gpm	wpd	tc	lat	gpm	wpd	tc	lat	gpm	wpd	tc	lat	gpm	wpd	tc	lat	gpm
12	300	15.3	106.9	3.0	0.71	13.7	102.1	1.8	0.26	12.1	97.1	1.2	0.12	10.2	91.2	0.8	0.05	7.6	83.5	0.5	0.02	5.2	76.0	0.3	0.01
	400	17.5	100.4	3.5	0.94	15.7	96.2	2.1	0.34	13.9	91.9	1.4	0.15	11.8	87.1	0.9	0.07	9.1	81.1	0.6	0.03	5.5	72.6	0.3	0.01
	500	19.4	95.9	3.9	1.15	17.4	92.0	2.3	0.42	15.3	88.3	1.5	0.19	13.1	84.1	1.0	0.09	10.3	79.0	0.7	0.04	5.7	70.5	0.3	0.01
18	450	21.5	104.1	4.3	1.44	19.6	100.2	2.6	0.55	17.8	96.4	1.8	0.26	15.8	92.4	1.3	0.13	13.5	87.7	0.9	0.07	6.7	73.8	0.3	0.01
	600	24.6	97.9	4.9	1.88	22.4	94.5	3.0	0.71	20.3	91.1	2.0	0.33	18.1	87.8	1.4	0.17	15.6	84.0	1.0	0.09	7.1	70.8	0.4	0.01
	750	27.2	93.5	5.4	2.29	24.8	90.4	3.3	0.86	22.3	87.5	2.2	0.40	19.9	84.5	1.6	0.21	17.3	81.3	1.2	0.11	7.3	69.0	0.4	0.01
24	600	32.1	109.3	6.4	1.35	29.3	105.1	3.9	0.51	26.6	100.9	2.7	0.24	23.6	96.3	1.9	0.12	20.0	90.7	1.3	0.06	10.8	76.5	0.5	0.01
	800	37.0	102.6	7.4	1.79	33.7	98.9	4.5	0.67	30.5	95.2	3.0	0.32	27.2	91.3	2.2	0.16	23.3	86.9	1.6	0.09	11.3	73.1	0.6	0.01
	1000	41.1	97.9	8.2	2.20	37.4	94.5	5.0	0.83	33.8	91.1	3.4	0.39	30.1	87.8	2.4	0.20	26.1	84.0	1.7	0.11	11.8	70.8	0.6	0.01
36	900	52.0	113.3	10.4	3.72	48.8	109.9	6.5	1.49	45.5	106.6	4.5	0.75	42.3	103.4	3.4	0.42	39.1	100.0	2.6	0.25	31.3	92.0	1.6	0.10
	1200	60.2	106.2	12.0	4.95	56.3	103.3	7.5	1.97	52.5	100.3	5.2	0.98	48.7	97.4	3.9	0.55	44.9	94.5	3.0	0.33	36.6	88.1	1.8	0.13
	1500	67.0	101.2	13.4	6.10	62.6	98.5	8.3	2.42	58.3	95.8	5.8	1.21	54.0	93.2	4.3	0.68	49.8	90.6	3.3	0.40	41.0	85.2	2.0	0.16
54	1350	75.5	111.5	15.1	3.31	70.7	108.3	9.4	1.33	66.0	105.1	6.6	0.67	61.3	101.9	4.9	0.38	56.6	98.7	3.8	0.23	45.5	91.1	2.3	0.09
	1800	87.1	104.6	17.4	4.37	81.5	101.7	10.8	1.75	76.0	98.9	7.6	0.88	70.5	96.1	5.6	0.49	65.0	93.3	4.3	0.30	53.1	87.2	2.7	0.12
	2250	96.8	99.7	19.3	5.37	90.5	97.1	12.0	2.14	84.2	94.5	8.4	1.07	78.1	92.0	6.2	0.60	71.9	89.5	4.8	0.36	59.3	84.3	3.0	0.14
72	1800	99.0	110.7	19.8	5.88	93.5	107.9	12.5	2.40	88.1	105.1	8.8	1.23	82.6	102.3	6.6	0.71	77.2	99.5	5.1	0.44	66.2	93.9	3.3	0.19
	2400	114.2	103.9	22.8	7.75	107.7	101.4	14.3	3.15	101.3	98.9	10.1	1.61	94.9	96.5	7.6	0.92	88.5	94.0	5.9	0.57	76.3	89.3	3.8	0.25
	3000	126.8	99.0	25.3	9.50	119.4	96.7	15.9	3.86	112.2	94.5	11.2	1.96	105.1	92.3	8.4	1.12	97.9	90.1	6.5	0.69	84.5	86.0	4.2	0.30
90	2250	125.5	111.4	25.1	7.14	118.5	108.6	15.8	2.90	111.6	105.7	11.2	1.48	104.8	102.9	8.4	0.85	97.9	100.1	6.5	0.52	83.9	94.4	4.2	0.22
	3000	144.8	104.5	28.9	9.44	136.6	102.0	18.2	3.82	128.5	99.5	12.8	1.94	120.4	97.0	9.6	1.11	112.3	94.5	7.5	0.68	96.8	89.8	4.8	0.29
	3750	160.9	99.6	32.1	11.60	151.6	97.3	20.2	4.68	142.5	95.0	14.2	2.37	133.4	92.8	10.7	1.35	124.3	90.6	8.3	0.83	107.2	86.4	5.4	0.36

**Table PD-22. Two-Row Hot Water Heating Coil, EAT = 60°F and EWT= 180°F**

Unit Size		Water Temperature Drop, ΔT																							
		10°F				15°F				20°F				25°F				30°F				40°F			
		airflow	tc	lat	gpm	wpd	tc	lat	gpm	wpd	tc	lat	gpm	wpd	tc	lat	gpm	wpd	tc	lat	gpm	wpd	tc	lat	gpm
12	300	24.6	135.7	4.9	2.2	23.3	131.7	3.1	0.9	22.0	127.7	2.2	0.5	20.7	123.6	1.7	0.3	19.3	119.2	1.3	0.2	15.8	108.5	0.8	0.1
	400	29.9	128.9	6.0	3.2	28.3	125.1	3.8	1.3	26.6	121.3	2.7	0.7	24.9	117.4	2.0	0.4	23.2	113.4	1.5	0.2	19.1	104.1	1.0	0.1
	500	34.3	123.3	6.9	4.2	32.4	119.7	4.3	1.7	30.4	116.0	3.0	0.9	28.4	112.4	2.3	0.5	26.4	108.7	1.8	0.3	21.8	100.3	1.1	0.1
18	450	35.4	132.5	7.1	4.6	33.8	129.2	4.5	1.9	32.1	125.7	3.2	1.0	30.4	122.3	2.4	0.6	28.6	118.7	1.9	0.4	24.8	110.8	1.2	0.2
	600	42.5	125.4	8.5	6.6	40.4	122.1	5.4	2.7	38.3	118.9	3.8	1.4	36.2	115.6	2.9	0.8	34.0	112.3	2.3	0.5	29.5	105.3	1.5	0.2
	750	48.3	119.4	9.7	8.4	45.9	116.4	6.1	3.5	43.4	113.4	4.3	1.8	40.9	110.3	3.3	1.0	38.4	107.2	2.6	0.7	33.2	100.8	1.7	0.3
24	600	50.5	137.6	10.1	3.9	48.3	134.2	6.4	1.6	46.0	130.6	4.6	0.9	43.6	127.0	3.5	0.5	41.2	123.3	2.7	0.3	35.6	114.7	1.8	0.1
	800	61.6	131.0	12.3	5.7	58.7	127.6	7.8	2.4	55.7	124.2	5.6	1.2	52.8	120.8	4.2	0.7	49.7	117.3	3.3	0.5	43.1	109.6	2.2	0.2
	1000	70.9	125.4	14.2	7.5	67.4	122.1	9.0	3.1	63.9	118.9	6.4	1.6	60.3	115.6	4.8	0.9	56.7	112.3	3.8	0.6	49.2	105.3	2.5	0.3
36	900	78.8	140.7	15.7	10.2	76.1	138.0	10.1	4.4	73.5	135.3	7.3	2.4	70.7	132.4	5.7	1.4	67.9	129.5	4.5	0.9	61.9	123.4	3.1	0.5
	1200	96.6	134.2	19.3	15.0	93.1	131.6	12.4	6.4	89.6	128.9	9.0	3.4	86.1	126.1	6.9	2.1	82.4	123.3	5.5	1.4	74.9	117.5	3.7	0.7
	1500	111.6	128.6	22.3	19.9	107.5	126.1	14.3	8.5	103.3	123.5	10.3	4.5	99.0	120.9	7.9	2.7	94.7	118.2	6.3	1.8	85.7	112.7	4.3	0.8
54	1350	111.9	136.5	22.4	2.5	106.1	132.5	14.1	1.0	100.2	128.5	10.0	0.5	94.2	124.3	7.5	0.3	87.3	119.7	5.8	0.2	68.1	106.5	3.4	0.1
	1800	136.3	129.8	27.2	3.6	128.8	126.0	17.2	1.5	121.3	122.2	12.1	0.8	113.7	118.2	9.1	0.5	105.7	114.2	7.0	0.3	84.9	103.5	4.2	0.1
	2250	156.7	124.2	31.3	4.8	147.8	120.6	19.7	2.0	138.9	116.9	13.9	1.0	129.8	113.2	10.4	0.6	120.6	109.4	8.0	0.4	98.2	100.3	4.9	0.1
72	1800	148.6	136.1	29.7	4.6	141.9	132.7	18.9	2.0	135.0	129.2	13.5	1.0	128.1	125.6	10.2	0.6	120.9	121.9	8.1	0.4	103.6	113.1	5.2	0.2
	2400	180.3	129.3	36.0	6.7	171.7	126.0	22.9	2.8	163.0	122.6	16.3	1.5	154.2	119.2	12.3	0.9	145.2	115.8	9.7	0.6	125.4	108.2	6.3	0.2
	3000	206.7	123.5	41.3	8.7	196.4	120.4	26.2	3.6	186.1	117.2	18.6	1.9	175.7	114.0	14.0	1.1	165.1	110.7	11.0	0.7	142.8	103.9	7.1	0.3
90	2250	187.3	136.7	37.4	6.1	178.8	133.3	23.8	2.5	170.3	129.8	17.0	1.3	161.5	126.2	12.9	0.8	152.5	122.5	10.2	0.5	130.5	113.5	6.5	0.2
	3000	227.7	130.0	45.5	8.9	216.8	126.6	28.9	3.7	205.9	123.3	20.6	1.9	194.8	119.9	15.6	1.1	183.5	116.4	12.2	0.7	158.4	108.7	7.9	0.3
	3750	261.4	124.3	52.2	11.6	248.5	121.1	33.1	4.8	235.5	117.9	23.5	2.5	223.3	114.7	17.8	1.4	209.0	111.4	13.9	0.9	180.8	104.4	9.0	0.4

EAT = entering air temperature  
 EWT = entering water temperature  
 tc = total capacity MBH  
 lat = leaving air temperature  
 gpm = gallons per minute, waterflow  
 wpd = water pressure drop, feet of water  
 Notes:

- Capacities calculated with 0.00025 fouling factor.
- Lat must be less than 130°F to avoid overheating the motor.

Do not operate at this condition, lat > 130°F. Data shown only to allow performance calculations.



# Electrical Data

## Minimum Circuit Ampacity (MCA) and Maximum Fuse Size (MFS) Calculations for Units with Electric Heat

Heater amps = (heater kW x 1000)/  
heater voltage

**Note:** Use 120V heater voltage for 115V units. Use 240V heater voltage for 230V units. Use 480V heater voltage for 460V units. Use 600V heater voltage for 575V units.

MCA = 1.25 x (heater amps + all motor FLA's)

MFS or HACR type circuit breaker =  
(2.25 x largest motor FLA) + second  
motor FLA

+ heater amps (if applicable)

HACR (Heating, Air-Conditioning and Refrigeration) type circuit breakers are required in the branch circuit wiring for all units with electric heat.

See Table ED-3 on page 60 for motor FLA's.

Select a standard fuse size or HACR type circuit breaker equal to the MCA.

Use the next larger standard size if the MCA does not equal a standard size.

Standard fuse sizes are: 15, 20, 25, 30, 35, 40, 45, 50, 60 amps

### Useful Formulas

kW = (cfm x ΔT)/3145

ΔT = (kW x 1000)/voltage

Single phase amps = (kW x 1000)/voltage

Three phase amps = (kW x 1000)/(voltage x 1.73)

Electric heat MBh = (Heater kW) (3.413)

**Table ED-1. Available Electric Heat Kw (min.-max)**

Voltage	Unit Size						
	12	18	24	36	54	72	90
115/60/1	1-3	1-3	1-3	1-3	1-3	1-3	1-3
208/60/1	1-4	1-6	1-8	1-8	1-8	1-8	1-8
230/60/1	1-4	1-6	1-8	1-8	1-8	1-8	1-8
277/60/1	1-4	1-6	1-8	1-11	1-11	1-11	1-11
208/60/3	1-4	1-6	1-8	1-11	1-12	1-12	1-12
230/60/3	1-4	1-6	1-8	1-11	1-12	1-12	1-12
460/60/3	1.5-4	1.5-5	1-8	1-11	1-16	1-21	1-30
575/60/3	2-4	2-4	1-8	1-11	1-16	1-21	1-30
220/50/1	1-4	1-6	1-8	1-8	1-8	1-8	1-8
240/50/1	1-4	1-6	1-8	1-8	1-8	1-8	1-8
380/50/3	1-4	1-5	1-8	1-11	1-16	1-20	1-28
415/50/3	1.5-4	1.5-5	1-8	1-11	1-16	1-21	1-30
190/50/3	na	na	na	na	na	na	na

### Notes:

1. Heaters are available in the following Kw increments : 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 24.0, 26.0, 28.0, 30.0.
2. Magnetic contactors are standard. Mercury contactors are available on horizontal units only.
3. Units with electric heat are available with or without door interlocking disconnect switch.
4. Units with electric heat are available with or without line fuses.
5. Units with electric heat must not be run below the minimum cfm listed in the general data section.
6. Electric heat is balanced staging: 1 stage = 100%, 2 stages = 50%/50%
7. Electric heat is not available on 190/50/3 units.

**Table ED-2. Available Motor Horsepower**

Motor	unit voltage	Motor Horsepower						
		0.33	0.50	0.75	1.00	1.50	2.00	3.00
two speed 60 hz	115/60/1			•	•			
	115/1	•	•	•	•			
	208/1	•	•	•	•			
	230/1	•	•	•	•			
	277/1	•	•	•	•			
	208/3		•	•	•	•	•	•
	230/3		•	•	•	•	•	•
	460/3		•	•	•	•	•	•
	575/3			•	•	•	•	•
	575/3			•	•	•	•	•
50 hz	220/1	•	•	•	•			
	240/1	•	•	•	•			
	380/3	•	•	•	•	•	•	
	415/3	•	•	•	•	•	•	
	415/3	•	•	•	•	•	•	
	190/3	•	•	•	•	•	•	

# Electrical Data

**Table ED-3. Motor Electrical Data**

Voltage	voltage range	rpm	rated hp	lbs.	fla	lra
115/60/1	104-126	1750	1/3	18	5.8	22.8
			1/2	21	7.2	30.4
			3/4	29	12.0	58.4
			1.0	29	12.8	58.4
two-speed						
115/60/1	104-126	1750/1160	3/4	40	8.9/6.1	42.0
			1.0	41	11.5/8.1	58.2
208-230/60/1	187-253	1750	1/3	18	3.1	11.4
			1/2	21	3.6	15.2
			3/4	29	6.0	29.2
			1.0	29	6.4	29.2
277/60/1	249-305	1750	1/3	15.5	2.5	12.1
			1/2	21.5	3.6	19.3
			3/4	25	4.3	25.3
			1.0	29	5.6	32.6
208/60/3	187-229	1750	1/2	22	2.3	11.4
			3/4	26	2.9	15.9
			1.0	28	3.5	20.2
			1.5	29	4.8	30.0
			2.0	34	6.2	38.5
			3.0	49	8.6	55.1
230/60/3	207-253	1750	1/2	22	2.4	12.8
			3/4	26	3.0	18.6
			1.0	28	3.6	23.0
			1.5	29	4.8	33.4
			2.0	34	6.2	43.6
			3.0	49	8.6	62.0
460/60/3	414-506	1750	1/2	22	1.2	6.4
			3/4	26	1.5	9.3
			1.0	28	1.8	11.5
			1.5	29	2.4	16.7
			2.0	34	3.1	21.8
			3.0	49	4.3	31.0
575/60/3	518-632	1750	3/4	20.5	1.1	7.5
			1.0	22.5	1.4	9.0
			1.5	31	1.9	13.3
			2.0	36	2.5	17.9
			3.0	49	3.3	23.7
220/50/1	198-242	1450	1/3	20.5	3.0	15.6
			1/2	25	3.6	20.5
			3/4	29	5.2	25.6
			1.0	38	9.3	52.2
240/50/1	216-264	1450	1/3	20.5	3.3	17.1
			1/2	25	4.0	22.7
			3/4	29	5.5	39.1
			1.0	38	10.6	57.8
190/50/3	171-209	1450	1/3	22	1.1	5.6
380/50/3	342-418		1/2	26	1.4	7.8
3/4	28		1.7	9.8		
1.0	29		2.1	14.6		
1.5	34		2.8	18.7		
2.0	49	3.6	27.2			
415/50/3	374-456	1450	1/3	22	1.2	6.8
			1/2	26	1.5	9.4
			3/4	28	1.9	11.0
			1.0	29	2.5	17.4
			1.5	34	3.1	22.6
			2.0	49	3.6	32.3

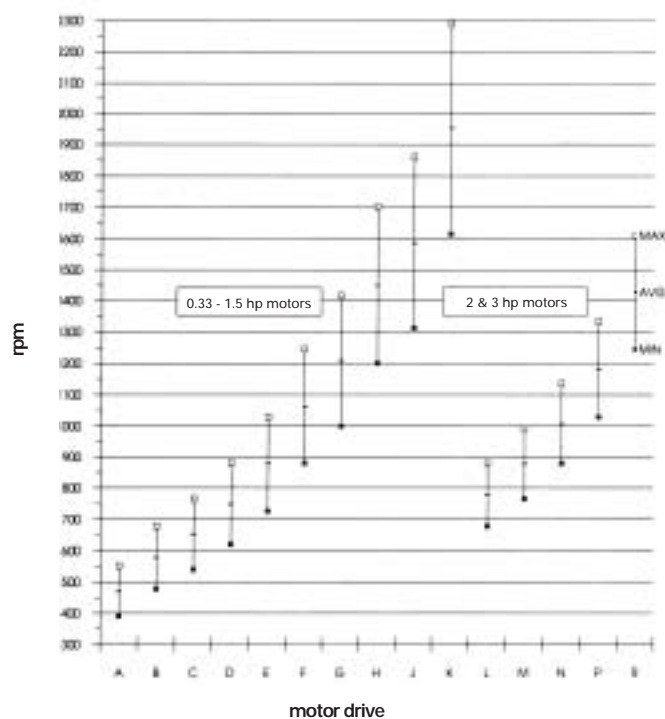
# Electrical Data

**Table ED-4. Motor Drive Selections**

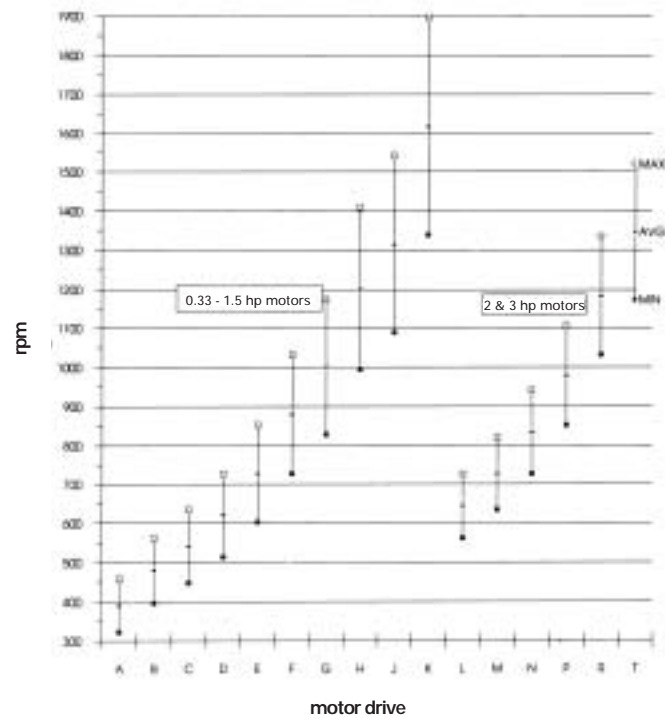
Unit Size	drive	0.33	0.50	0.75	motor horsepower			
12, 18	D - H	■	■	■	■			
	J	■	■	■	■			
	K	○	■	■	■			
24, 36	A-F	■	■	■	■	■		
	G	○	■	■	■	■		
	H		○	■	■	■		
	J		○	■	■	■		
	K			○	○	○		
54, 72, 90	A-D	■	■	■	■	■		
	E	■	■	■	■	■		
	F	○	○	○	■	■		
	G		○	○	■	■		
	H			○	○	○		
	J					○		
	L-R						■	■
	T						○	○

■ Valid for 50 and 60 hz motors.  
○ Valid for 50 hz motors only.

**Chart ED-1. Size 012-090 Drives, 60 Hz Motors**



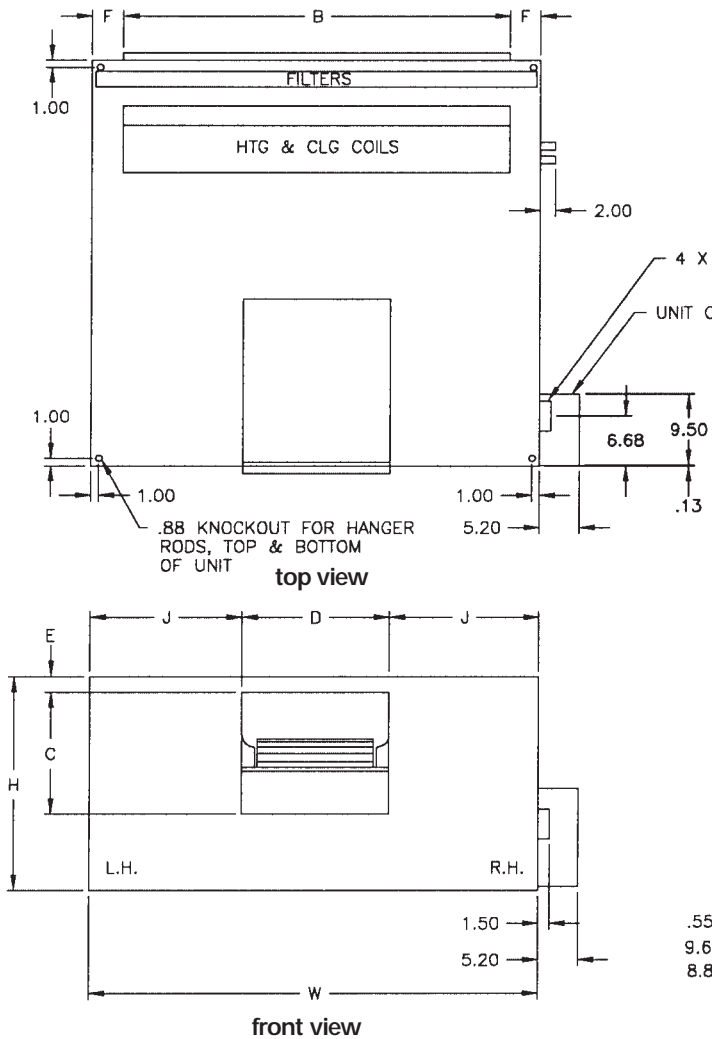
**Chart ED-2. Size 012-090 Drives, 50 Hz Motors**



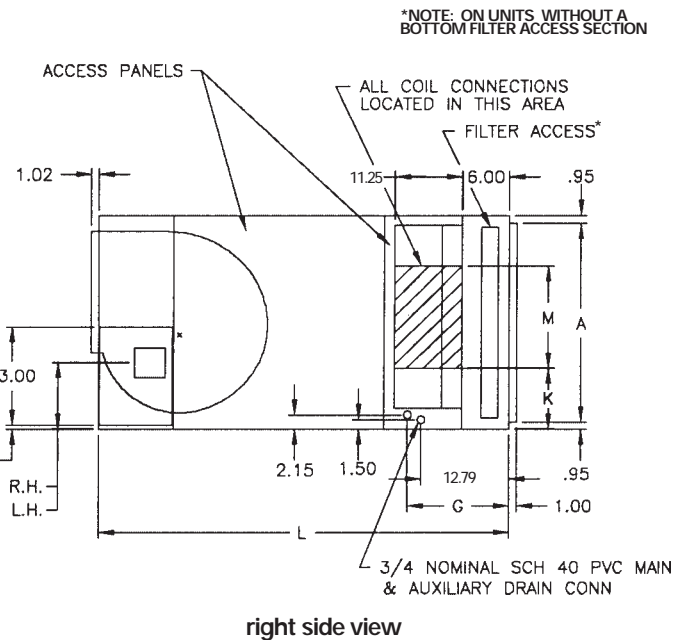


# Dimensions and Weights

## Horizontal Blower Coil



NOTES: ALL DIMENSIONS ARE IN INCHES.  
 ALL COIL CONNECTIONS ARE SWEAT STYLE.  
 WEIGHT OF BASIC UNIT INCLUDES CABINET, FAN, AVERAGE DRIVE, WIRING AND AVERAGE FILTER. IT DOES NOT INCLUDE COIL, MOTOR OR SHIPPING PACKAGE. PLEASE REFER TO CATALOG FOR MOTOR WEIGHTS.  
 \*ADD TO BASIC UNIT WEIGHT, 9 LBS FOR WEIGHT OF CONTROL BOX.  
 4 X 4 JUNCTION BOX OR CONTROL BOX FACTORY MOUNTED ON DRIVE SIDE.



Horizontal Blower Coil Unit Dimensions and Weights, in-lbs.

Unit Size	H	W	L	A	B	C	D	E	F	G (RH)	G (LH)	J	K	M	unit weight
12	14.00	24.00	40.75	12.09	18.00	10.56	7.09	0.55	3.00	10.79	14.79	8.46	2.82	6.80	71.5
18	14.00	28.00	40.75	12.09	22.00	10.56	7.09	0.55	3.00	10.79	14.79	10.46	2.82	6.80	77.4
24	18.00	28.00	46.00	16.09	22.00	13.56	12.56	1.30	3.00	10.79	14.79	7.72	3.58	9.00	104.1
36	18.00	40.00	46.00	16.09	34.00	13.56	12.56	1.30	3.00	10.79	14.79	13.72	3.57	9.00	121.6
54	22.00	40.00	49.00	20.09	34.00	13.56	12.56	0.72	3.00	10.79	14.79	13.72	4.21	10.43	138.9
72	22.00	48.00	49.00	20.09	40.00	13.56	12.56	0.72	4.00	10.79	14.79	17.72	4.18	10.43	152.2
90	28.00	48.00	52.00	26.09	40.00	13.56	12.56	1.66	4.00	10.79	14.79	17.72	4.81	15.61	174.8

# **Outreach Innovation Building**

Penn State Research Park  
State College, PA.

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## **Appendix G**

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### **Pump Data and Schematics**

# Outreach Innovation Building

Penn State Research Park  
State College, PA.

ESP-PLUS ON-LINE

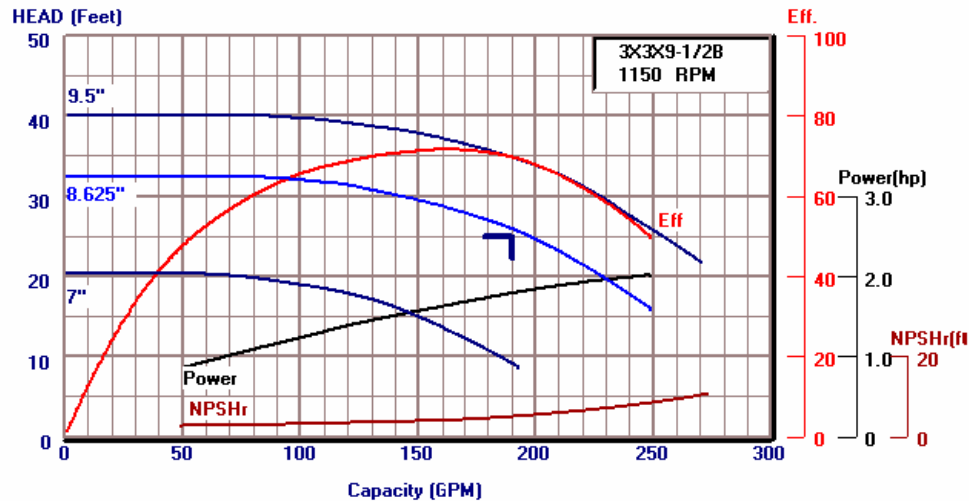
Page 1 of 2

**Bell & Gossett**



ITT Industries

Curve Generation  
Version C1.18



Pump Series: 80  
Suction Size = 3 "  
Discharge Size = 3 "

Min Imp Dia = 7 "  
Max Imp Dia = 9.5 "  
Cut Dia = 8.625 "

Design Capacity = 190.0  
Design Head = 25.0  
Motor Size = 2 HP

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

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

## 80 3X3X9-1/2B

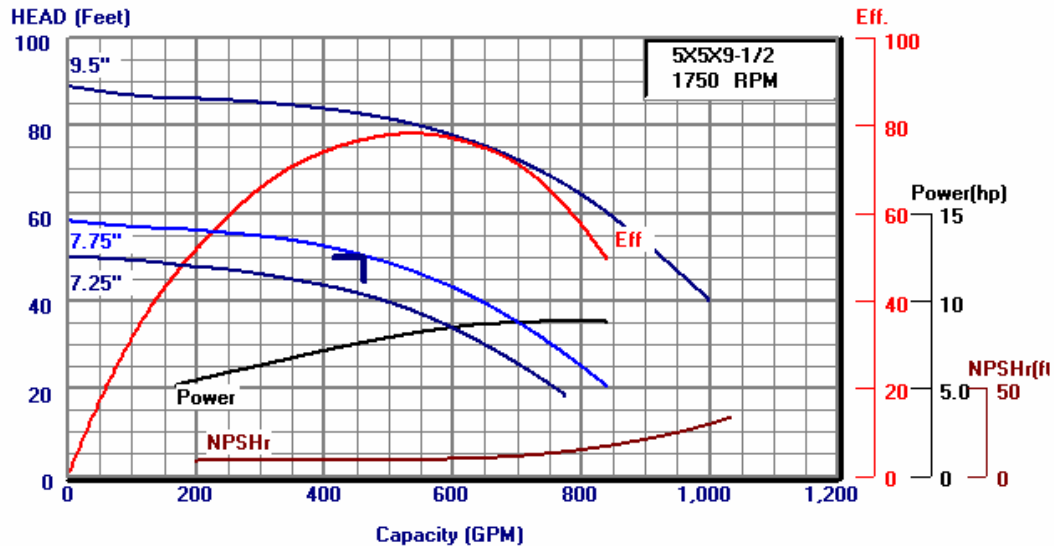
Flow Rate (GPM)	190	Pump Head (Feet)	25
Speed (RPM)	1150	NPSHr (Feet)	5.0
Weight (lbs)	**	Cost Index	**
Suction Size (in.)	3	Suction Velocity (fps)	8.2
Discharge Size (in.)	3	Discharge Velocity (fps)	8.2
Impeller Size (in.)	8.625	Pump Efficiency (%)	68.20
Max. Flow (GPM)	245	Duty Flow/Max Flow (%)	77.7
Flow @ BEP (GPM)	155	Min. Rec. Flow (GPM)	38.9
Selected Motor Size (HP)	2	Selected Motor Size (kw)	1.49
Duty-Point Power (BHP)	1.76	Duty-Point Power (kw)	1.32
Maximum Power (BHP)	2.00	Maximum Power (kw)	1.49
Est. Full Load Amps	**	Est. Full Load Efficiency (%)	**
Frame Size	**	Est. Full Load Power Factor (%)	**

[View Published Pump Curve](#)

[Download CAD Drawing](#)

# Outreach Innovation Building

Penn State Research Park  
State College, PA.



Pump Series: 80  
Suction Size = 5 "  
Discharge Size = 5 "

Min Imp Dia = 7.25 "  
Max Imp Dia = 9.5 "  
Cut Dia = 7.75 "

Design Capacity = 460.0  
Design Head = 50.0  
Motor Size = 10 HP

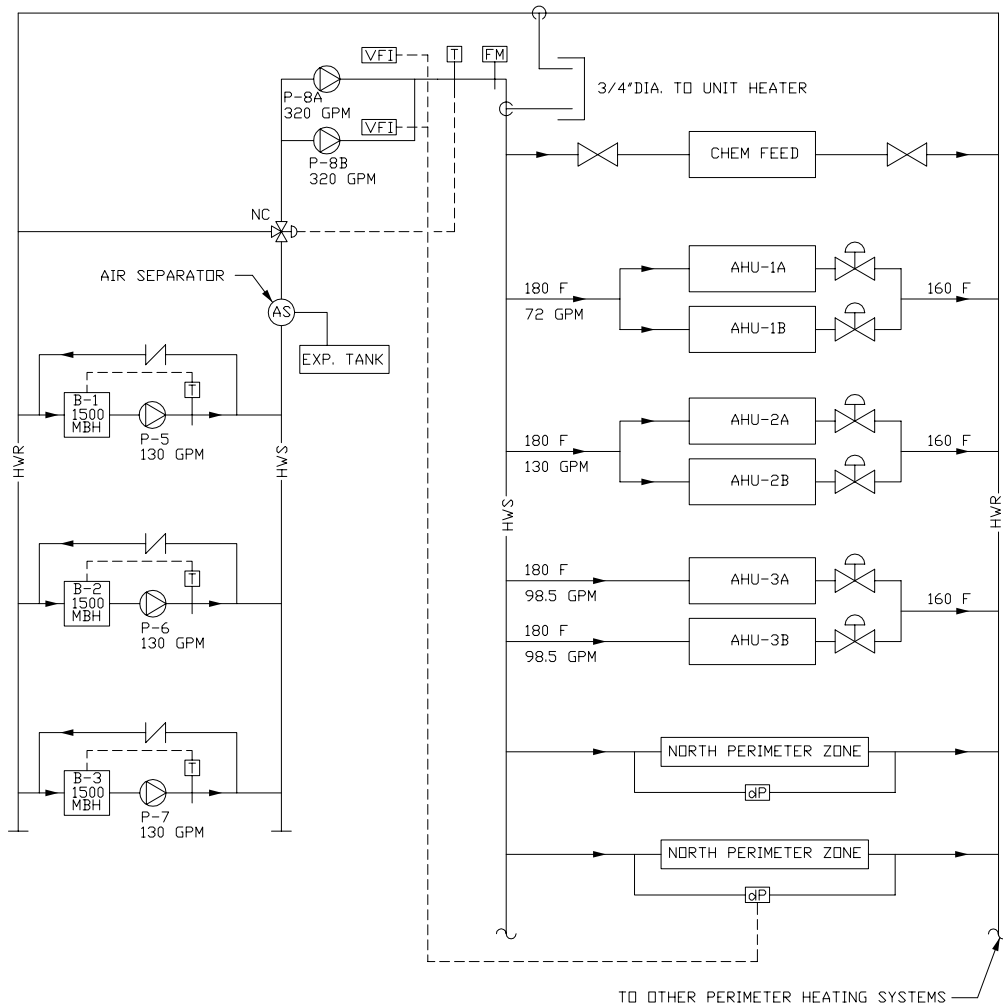
ITT Bell & Gossett  
8200 N. Austin  
Morton Grove, IL 60053

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

80 5X5X9-1/2			
Flow Rate (GPM)	460	Pump Head (Feet)	50
Speed (RPM)	1750	NPSHr (Feet)	9.2
Weight (lbs)	**	Cost Index	**
Suction Size (in.)	5	Suction Velocity (fps)	7.4
Discharge Size (in.)	5	Discharge Velocity (fps)	7.4
Impeller Size (in.)	7.75	Pump Efficiency (%)	75.95
Max. Flow (GPM)	835	Duty Flow/Max Flow (%)	55.1
Flow @ BEP (GPM)	518	Min. Rec. Flow (GPM)	129.6
Selected Motor Size (HP)	10	Selected Motor Size (kw)	7.46
Duty-Point Power (BHP)	7.63	Duty-Point Power (kw)	5.69
Maximum Power (BHP)	8.90	Maximum Power (kw)	6.63
Est. Full Load Amps	**	Est. Full Load Efficiency (%)	**
Frame Size	**	Est. Full Load Power Factor (%)	**
<a href="#">View Published Pump Curve</a>		<a href="#">Download CAD Drawing</a>	

# Outreach Innovation Building

Penn State Research Park  
State College, PA.

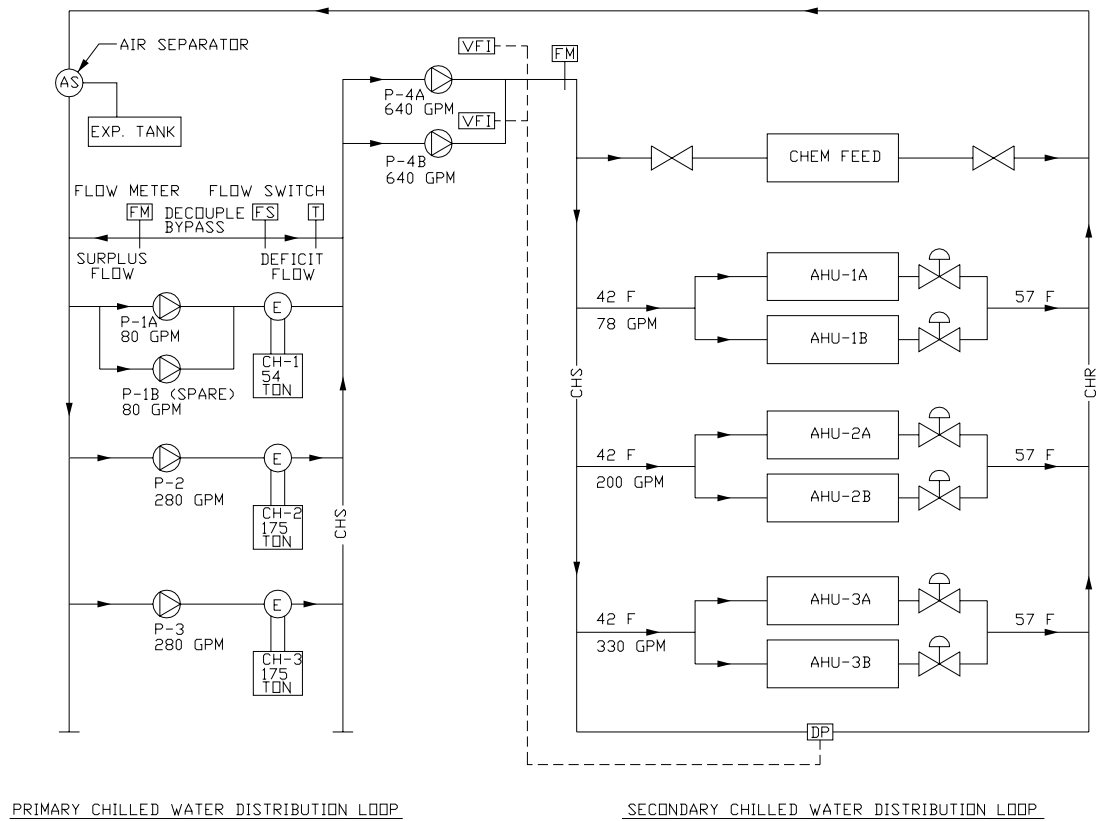


HEATING HOT WATER DIAGRAM



# Outreach Innovation Building

Penn State Research Park  
State College, PA.



CHILLED WATER DIAGRAM

# **Outreach Innovation Building**

Penn State Research Park  
State College, PA.

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## **Appendix H**

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### **Cost Analysis**

## Outreach Innovation Building

Penn State Research Park  
State College, PA.

Mechanical Equipment Cost Analysis						
Unit	Size		Quantity	Cost/Unit	Total Cost	
New Chiller	120 ton		2	95000	190000	<div>New Cost</div> <div>448850</div>
New AHU	77 ton	11500 cfm	1	7275	7275	
New P-1	2 Hp		2	2650	5300	
New P-2	12 Hp		2	3425	6850	
Enthalpy Wheel		11500 cfm	1	11000	11000	
Fan Coils	12-2	5 ton	16	5825	93200	
	12-4	8 ton	4	7000	28000	
	12-6	10 ton	11	7475	82225	
Pipe Cost					25000	
Old Chiller	220 ton		2	155000	310000	<div>Old Cost</div> <div>388650</div>
Old P-2&3	5 Hp		2	2875	5750	
Old P-4A&B	15 Hp		2	4450	8900	
Old AHU 2A&B	64 ton	17500	2	11000	22000	
Old AHU 3A&B	81.2 ton	35000	2	21000	42000	

# **Outreach Innovation Building**

Penn State Research Park  
State College, PA.

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## **Appendix I**

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### **Fire Protection Data**

## Outreach Innovation Building

Penn State Research Park  
State College, PA.

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Table FP-1	HFC-227ea
Chemical Name	Heptafluoropropane
Formula	C3F7H
Molecular Weight	170.3
Boiling Point @760 mmHG	2.6
Freezing Point	-204
Critical Temp	215
Critical Pressure	422
Critical Volume	0.0258
Critical Density	38.76
Specific Heat, Liq @77F	0.2831
Specific Heat, Vap @ 77F	0.1932
Heat of Vap @BP@25C	57
Thermal Conductivity of Liq @77F	0.04
Viscosity of Liq @ 77F	0.443
Relative Dielectric Strength @ 1atm 77F	2
Solubility of Water in agent @ 70F	0.06% by weight
Vapor Pressure @ 77F	66.4
Agent Vapor Density @ 70F	0.453 lb/ft <sup>3</sup>
Design Concentration	8% - 10.8%

Table FP-2					
Designation	NOAEL % V/V*	LOAEL % V/V*	LC50 or ALC	ODP	MEC
HFC-227ea	9%	>10.5%	>80%	0	7%

ALC = Allowable Lethal Concentration

ODP = Ozone Depletion Potential

MEC = Minimum Extinguishing Concentration

Table FP-3 for HFC-227ea			
Deg F		Deg C	
k1	k2	k1	k2
1.885	0.0046	0.1269	0.0005



## HFC-227ea

### APPLICATION/DESCRIPTION

HFC-227ea provides superior fire protection in a wide range of applications from sensitive electrical equipment to industrial applications using flammable liquids. HFC-227ea is ideal for applications where clean-up of other media presents a problem, where weight versus suppression potential is a factor, where an electrically non-conductive medium is needed and where people compatibility is an overriding factor. When environmental impact is a consideration, HFC-227ea is particularly useful. It has zero ozone-depleting potential, low global warming potential and a short atmospheric lifetime. These characteristics make it suitable not only for new installations using Fike's total flooding systems, but also for Halon 301 replacement applications.

HFC-227ea is an odorless, colorless, liquefied compressed gas. (See Physical Properties Table for additional information). It is stored as a liquid and dispensed into the hazard as a colorless, electrically non-conductive vapor that is clear and does not obscure vision. It leaves no residue and has acceptable toxicity for use in occupied spaces at design concentration. HFC-227ea extinguishes a fire by a combination of chemical and physical mechanisms. HFC-227ea does not displace oxygen and therefore is safe for use in occupied spaces without fear of oxygen deprivation.

### Performance

HFC-227ea is an effective fire extinguishing agent that can be used on many types of fires. It is effective for many surface fires, such as flammable liquids, and most solid combustible materials.

On a weight-of-agent basis, HFC-227ea is a very effective gaseous extinguishing agent. The HFC-227ea extinguishing concentration for normal Class A combustibles is 6.25 - 7% by volume. The minimum design concentration for total flood applications should be in accordance with NFPA 2001.

### Specifications

HFC-227ea is manufactured to these specifications:

- Mole%: 99.0 Minimum
- Acidity, ppm by weight 3.0: Maximum
- Water content, % by weight: 0.001 Maximum
- Non-volatile residues, gram/100mL: 0.05 Maximum

### Toxicity

The toxicology of HFC-227ea compares favorably with other suppression agents. The LC50 of HFC-227ea is greater than 800,000 ppm. HFC-227ea has been evaluated for cardiac sensitization via test protocols approved by the United States Environmental Protection Agency. Test results show that cardiac tolerance to HFC-227ea is higher than that of other suppression agents and is acceptable for safe use in occupied spaces. HFC-227ea will decompose to form halogen acids when exposed to open flames. The formation of these acids is minimized by using Fike early warning detection systems and proper system installation. When properly applied and installed, the generation of these by-products by HFC-227ea should be minimal.

### APPROVALS

HFC-227ea complies with NFPA Standard 2001 - current edition. Fike HFC-227ea systems are U.L. listed and FM approved for Clean Agent Fire Suppression Systems.

- UL Listed Ex 4623
- FM Approved 0Y4A8.AF
- USCG 162.161/2/0

## PHYSICAL PROPERTIES

- Chemical Name: Heptafluoropropane ( $\text{CF}_3\text{CHF}\text{CF}_3$ )
- Molecular Weight: 170.03
- Boiling Point @ 760 mm Hg: 2.55°F (-16.4°C)
- Freezing Point : -204°F (-131.1°C)
- Critical Temperature: 215°F (101.7°C)
- Critical Pressure (psia): 422 psia (2912 kPa)
- Critical Volume (ft<sup>3</sup>/lbm) (cc/mole): 0.0258 (274)
- Critical Density (lbm/ft<sup>3</sup>): 38.8 (621 kg/m<sup>3</sup>)
- Specific Heat, Liquid (BTU/lb-F°) @ 77°F (25°C): 0.283 (1.184 kJ/kg/°C)
- Specific Heat, Vapor (BTU/lb-°F) @ constant pressure of 1 ATM @ 77°F (25°C): 0.1932 (0.808 kJ/kg/°C)
- Heat at Vaporization (BTU/lb) at Boiling Point: 57.0 (132.6 kJ/kg)
- Thermal Conductivity (BTU/h ft°F) of Liquid @ 77°F (25°C): 0.040 (0.069 W/m°C)
- Viscosity, Liquid (lb/ft hr) @ 77°F (25°C): 0.443 (0.184 centipoise)
- Vapor Pressure (psia) @ 77°F (25°C): 66.4 (457.7 kPa)
- Ozone Depletion Potential: 0
- Estimated Atmospheric Lifetime (years): 31-42
- LC50 (Rats; 4hrs - ppm): >800,000





## HFC-227<sub>EA</sub> AGENT STORAGE CONTAINERS

### DESCRIPTION

Fike Series 70 Clean Agent Containers are used in fire extinguishing systems to store the Clean Agent until a fire develops and the agent must be released. The Clean Agent is retained in the container by a valve assembly which contains a fast acting rupture disc. The disc will be ruptured, and the Clean Agent released, through two methods: (1) Operation of an actuator by an electric signal that is automatically or manually controlled; (2) When the contained Clean Agent reaches an internal temperature range of 160 to 187°F (71.1 to 86.1°C), it will create sufficient internal pressure to burst the rupture disc and release the Clean Agent. The valve, which contains the rupture disc and actuator, is available in three sizes: 1" (25mm), 2 1/2" (65mm) and 3" (80mm). The 1" (25mm) valve is used on the 10 (4), 20 (8), 35 (15), 60 (27), and 100 pound (44 L) containers; the 2 1/2" (65mm) valve is used on the 125i (51 L) and 215i pound (90 L) containers; the 3" (80mm) valve is used on the 215 (87), 375 (153), 650 (267) and 1000 pound (423 L) containers. After a discharge, the valve is field reconditioned by simply replacing three components.

Fike Series 70 Clean Agent Containers have passed extensive testing by Underwriters Laboratories and Factory Mutual and are used in installations where 8 to 1045 pounds (3.5 to 474 kg) of HFC-227<sub>ea</sub> is required. To eliminate the need of multiple containers, or using more Clean Agent than necessary, these containers can be filled in 1 pound (0.5 kg) increments to their maximum capacity.

Each container for HFC-227<sub>ea</sub> Clean Agent Systems is super pressurized with dry nitrogen to 360 psig (25 bar), at 70° F (21° C), to provide a quick and effective discharge in 10 seconds or less.

Fike Series 70 Clean Agent Containers are supplied with a pressure gauge that permits a quick, visual, inspection of container pressure. Optional items include a Liquid Level Indicator, and a Low Pressure Supervisory Switch. The Liquid Level indicator provides the convenience of determining the container's agent weight without removing it from its installed location. The Low Pressure Supervisory Switch provides constant monitoring of the container's internal pressure. It is available in two styles; normally opened and normally closed contacts. In the event of a decrease in container internal pressure from 360 psig to 288 psig (24.8 bar to 18.8 bar), the Supervisory Switch normally opened/closed contacts will close/open. This will cause a supervisory trouble alarm at the system control panel.

Fike Series 70 Clean Agent Containers are available for installation in the upright, inverted or horizontal positions, depending upon the user's particular needs and the type and size container specified. The mounting location of the container is quite flexible. It can be mounted at the exact point of discharge or at a remote location by adding distribution piping from the container to the nozzle system. (Refer to the Fike Design, Installation and Maintenance Manual - P/N 06-215). The operating temperature range is +32 to +130°F (0 to 54.4°C) in any installation.

The Fike Series 70 Clean Agent Containers can be used in a pre-engineered system, utilizing a balanced piping configuration(s); an engineered system, utilizing unbalanced piping configurations, or a combination of both designs. For assistance, consult your local Fike Distributor or Fike Corporation.

*Continued next page.*



*Series 70 Clean Agent Containers*

### APPROVALS

- U.L. Listed, Ex4623
- FM Approved 0Y4AB.AF (HFC-227<sub>ea</sub>)



## DESCRIPTION (Cont.)

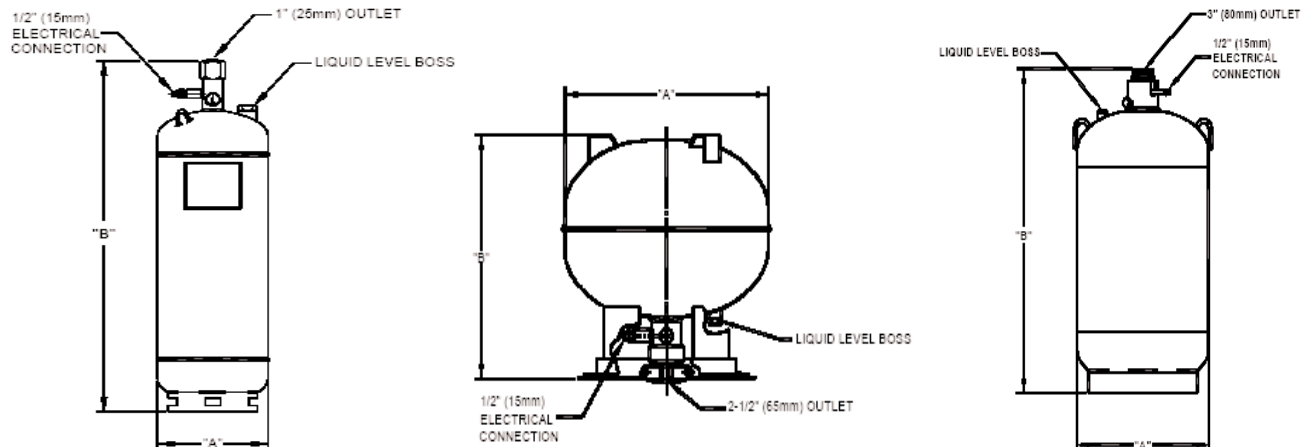
### Reliability

Fike Series 70 Clean Agent Containers are manufactured in strict accordance with Department of Transportation (D.O.T.) regulations. The Fike Series 70 Clean Agent Containers have successfully passed testing by Factory Mutual and Underwriters Laboratories, Inc. Before leaving the factory, each container must pass extensive leakage testing, and pressure testing to 1000 psig (68.9 bar). The containers are constructed from carbon steel alloys and painted with a durable, baked enamel finish.

### Installation

Fike Series 70 Clean Agent Containers are supplied with a mounting bracket that is designed to provide the most effective and versatile installation for that particular container. The 10, 20 and 35 pound (4, 8 and 15 L) container brackets employ two U-bolts for securing the container to the bracket. The 60 pound (27 L) container is secured using two quick connecting, over-center handle clamps. The 125i and 215i pound (51 and 90 L) containers utilize an "L" shaped bracket for direct wall mounting or, with an optional floor mounting kit, can be mounted on a floor in the "valve down" position. The 100 pound (44 L) and 215 pound (87 L) through 1000 pound (423 L) containers are supplied with one or two U-shaped mounting brackets, depending upon container size, for mounting to a wall or other secure surface.

## Container Sizes and Dimensions: U.S. Standard and Metric



U.S. SIZES & DIMENSIONS											
SIZE-LB	10	20	35	60	100	125i	215i	215	375	650	1000
A (in.)	5.5	7.25	7.25	10.75	10.75	20.00	24.00	20.00	20.00	24.00	24.00
B (in.)	19.75	21.50	32.50	28.00	38.75	20.25	23.75	28.87	42.50	48.75	70.00
METRIC SIZES & DIMENSIONS											
SIZE-L	4	8	15	27	44	51	90	87	153	267	423
A (MM)	140	184	184	273	273	508	610	508	508	610	610
B (MM)	502	546	826	711	984	515	605	733	1080	1237	1778

## AVAILABLE MODELS AND SPECIFICATIONS

### CLEAN AGENT STORAGE CONTAINER DATA - U.S. STANDARD

FIKE P/N	SIZE (LB)	VALVE (IN)	EMPTY WT (LB)	HFC-227ea AGENT FILL RANGE (LBS)	VALVE POSITION	D.O.T. REGULATION
70-108	10	1	14	8-10	Horiz. or Upright	4B500
70-098	20	1	35	12-21	Horiz. or Upright	4B500
70-089	35	1	55	22-38	Horiz. or Upright	4B500
70-152	60	1	53	39-68	Horiz. or Upright	4BW500
70-153	100	1	60	63-108	Upright	4BW500
70-041	125i	2 1/2	180	73-126	Inverted	4BA500
70-077	215i	2 1/2	225	128-223	Inverted	4BA500
70-154	215	3	150	124-216	Upright	4BW500
70-155	375	3	218	217-378	Upright	4BW500
70-156	650	3	350	378-660	Upright	4BW500
70-157	1000	3	515	598-1045	Upright	4BW500

### CLEAN AGENT STORAGE CONTAINER DATA - METRIC

FIKE P/N	SIZE (L)	VALVE (MM)	EMPTY WT (KG)	HFC-227ea AGENT FILL RANGE (KG)	VALVE POSITION	D.O.T. REGULATION
70-108	4	25	6.4	4.0-4.5	Horiz. or Upright	4B500
70-098	8	25	16.0	5.5-9.5	Horiz. or Upright	4B500
70-089	15	25	25.0	10.0-17.0	Horiz. or Upright	4B500
70-152	27	25	24.0	18.0-30.5	Horiz. or Upright	4BW500
70-153	44	25	27.0	28.5-48.5	Upright	4BW500
70-041	51	65	82.0	33.5-57.0	Inverted	4BA500
70-077	90	65	103.0	58.5-101.0	Inverted	4BA500
70-154	87	80	68.0	56.5-98.0	Upright	4BW500
70-155	153	80	99.0	98.5-171.5	Upright	4BW500
70-156	267	80	159.0	171.5-299.0	Upright	4BW500
70-157	423	80	234.0	271.5-474.0	Upright	4BW500

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## ARCHITECT AND ENGINEERING SPECIFICATIONS

The Clean Agent shall be stored in Fike Series 70 Clean Agent Storage Containers. The containers shall be capable of being filled, in one pound (0.5kg) increments, to their listed maximum capacity. The Clean Agent container shall be activated by a signal from the control panel which is processed by the Agent Release Module. This module shall store the power required to operate the actuator. The valve shall contain a scored, non-fragmenting, rupture disc to provide an immediate, total discharge of all the agent. HFC-227ea Clean Agent is stored in the container as a liquid, having a natural vapor pressure of 66 psig at 77°F (5 barg at 25°C). To aid in discharge, the container shall be super-pressurized to 360 psig at 70°F (25 bar at 21.1°C) with dry nitrogen. Agent discharge shall be completed in 10 seconds or less.

Clean Agent Storage Containers shall be actuated by either an electrical manual discharge station, an automatic detection device(s) or an increase in internal pressure due to heating the Clean Agent to approximately 160°F (71.1°C). At this temperature, internal pressure will be adequate to burst the rupture disc, discharging the contents of the container. Normal operating temperature shall be +32 to +130°F (0 to 54.4°C) in any installation.

Clean Agent Storage Containers shall be equipped with a pressure gauge to display internal pressure. This gauge shall be an integral part of the container and color coded for fast referencing of pressure readings. A Low Pressure Supervisory Switch shall be made available as an option. A decrease in internal container pressure from 360 psig to 288 psig (24.8 bar to 18.8 bar) shall cause the normally opened/closed Supervisory Switch contacts to close/open, indicating a trouble or supervisory condition at the control panel.

Clean Agent Storage Containers shall be fastened to a wall, or other secure surface, using a one piece mounting bracket that is designed for the most effective and versatile installation of each container.



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Form No. C.1.01.01-1 August, 2004 Specifications are subject to change without notice.

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## HFC-227<sub>EA</sub> ENGINEERED NOZZLES

### DESCRIPTION

The function of the Fike Engineered Discharge Nozzle in a fire extinguishing system is to distribute the Clean Agent in a uniform, predetermined pattern and concentration. The nozzles are designed to complete the discharge of Clean Agent in 10 seconds or less when installed within the design limitations of the Fike Design, Installation and Maintenance Manual, P/N 06-202 or 06-215 and the Fike Flow Calculation computer program.

Fike Engineered Discharge Nozzles are available in sizes of 3/8" (10mm) thru 2" (50mm). Each nozzle is available in 180 and 360 degree discharge patterns.

The Discharge Nozzle size refers to the size of Schedule 40 or 80 steel pipe to which it can be connected. The nozzle discharge orifices are drilled perpendicular to the center line of the threads. The nozzles are mounted to allow the agent to be discharged on a horizontal axis.

Nozzle orifices are available in a wide range of sizes to provide accurate Clean Agent flow results. All nozzles have been tested for their ability to discharge the Clean Agent under extreme conditions.

Nozzle orifice drilling must be done at the Fike factory, or other U.L. listed nozzle drill station, only after "As-Built" calculations of the installed piping system(s) have been performed, using the Fike Flow Calculation computer program.

As an option, deflector plates are available for use where sensitive ceiling tiles must be protected. Deflector plates are not UL Listed or FM Approved.

The Fike Discharge Nozzle used shall be Factory Mutual (FM) approved and Underwriters Laboratories (UL) listed.

### APPROVALS

- U.L. Listed - Ex4623
- U.L.C. Listed - CEx1136
- FM Approved - 0Y4A8.AF



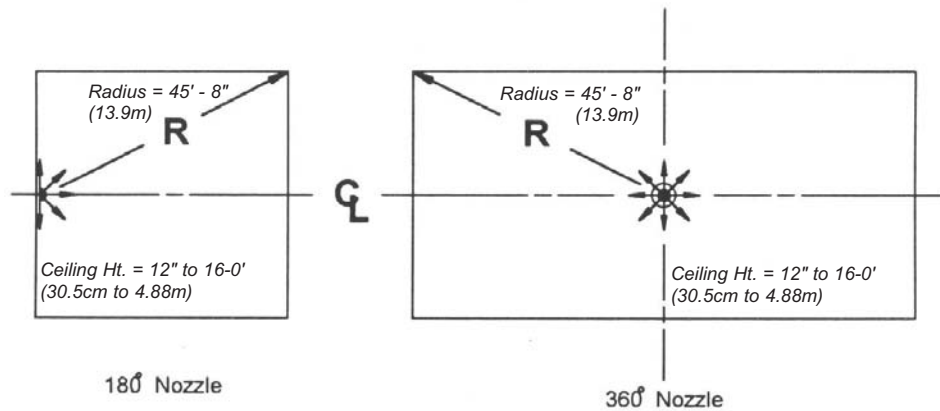
*Fike Engineered Nozzles*



*Nozzle with Optional Deflector Plate*

Data Sheet

## Nozzle Size and Area Coverage



NOZZLE SIZE		180° NOZZLE	360° NOZZLE
(NPT)	(mm)	PART NUMBER	PART NUMBER
3/8"	(10)	80-060	80-052
1/2"	(15)	80-061	80-053
3/4"	(20)	80-062	80-054
1"	(25)	80-063	80-055
1 1/4"	(32)	80-064	80-056
1 1/2"	(40)	80-065	80-057
2"	(50)	80-066	80-058

### NOTES:

- The maximum allowable area coverage includes any area within the radius distance from the nozzle ("R" dimension) to the most extreme wall or corner.
- Nozzles should be located on center line of hazard area.
- When working with ceiling heights exceeding the values tabulated above, the hazard volume must be broken down into vertically stacked hazard volumes, with heights less than the maximums shown in the table.  
It is imperative that unusual applications of this nature be handled by experienced design engineers and, in most cases, operational tests should be performed before the system is put into service.
- Dimensions and nozzle data shown are taken from the UL listed and FM approved Design, Installation & Maintenance Manual - P/N 06-202 or 06-215.
- 180 and 360 degree nozzles may be placed a maximum of 1 foot (30.5cm) down from the ceiling, and 180 degree nozzles may be placed a maximum of 1 foot (30.5cm) from the wall.
- Nozzle threading is NPT.

## ARCHITECT AND ENGINEERING SPECIFICATIONS

The nozzle used to disperse Clean Agent shall be a Fike Series 80. The nozzle shall be available in 3/8" (10mm) thru 2" (50mm) sizes. Each size shall be available in both 180 and 360 degree dispersion patterns. The nozzle used shall have pipe threads that correspond to the nozzle size. All nozzles shall have an orifice size determined by a UL listed and FM approved flow calculation program. All nozzle orifice drilling shall be performed by the manufacturer or a UL listed nozzle drilling facility. Deflector plates shall be available as an option.





## MANUAL ACTUATOR

### DESCRIPTION

The Manual Actuator (MA), Fike P/N 10-2225, provides an independent means of operating Fike clean agent systems which use the Gas Cartridge Actuator (GCA). It is designed to allow activation of GCAs in stand alone mode or supplementary to a normal releasing system in the event of a total power loss.

The MA consists of a DC generator and a supervisory module. The generator produces enough energy to fire up to six GCAs. The supervisory module supervises the field wiring between the MA and each GCA. The supervisory module annunciates a trouble condition by the transfer of two sets of normally energized relay contacts. The supervisory module requires a separate 24Vdc power source. Since the DC generator does not require a 24Vdc power source, power is not required to activate the GCAs.

The MA provides two green LEDs for indication of system status. The green power LED indicates status of 24Vdc power. If the LED is not illuminated, then 24Vdc power is not present. The green GCA circuit LED indicates a GCA wiring fault. If an "open" exists in the GCA wiring or 24Vdc power is not present then this green LED will not illuminate.

The MA also provides two sets of normally energized relay contacts. A loss of 24Vdc power and/or an "open" in the GCA wiring will cause the relay contacts to transfer.

The MA also provides an arm/disable switch which will safely disconnect the MA from the GCA circuit for testing or maintenance purposes. The switch will not disconnect the GCAs from other sources of power such as a releasing panel.

### Operation

To operate the MA, simply pull the ring pin and push the handle up a quarter turn. This action will provide the power necessary to activate all GCAs. Exit the hazard area.

### Installation

The Manual Actuator should be mounted as close to the Clean Agent containers as possible. Consideration should be given for convenience of operation and egress from the hazard area.

### STANDARD FEATURES/SPECIFICATIONS

- No External Power Required
- No Stored Energy
- Supervision of Connectors
- Two-Step Operation
- Activates up to Six Containers

#### Manual Actuator Ratings:

- 24 Volt Power (Supervision only): 18-31 volts DC, 50 ma. max.
- GCA Circuit: 10 ohms max (field wiring plus GCAs)

#### Trouble Relay Contact Ratings:

- DC operation: 2A, 30V
- AC operation: 0.5A, 110V



*Fike Manual Actuator*

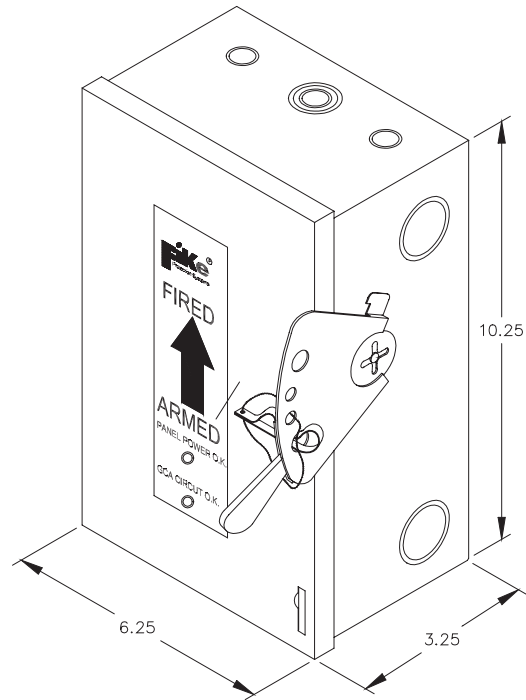
Data Sheet

### APPROVALS

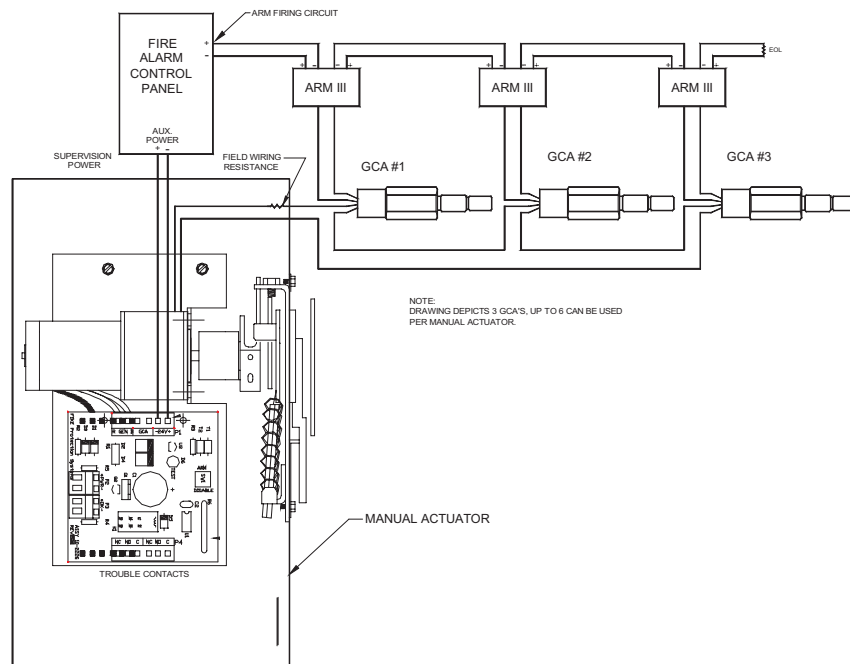
- UL Listed - S5566

Form No. C.1.09.01-2

## DIMENSIONS



## WIRING DIAGRAM







## AGENT RELEASE MODULE

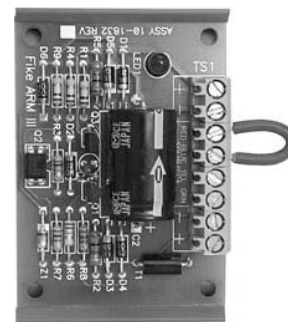
### DESCRIPTION

The Agent Release Module (ARM III), Fike P/N 10-1832, in conjunction with a Fike Control Panel, allows the electrical actuators used with Fike Clean Agent containers to be wired in parallel. This configuration substantially increases the overall reliability of the Clean Agent releasing circuit. With series-wired actuator circuits, a problem in a single actuator will incapacitate the entire system. Utilizing parallel-wired actuators, that same incident would incapacitate only that individual Clean Agent container; all others would still be active.

The Agent Release Module (ARM III) is compatible with either Class A or Class B wiring. When an ARM III is used in a Class A wiring configuration, the resulting system is the most reliable available for today's Fire Protection.

### Installation

The Fike Agent Release Module (ARM III) is mounted in the lower right corner of a 4 11/16" (11.9 cm) square box which connects to the actuator boss on the Clean Agent container. The ARM III is a solid-state circuit board and contains a terminal strip for the connections of field wiring and actuator leads. The module is also equipped with a polarity diode that illuminates if the field wiring has been installed with reversed polarity. Special care should be taken to assure proper polarity.



*Fike Agent Release Module*

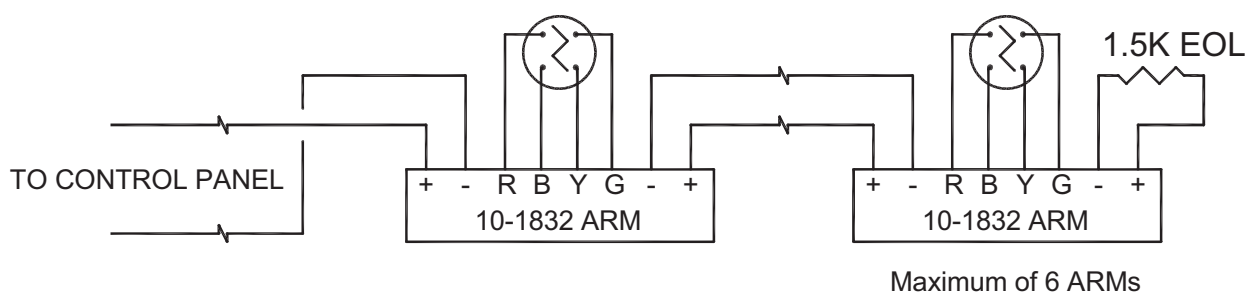
### ARCHITECT AND ENGINEERING SPECIFICATIONS

Each Clean Agent container shall be provided with a Fike P/N 10-1832 Agent Release Module (ARM III) to allow all electrical actuators to be connected in parallel. Series-wired actuators are not acceptable. The ARM III shall be located at each container and shall be securely mounted in the lower right hand corner of a 4 11/16" (11.9cm) square electrical box, with cover. All wiring to the Clean Agent container and the actuator leads shall connect to a terminal strip located on the ARM III.

### APPROVALS

- UL Listed - S3217
- FM Approved
  - Cheetah: 0B4A6.AY
  - Rhino: 0Y4A4.AY
  - SHP Pro: 0Z8A0.AY

### WIRING DIAGRAM



Form# C.1.04.01-2



# **Outreach Innovation Building**

Penn State Research Park  
State College, PA.

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## **Appendix J**

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### **Electrical Data**

## Outreach Innovation Building

Penn State Research Park  
State College, PA.

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### New Chiller (Quantity 12 fans)

(12 @ 1 HP ea, 480 V, 3 Phase, P.F. = 0.90)

NEC Table: 430-150 => FLC=**2.1 A**

KVA=  $1.73 * 2.1 \text{ A} * 480\text{V} * 0.9 =$  **1.569 KVA**

**Circuit Breaker Size:**  $2.1 \text{ A} * 250\% = 5.25 \text{ A} \Rightarrow$  **30 A, 3 P Breaker**

**Conductor Size:**  $2.1 \text{ A} * 125\% = 2.625\text{A}$

NEC Table 310.16 => **#12 THW (Cu)**

**Conduit Size:**

NEC Table C1 => **3/4"** (2 Fans per 3-phase circuit = 8 wires)

### New Primary Chilled Water Pump (Quantity 2)

(2 HP, 480V, 3-Phase, P.F. = 0.90)

NEC Table: 430-150 => FLC=**2.7 A**

KVA=  $1.73 * 2.7 \text{ A} * 480\text{V} * 0.9 =$  **2.017 KVA**

**Circuit Breaker Size:**  $2.7 \text{ A} * 250\% = 6.75 \text{ A} \Rightarrow$  **20 A, 3 P Breaker**

**Conductor Size:**  $2.7 \text{ A} * 125\% = 3.375 \text{ A}$

NEC Table 310.16 => **#12 THW (Cu)**

**Conduit Size:** NEC Table C1 => **1/2"**

### New Secondary Chilled Water Pump (Quantity 2)

(14.92 kW, 480 V, 3 Phase)

$I = P / (1.73 * V * pf) = 14.92 \text{ kW} / (1.73 * 0.48 \text{ kV} * 1) =$  **17.97A**

KVA=  $1.73 * 17.97 \text{ A} * 480\text{V} * 0.9 =$  **13.43 KVA**

**Circuit Breaker Size:**  $17.97 \text{ A} * 2.5\% = 44.925 \Rightarrow$  **60 A, 3 P Breaker**

**Conductor Size:**  $22.45 \text{ A} * 125\% = 28.06 \text{ A}$

NEC Table 310.16 => **#10 THW (Cu)**

**Conduit Size:** NEC Table C1 => **1/2"**

### New Enthalpy Wheel

(1/4 HP, 480 V, 3 Phase, P.F. = 0.90)

NEC Table: 430-150 => FLC= **1.1 A**

KVA=  $1.73 * 1.1 \text{ A} * 480\text{V} * 0.9 =$  **0.822 KVA**

**Circuit Breaker Size:**  $1.1 \text{ A} * 250\% = 2.75 \text{ A} \Rightarrow$  **15 A, 3 P Breaker**

**Conductor Size:**  $1.1 \text{ A} * 125\% = 1.375 \text{ A}$

NEC Table 310.16 => **#12 THW (Cu)**

**Conduit Size:** NEC Table C1 => **1/2"**

## Outreach Innovation Building

Penn State Research Park  
State College, PA.

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### New Fan Coil Units (Quantity 31)

(3 kW, 480 V, 3 Phase)

$$I = P / (1.73 * V * pf) = 3 \text{ kW} / (1.73 * 0.48 \text{ kV} * 1) = \mathbf{3.6 \text{ A}}$$

$$\text{KVA} = 1.73 * 3.6 \text{ A} * 480 \text{ V} * 0.9 = \mathbf{2.69 \text{ KVA}}$$

$$\text{Circuit Breaker Size: } 3.6 \text{ A} * 2.5\% = 9 \Rightarrow \mathbf{40 \text{ A, 3 P Breaker}}$$

$$\text{Conductor Size: } 3.6 \text{ A} * 125\% = 4.5 \text{ A}$$

$$\text{NEC Table 310.16} \Rightarrow \mathbf{\#12 \text{ THW (Cu)}}$$

$$\text{Conduit Size: NEC Table C1} \Rightarrow \mathbf{1''} \text{ (3 Coils per circuit = 12 wires)}$$

### New AHU

(20 HP, 480V, 3-Phase, P.F. = 0.90)

$$\text{NEC Table: 430-150} \Rightarrow \text{FLC} = \mathbf{27 \text{ A}}$$

$$\text{KVA} = 1.73 * 27 \text{ A} * 480 \text{ V} * 0.9 = \mathbf{20.17 \text{ KVA}}$$

$$\text{Circuit Breaker Size: } 27 \text{ A} * 250\% = 67.5 \text{ A} \Rightarrow \mathbf{100 \text{ A, 3 P Breaker}}$$

$$\text{Conductor Size: } 27 \text{ A} * 125\% = 33.75 \text{ A}$$

$$\text{NEC Table 310.16} \Rightarrow \mathbf{\#10 \text{ THW (Cu)}}$$

$$\text{Conduit Size: NEC Table C1} \Rightarrow \mathbf{1/2''}$$

### Old Chiller (Quantity 2)

(217 kW, 480 V, 3 Phase)

$$I = P / (1.73 * V * pf) = 217 \text{ kW} / (1.73 * 0.48 \text{ kV} * 1) = \mathbf{261 \text{ A}}$$

$$\text{KVA} = 1.73 * 261 \text{ A} * 480 \text{ V} * 0.9 = \mathbf{195.06 \text{ KVA}}$$

$$\text{Circuit Breaker Size: } 261 \text{ A} * 2.5\% = 652.5 \Rightarrow \mathbf{800 \text{ A, 3 P Breaker}}$$

$$\text{Conductor Size: } 261 \text{ A} * 125\% = 326.25 \text{ A}$$

$$\text{NEC Table 310.16} \Rightarrow \mathbf{400 \text{ THW (Cu)}}$$

$$\text{Conduit Size: NEC Table C1} \Rightarrow \mathbf{3''}$$

### Old Chilled Water Pumps (P-2 & P-3) (Quantity 2)

(5 HP, 480V, 3-Phase, P.F. = 0.90)

$$\text{NEC Table: 430-150} \Rightarrow \text{FLC} = \mathbf{7.6 \text{ A}}$$

$$\text{KVA} = 1.73 * 7.6 \text{ A} * 480 \text{ V} * 0.9 = 5.68 \text{ KVA}$$

$$\text{Circuit Breaker Size: } 7.6 \text{ A} * 250\% = 19 \text{ A} \Rightarrow \mathbf{25 \text{ A, 3 P Breaker}}$$

$$\text{Conductor Size: } 7.6 \text{ A} * 125\% = 9.5 \text{ A}$$

$$\text{NEC Table 310.16} \Rightarrow \mathbf{\#12 \text{ THW (Cu)}}$$

$$\text{Conduit Size: NEC Table C1} \Rightarrow \mathbf{1/2''}$$

### Old Chilled Water Pumps (P-4A & P-4B) (Quantity 2)

(15 HP, 480V, 3-Phase, P.F. = 0.90)

$$\text{NEC Table: 430-150} \Rightarrow \text{FLC} = \mathbf{21 \text{ A}}$$

$$\text{KVA} = 1.73 * 21 \text{ A} * 480 \text{ V} * 0.9 = 15.695 \text{ KVA}$$

$$\text{Circuit Breaker Size: } 21 \text{ A} * 250\% = 52.5 \text{ A} \Rightarrow \mathbf{70 \text{ A, 3 P Breaker}}$$

$$\text{Conductor Size: } 21 \text{ A} * 125\% = 26.25 \text{ A}$$

$$\text{NEC Table 310.16} \Rightarrow \mathbf{\#10 \text{ THW (Cu)}}$$

$$\text{Conduit Size: NEC Table C1} \Rightarrow \mathbf{1/2''}$$

## Outreach Innovation Building

Penn State Research Park  
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### Old AHU-2A & B (Quantity 2)

(25 HP, 480V, 3-Phase, P.F. = 0.90)

NEC Table: 430-150 => FLC= 34 A

KVA=  $1.73 * 34 \text{ A} * 480\text{V} * 0.9 = 25.4 \text{ KVA}$

**Circuit Breaker Size:**  $34 \text{ A} * 250\% = 85 \text{ A} \Rightarrow 115 \text{ A}, 3 \text{ P Breaker}$

**Conductor Size:**  $34 \text{ A} * 125\% = 42.5 \text{ A}$

NEC Table 310.16 => **#8 THW (Cu)**

**Conduit Size:** NEC Table C1 => **3/4"**

(10 HP, 480V, 3-Phase, P.F. = 0.90)

NEC Table: 430-150 => FLC= 14 A

KVA=  $1.73 * 14 \text{ A} * 480\text{V} * 0.9 = 10.5 \text{ KVA}$

**Circuit Breaker Size:**  $14 \text{ A} * 250\% = 35 \text{ A} \Rightarrow 40 \text{ A}, 3 \text{ P Breaker}$

**Conductor Size:**  $14 \text{ A} * 125\% = 17.5 \text{ A}$

NEC Table 310.16 => **#12 THW (Cu)**

**Conduit Size:** NEC Table C1 => **1/2"**

### Old AHU-2A & B (Quantity 2)

(60 HP, 480V, 3-Phase, P.F. = 0.90)

NEC Table: 430-150 => FLC= 77 A

KVA=  $1.73 * 77 \text{ A} * 480\text{V} * 0.9 = 57.5 \text{ KVA}$

**Circuit Breaker Size:**  $77 \text{ A} * 250\% = 192.5 \text{ A} \Rightarrow 250 \text{ A}, 3 \text{ P Breaker}$

**Conductor Size:**  $77 \text{ A} * 125\% = 96.25 \text{ A}$

NEC Table 310.16 => **3 THW (Cu)**

**Conduit Size:** NEC Table C1 => **1-1/4"**

(25 HP, 480V, 3-Phase, P.F. = 0.90)

NEC Table: 430-150 => FLC= 34 A

KVA=  $1.73 * 34 \text{ A} * 480\text{V} * 0.9 = 25.4 \text{ KVA}$

**Circuit Breaker Size:**  $34 \text{ A} * 250\% = 85 \text{ A} \Rightarrow 110 \text{ A}, 3 \text{ P Breaker}$

**Conductor Size:**  $34 \text{ A} * 125\% = 42.5 \text{ A}$

NEC Table 310.16 => **#8 THW (Cu)**

**Conduit Size:** NEC Table C1 => **3/4"**

## Outreach Innovation Building

Penn State Research Park  
State College, PA.

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Panel Comparison Schedule								
Unit	Hp	Voltage	Phase	FLC	A	kVA	Quantity	Total kVA
New Chiller	12	480	3	2.1	30	1.569	12	18.8
New AHU	20	480	3	27	100	20.17	1	20.17
New P-1	2	480	3	2.7	20	2.017	2	4.034
New P-2	14.92 kW	480	3	17.97	60	13.43	2	26.86
Enthalpy Wheel	1/4	480	3	1.1	15	0.822	1	0.822
Fan Coils	3 kW	480	3	3.6	40	2.69	31	83.39
Old Chiller	217 kW	480	3	261	800	195.06	2	390.12
Old P-2&3	5	480	3	7.6	25	5.68	2	11.36
Old P-4A&B	15	480	3	21	70	15.695	2	31.39
Old AHU 2A&B	25	480	3	34	110	25.4	2	50.8
	10	480	3	14	40	10.5	2	21
Old AHU 3A&B	60	480	3	77	250	57.5	2	115
	25	480	3	34	110	25.4	2	50.8

### New Equipment

Total kVA = Sum kVA + 25% \* kVAm<sub>ax</sub> = 175

Min Ampacity = Total kVA / (0.48kV \* 1.73) = 210.75

Max Ampacity = (Sum kVA + 75% \* kVAm<sub>ax</sub>) / (0.48 kV \* 1.73) = 260.86

Panel Ampacity = 300 A

### Old Equipment

Total kVA = Sum kVA + 25% \* kVAm<sub>ax</sub> = 768

Min Ampacity = Total kVA / (0.48kV \* 1.73) = 925

Max Ampacity = (Sum kVA + 75% \* kVAm<sub>ax</sub>) / (0.48 kV \* 1.73) = 963.06

Panel Ampacity = 1000 A