April 7th, 2011

UNIT 4 APPENDICES: MECHANICAL REPORT

KGB Maser
Management. Engineering. Consulting.

IPD/BIM TEAM #3

JASON BROGNANO | MICHAEL GILROY | DAVID MASER | STEPHEN KIJAK

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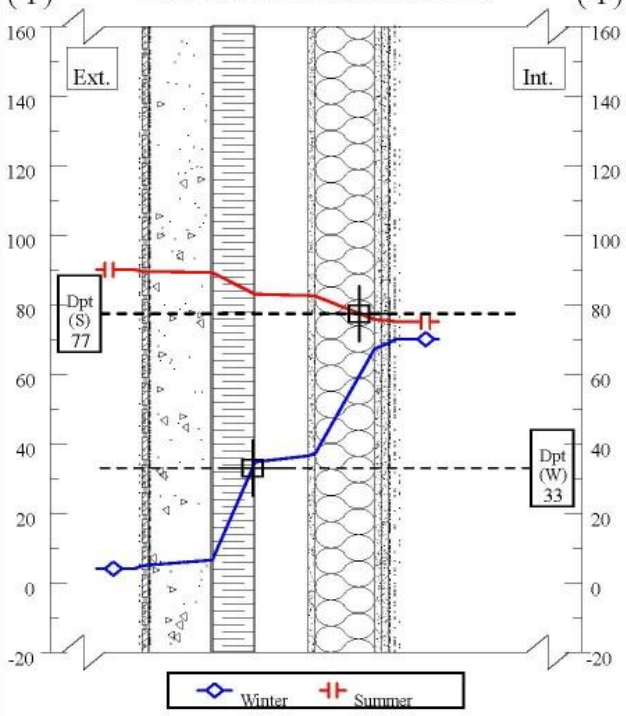
APPENDIX 4.A: R-VALUE ANALYSIS

R VALUE ANALYSIS

The Heat, Air and Moisture Building Science Toolbox - V.1B-E/U (12)

WALL SECTION AND TEMPERATURE GRADIENTS



PROJECT

Name	MSCexisting
Number	111
City	Pittsburgh AP, PA
Date	1/21/2011
Analysis by:	MPG
Wall Type	
Option	

CLIMATIC CONDITIONS

	Winter		Summer	
	Int.	Ext.	Int.	Ext.
Temp (°F)	70	4	75	90
RH (%)	25	80	50	66
DPT (°F)	33	-1	56	77

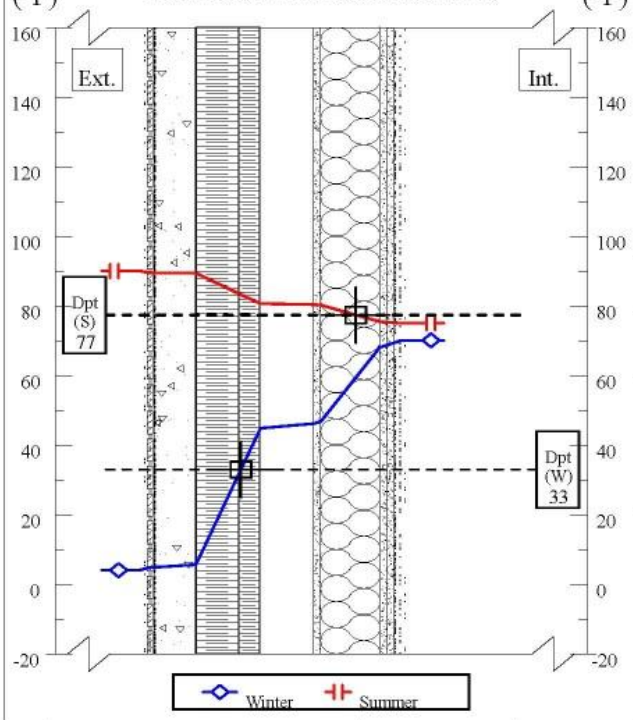
PENNSYLVANIA STATE UNIVERSITY
104 ENGINEERING, UNIT A
UNIVERSITY PARK, PA, USA, 16802

	Generic Material	Manufacturer	Model No.	Thick (in.)	RVal (R)	W.Temp. (°F)	S.Temp. (°F)
1	air film (ext), 3/4 in.	No Recor...	Generic...	0.75	0.17	4.8	89.5
2	brick, facing, 1/2 in.	No Recor...	Generic...	0.50	0.12	5.0	89.5
3	concrete wall, 6 in.	No Recor...	Generic...	6.02	0.87	6.5	89.1
4	rigid ins.,(expand.), 4 in.	No Recor...	Generic...	4.00	15.81	34.7	82.9
5	cavity, 5-1/2 in.	No Recor...	Generic...	5.00	0.98	36.5	82.5
6	gypsum bd., 5/8 in., (#1)	No Recor...	Generic...	0.63	0.46	37.3	82.3
7	batt ins., 5-1/2 in.	No Recor...	Generic...	5.50	16.76	67.2	75.6
8	gypsum bd., 5/8 in., (#2)	No Recor...	Generic...	0.63	0.46	68.0	75.4
9	gypsum bd., 5/8 in., (#2)	No Recor...	Generic...	0.63	0.46	68.9	75.3
10	air film (int), 3/4 in.	No Recor...	Generic...	0.75	0.64	70.0	75.0
	Total or (Layer 0)			22.90	36.73	(4.5)	(89.6)

R VALUE ANALYSIS

The Heat, Air and Moisture Building Science Toolbox - V.1B-E/U (12)

WALL SECTION AND TEMPERATURE GRADIENTS



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	Generic Material	Manufacturer	Model No.	Thick (in.)	RVal (R)	W.Temp. (°F)	S.Temp. (°F)
1	air film (ext), 3/4 in.	No Recor...	Generic...	0.75	0.17	4.7	89.6
2	brick, facing, 1/2 in.	No Recor...	Generic...	0.50	0.12	4.8	89.5
3	concrete wall, 4 in.	No Recor...	Generic...	4.00	0.58	5.6	89.4
4	rigid ins.,(extru.), 4 in.	No Recor...	Generic...	4.00	20.55	31.7	83.5
5	rigid ins.,(extru.), 2 in.	No Recor...	Generic...	2.00	10.27	44.8	80.6
6	cavity, 5-1/2 in.	No Recor...	Generic...	5.00	0.98	46.1	80.3
7	gypsum bd., 5/8 in., (#1)	No Recor...	Generic...	0.63	0.46	46.7	80.2
8	batt ins., 5-1/2 in.	No Recor...	Generic...	5.50	16.76	68.0	75.4
9	gypsum bd., 5/8 in., (#2)	No Recor...	Generic...	0.63	0.46	68.6	75.3
10	gypsum bd., 5/8 in., (#2)	No Recor...	Generic...	0.63	0.46	69.2	75.2
11	air film (int), 3/4 in.	No Recor...	Generic...	0.75	0.64	70.0	75.0
				24.88	51.45	(4.5)	(89.6)

APPENDIX 4.B: CHILLED BEAM CUTSHEETS/ SELECTION DATA

T 2.4/12/US/2

Active Chilled Beams

DID631 and DID632 series

TROX® TECHNIK

TROX USA, Inc.
4305 Settingdown Circle
Cumming, GA 30028

www.troxusa.com
e-mail trox@troxusa.com

Telephone 770.569.1433
Facsimile 770.569.1435

Quick selection table

Reference Values - Cooling

t_R 75 °F t_{CWS} 57 °F
t_{Pr} 55 °F $\dot{V}_{CW}$ 1.25 GPM

Reference Values - Heating

t_R 70 °F t_{HWS} 120 °F
t_{Pr} 55 °F

Active Length	Nozzle Type	Primary Air		Cooling Two-pipe system			Cooling Four-pipe system			Heating Four-pipe system			Isothermal Throw[6]	NC[7]
		$\dot{V}pr$	Δp_t	$\dot{Q}_{tot}$[1]	$\dot{Q}_{CW}$[2]	Δp_w[3]	$\dot{Q}_{tot}$[1]	$\dot{Q}_{CW}$[2]	Δp_w[3]	$\dot{Q}_{NET}$[4]	$\dot{V}_{HW}$[5]	Δp_w[3]		
ft		CFM	in. H_20	Btu/h	Btu/h	ft. H_20	Btu/h	Btu/h	ft. H_20	Btu/h	GPM	ft. H_20	ft.	
4	Z	20	0.47	2,656	2,220	2.1	2,472	2,036	1.7	1,986	0.20	0.1	3-4-6	-
		25	0.56	3,177	2,632		2,963	2,418		2,261	0.20	0.1	3-4-7	-
		30	0.81	3,610	2,957		3,373	2,720		2,860	0.25	0.1	3-5-8	15
	M	25	0.25	2,482	1,937		2,320	1,775		2,169	0.30	0.1	3-4-6	-
		35	0.48	3,377	2,615		3,164	2,402		3,114	0.35	0.2	4-5-6	15
		45	0.80	4,072	3,092		3,827	2,847		3,870	0.40	0.2	4-5-8	22
	G	45	0.22	3,220	2,240		3,035	2,055		3,296	0.60	0.5	3-4-6	-
		65	0.46	4,384	2,988		4,147	2,731		4,640	0.80	0.9	4-5-8	19
		80	0.79	5,209	3,467		4,939	3,197		5,999	1.50	2.7	4-5-10	27
	U	80	0.22	4,446	2,704		4,227	2,485		4,372	1.50	2.7	4-5-9	-
		110	0.42	3,190	3,333		5,333	2,937		4,962	1.50	2.7	5-6-10	23
		140	0.68	6,591	3,542		6,316	3,267		5,267	1.50	2.7	5-7-12	30
6	Z	25	0.24	3,238	2,693	3.0	3,020	2,475	2.4	2,312	0.20	0.1	3-4-5	-
		35	0.48	4,324	3,562		4,047	3,285		3,338	0.25	0.1	3-4-6	15
		45	0.79	5,142	4,162		4,828	3,848		4,264	0.30	0.2	3-5-7	22
	M	45	0.35	4,276	3,296		4,017	3,037		3,785	0.35	0.3	3-4-6	19
		60	0.60	5,356	4,049		5,089	3,782		5,239	0.45	0.4	3-5-7	27
		75	0.98	6,228	4,594		5,889	4,255		6,434	0.55	0.6	4-6-9	34
	G	85	0.36	5,676	3,825		5,382	3,531		6,311	1.00	1.7	4-5-7	24
		105	0.55	6,649	4,362		6,323	4,036		7,739	1.50	3.6	5-6-9	30
		125	0.78	7,506	4,783		7,156	4,433		8,408	1.50	3.6	5-7-12	35
	U	130	0.27	6,823	3,992		6,520	3,689		6,465	1.50	3.6	4-5-7	26
		180	0.47	8,556	4,636		8,215	4,295		7,156	1.50	3.6	5-7-13	23
		230	0.76	10,101	5,092		9,736	4,727		7,430	1.50	3.6	7-8-14	30
8	Z	35	0.26	4,376	3,614	3.8	4,096	3,334	3.0	3,385	0.25	0.2	3-4-6	-
		50	0.53	5,603	4,714		5,457	4,368		4,711	0.30	0.3	3-5-7	15
		65	0.90	6,860	5,444		6,476	5,060		5,817	0.35	0.3	4-5-8	22
	M	60	0.34	5,498	4,191		5,182	3,875		5,031	0.40	0.4	3-5-7	16
		75	0.53	6,553	4,899		6,177	4,543		6,533	0.50	0.6	4-5-12	23
		90	0.76	7,398	5,436		7,015	5,055		7,804	0.60	0.9	5-6-10	28
	G	110	0.27	6,822	4,426		6,493	4,097		7,635	1.20	3.0	4-5-7	19
		140	0.53	8,513	5,464		8,128	5,079		9,978	1.50	4.4	5-6-10	29
		170	0.78	9,713	6,010		9,302	5,599		10,673	1.50	4.4	6-7-13	35
	U	150	0.19	7,934	4,667		7,591	4,324		7,721	1.50	4.4	4-5-8	16
		220	0.40	10,350	5,558		9,990	5,196		8,389	1.50	4.4	5-7-13	27
		290	0.70	12,513	6,197		12,094	5,778		9,174	1.50	4.4	6-8-16	35
10	Z	40	0.22	4,870	3,999	4.6	4,566	3,695	3.7	3,639	0.25	0.2	2-3-5	-
		60	0.49	6,772	5,465		6,367	5,080		5,230	0.30	0.3	3-4-7	18
		80	0.87	8,114	6,372		7,687	5,945		7,210	0.40	0.5	4-5-10	26
	M	70	0.30	6,267	4,742		5,920	4,395		5,996	0.45	0.6	3-4-6	19
		90	0.71	7,627	5,667		7,232	5,272		7,776	0.55	0.9	4-5-8	25
		110	0.75	8,735	6,339		8,310	5,914		10,215	0.80	1.8	5-6-9	32
	G	120	0.26	7,735	5,121		7,368	4,754		8,416	1.00	2.6	4-5-10	24
		150	0.41	9,193	5,926		8,886	5,619		10,515	1.35	4.4	5-6-9	30
		180	0.59	10,450	6,530		10,017	6,097		11,826	1.50	5.3	5-7-11	35
	U	160	0.18	9,348	5,428		8,965	5,045		9,067	1.50	0.8	4-5-10	20
		270	0.41	12,412	6,531		11,979	6,098		10,354	1.50	0.8	5-6-17	32
		360	0.72	15,073	7,232		14,613	6,772		10,695	1.50	0.8	7-9-19	40

PERFORMANCE NOTES:

[1] $\dot{Q}_{tot}$ includes $\dot{Q}_{CW}$ plus sensible cooling provided by primary air 20°F below room temperature at the flow rate indicated.
[2] $\dot{Q}_{CW}$ is coil sensible cooling using 1.25 GPM of chilled water supplied 18°F below the room temperature.
[3] Δp_w is the water head loss at the referenced water supply flow rate.
[4] $\dot{Q}_{NET}$ is coil heating using referenced hot water flow rate supplied 50°F above the room temperature.
[5] $\dot{V}_{HW}$ is hot water flow rate limited to the lesser of 1.5 GPM or that which results in a supply to room air temperature differential not exceeding 15°F.
[6] Isothermal throw values presented to 150, 100 and 50 FPM, indicated as VH_i in selection program.
[7] NC values are based on a room absorption of 10 dB (per octve band) re 10^{-12} watts. (-) indicates NC value less than 15.

8

Functional description

Active chilled beams supply conditioned fresh air (primary air) to the space from a central air handling unit (AHU). This air is required to maintain indoor air quality while providing additional cooling and/or heating using an integral heat exchanger.

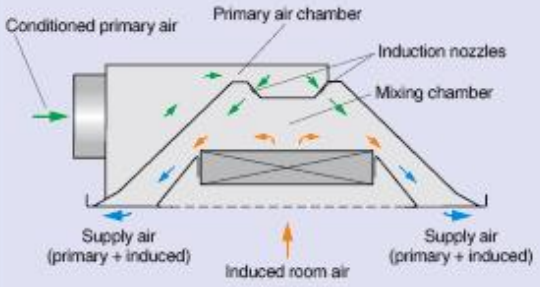
The primary air is discharged into the beam mixing chamber from the primary air chamber via induction nozzles. This causes room air to be induced through an induction grille before passing through a horizontally mounted heat exchanger and mixing with the primary air. This mixture is then discharged into the space through integral slot diffusers.

There are two types of heat exchange coil, a two-pipe system for cooling or heating (using a changeover mode) and a four-pipe system which enables any room to be cooled or heated independently.

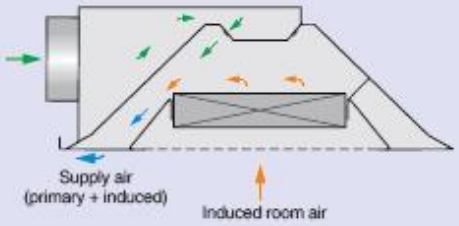
Caution!
The chilled water system must be designed to prevent the temperature of the water supplied to the heat exchanger from falling below the room dew point to ensure that the beam provides sensible cooling only. Chilled beam systems should not be designed to condense.

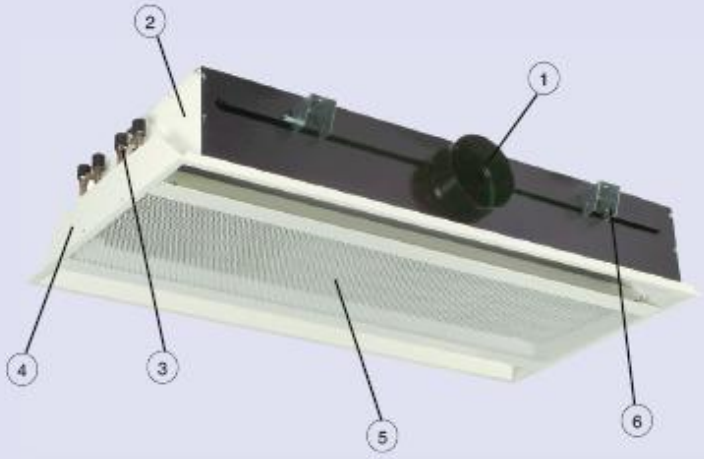
The primary air fed to the beams must be pretreated at the AHU to maintain the required ventilation and humidity control of the space.

Principle of operation DID632
2-way throw



Principle of operation DID631
1-way throw





1. Primary air connection
2. Primary air chamber
3. Water connections
4. Casing
5. Induction grille
6. Sliding hanging brackets

3

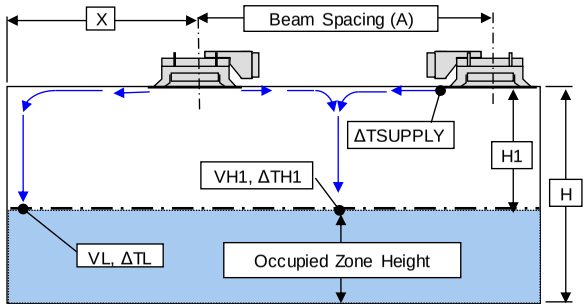
DID 632 Two Way Active Chilled Beam Selection Program

Input DID	4 pipe coil		2 pipe coil		Project	Room-No.	Comment
	cooling	heating	cooling	heating			
Vwater DID	1.25 GPM	1.25 GPM	1.00 GPM	0.50 GPM			
Unit length	4.0 ft						
Nozzle-type	U						
Vair-primary DID	140.0 CFM						
Connection-diameter / primary air	6 in						

Input Temperatures	cooling		heating		Input Room Dimensions	
Tair-primary	55.0 °F		55.0 °F		Room Height (H)	11.0 ft
Troom / rel. Humidity	75.0 °F	53.0 %	70.0 °F	50.0 %	A	12.0 ft
					X	10.0 ft
Twater-flow	58.0 °F		95.0 °F		Occupied Zone Height	6.0 ft

TROX® TECHNIK
The art of handling air

Results	4 pipe coil		2 pipe coil	
	cooling	heating	cooling	heating
Δtwater	-4.9 °F	5.9 °F	-6.7 °F	14.8 °F
Twater-return	62.9 °F	89.1 °F	64.7 °F	80.2 °F
ΔT room - water flow	-17.0 °F	25.0 °F	-17.0 °F	25.0 °F
ΔT Room water average	-14.5 °F	22.0 °F	-13.7 °F	17.6 °F
Qwater DID	-3085 BTUH	3694 BTUH	-3332 BTUH	3705 BTUH
Qair DID	-3048 BTUH	-2297 BTUH	-3048 BTUH	-2297 BTUH
Q DID	-6133 BTUH	1398 BTUH	-6380 BTUH	1408 BTUH
ΔP water	1.7 ft WG	2.0 ft WG	4.8 ft WG	1.4 ft WG
ΔP air	0.68 inch WG			
NC (Incl. 10 dB room absorbtion)	30			



NOTE: This calculation program is only applicable to DID632 beams manufactured by TROX USA.

Terminal Velocities and Temperatures					Support Values	
vL2 (measured 2" from wall)	91 FPM	64 FPM	91 FPM	64 FPM		
vL6 (measured 6" from wall)	55 FPM	38 FPM	54 FPM	38 FPM	N-nozzles total	90
vH1	53 FPM		53 FPM		Aeff	0.046295 ft²
ΔTL	-1.7 °F	0.1 °F	-1.6 °F	0.1 °F	veff	3024 FPM
ΔTH1	-0.8 °F		-0.7 °F		H1	5.0 ft
ΔTsupply	-15.8 °F	2.8 °F	-15.1 °F	2.8 °F	L	15.0 ft
Connection-diameter / primary air	DID632-HC		DID632-US		room air dew point-cooling	56.7 °F

TROX USA, Inc
4305 Settingdown Circle
Cumming, GA 30028
Phone: (770) 569-1433
Fax: (770) 569-1435
www.TROXUSA.com
Version 1.8
1/21/2011

Text in red represents a value that is not generally recommended (see user notes for details).

Active Chilled Beam Linear
ACBL / ACBL-HE

price

Product Features

Models

Active Chilled Beam Linear
ACBL / ACBL-HE

The Price Active Chilled Beam Linear combines fresh air supply with high heating and cooling capacities and is designed for performance, ease of installation and low maintenance. The ACBL induces room air through the heat exchanger, mixes it with supply air and delivers the combined air streams into the occupied zone via slots along the length of the beam. The ACBL lends itself to many different installation configurations and the low profile makes it suitable in both new and refurbished buildings. Chilled beams can be easily integrated into suspended and drywall ceilings.

ACBL-HE is an upgraded high efficiency model which maximizes cooling and heating capacity per unit of primary airflow.

Features

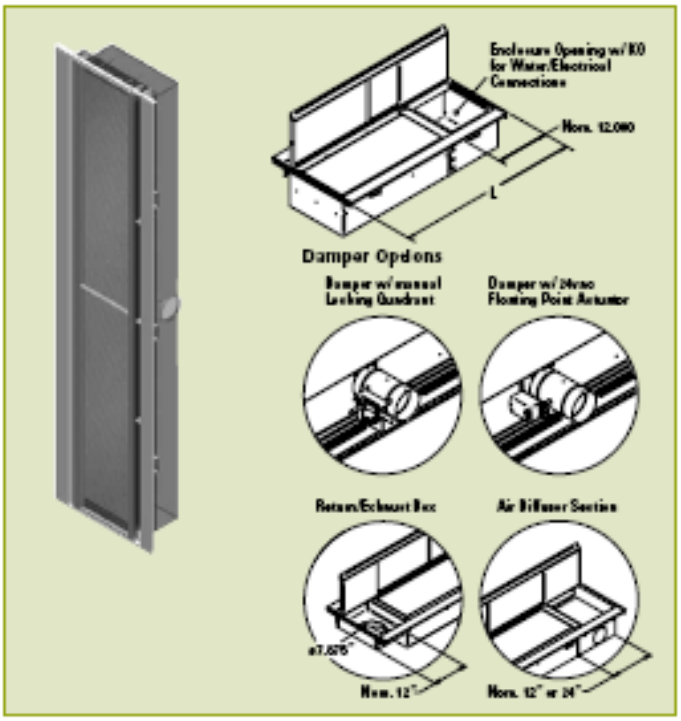
- 2- way and 1 way discharge option.
- Adjustable mounting brackets for ease of installation
- Hinged access face to allow easy room-side access to the coil and any control component
- Inlet damper option for easy balancing with optional manual locking damper or actuated damper for VAV control.
- Pressure port for balancing and monitoring
- Black plenum option hides beam internal elements
- Standard perforated face
  - Bar Grille face option (½" bar spacing)
- Optional 12" Access Blank section for room-side access to water connections and enclosure for controls.
- Optional 12" return/exhaust box allows the exit of room side air to the above return plenum, or ducted back to an air handler
- Optional 12" and 24" length active diffuser section allows for additional primary air separate from the main beam supply. Available with VAV damper for part load modulation or tie in with room occupancy control
- Optional Wings extend width by 6" per side to allow for proper air flow patterns when no ceiling is present. Architectural look for exposed mounting.
- Optional internal and external insulation.

Casing Construction

- Heavy duty aluminum face
- Steel plenum
- White powder coat finish

Water Coil Construction

- Aluminum fins
- Pressure tested copper piping

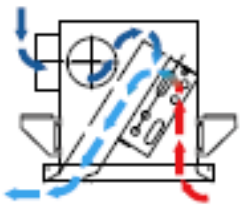


Water Connection Type

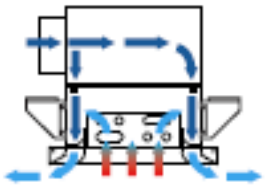
- Standard Connection Options:
  - ½" SWT
  - ½" NPT (female)
- Other connection types available

Air Pattern

1-Way



2-Way



✓ Product Selection Checklist

1) Select chilled beam size based on piping system and desired performance characteristics
2) Select face style and finishing options

Example: ACBL / 24 / 72 / 2-Way / ½" SWT / 2-Pipe / B12

All Metric dimensions ( ) are soft conversions.
Imperial dimensions are converted to metric and rounded to the nearest millimetre.

H-57

HYDRONIC HEATING & COOLING

ACBL / ACBL-HE Series

12" x 48" **12" x 60"**
Cooling
Heating

Performance Data

Cooling - 12" x 48" ACB1 (One-Way)

Primary Airflow (cfm)	Primary Inlet Size (in)	Nozzle Size (in ø)	Water Side Heating Capacity (BTU/hr)	Primary Air Cooling Capacity (BTU/hr)	Total Cooling Capacity (BTU/hr)	Cooling Water Flow Rate (usgpm)	Cooling Water Pressure Drop (ft head)
20	4	0.24	874	382	1256	0.43	0.30
30	4	0.24	1,112	579	1691	0.55	0.45
40	4	0.24	1,351	776	2127	0.67	0.61
50	4	0.24	1,591	972	2563	0.79	0.80
60	4	0.24	1,832	1,168	3000	0.91	1.00
70	4	0.24	2,074	1,364	3438	1.03	1.21
80	4	0.24	2,317	1,560	3877	1.15	1.44
90	4	0.24	2,561	1,756	4317	1.27	1.69
100	4	0.24	2,807	1,951	4758	1.39	1.95
110	4	0.24	3,053	2,146	5199	1.51	2.22
20	4	0.28	809	382	1191	0.40	0.27
30	4	0.28	1,014	579	1593	0.50	0.39
40	4	0.28	1,219	776	1995	0.60	0.51
50	4	0.28	1,424	972	2396	0.70	0.66
60	4	0.28	1,628	1,168	2796	0.81	0.83
70	4	0.28	1,832	1,364	3196	0.91	1.00
80	4	0.28	2,036	1,560	3596	1.01	1.17
90	4	0.28	2,239	1,756	3995	1.11	1.36
100	4	0.28	2,442	1,951	4393	1.21	1.56
110	4	0.28	2,645	2,146	4791	1.31	1.77
120	4	0.28	2,847	2,342	5189	1.41	1.99
130	4	0.28	3,049	2,537	5586	1.51	2.22
140	4	0.28	3,250	2,731	5981	1.61	2.46
20	4	0.31	747	382	1129	0.37	0.24
30	4	0.31	914	579	1493	0.45	0.33
40	4	0.31	1,080	776	1856	0.54	0.42
50	4	0.31	1,247	972	2219	0.62	0.54
60	4	0.31	1,415	1,168	2583	0.71	0.66
70	4	0.31	1,582	1,364	2946	0.79	0.78
80	4	0.31	1,749	1,560	3309	0.88	0.93
90	4	0.31	1,916	1,756	3672	0.96	1.07
100	4	0.31	2,083	1,951	4034	1.04	1.21
112	4	0.31	2,250	2,146	4396	1.13	1.36
120	4	0.31	2,418	2,342	4760	1.21	1.54
130	4	0.31	2,585	2,537	5122	1.29	1.71
140	4	0.31	2,753	2,731	5484	1.37	1.88
150	4	0.31	2,920	2,926	5846	1.45	2.06
160	4	0.31	3,088	3,120	6208	1.53	2.27

Performance Notes:

1. Water Side Capacity in BTU/hr is based on 18°F temperature difference. Mean Chilled Water Temp - Room Temp for cooling; Mean Heating Water Temp - Room Temp for heating;
2. Primary Air Capacity in BTU/hr is based on 18°F temperature difference between the primary air and the room air.
3. Heating & Cooling Capacity is based on a 4°F temperature difference between entering water and leaving water.
4. Blanks "--" indicate a sound level less than 15 NC.
5. Sound data NC values are based on a room absorption of -10 dB, re 10^{-12} watts.

APPENDIX 4.C: NEW PUMP SELECTIONS

NEW AHU CHW PUMP SELECTION

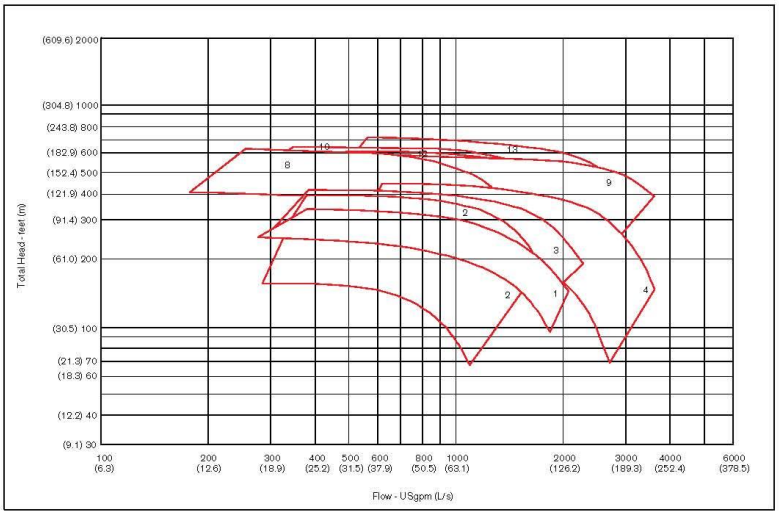
ARMSTRONG

FILE NO:	46.20
DATE:	Jan. 12, 2010
SUPERSEDES:	46.20
DATE:	Oct. 20, 2008

Series 4600

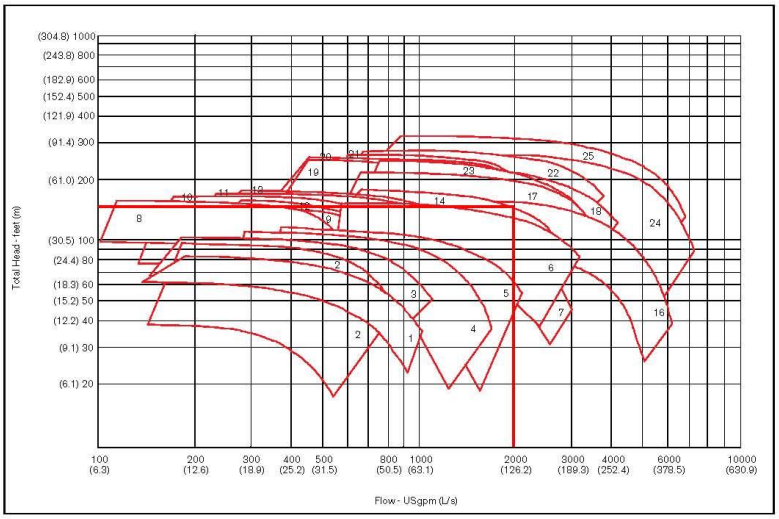
COMPOSITE CURVES

4600 - 3600 RPM



Legend	
No.	Suction x Discharge x Impeller
1	6x5x9.5M
2	5x4x10L
3	6x5x10H
4	8x6x10L
8	5x4x12L
9	5x4x12H
10	6x5x12L
12	6x5x12M
13	8x6x12.5L

4600 - 1800 RPM



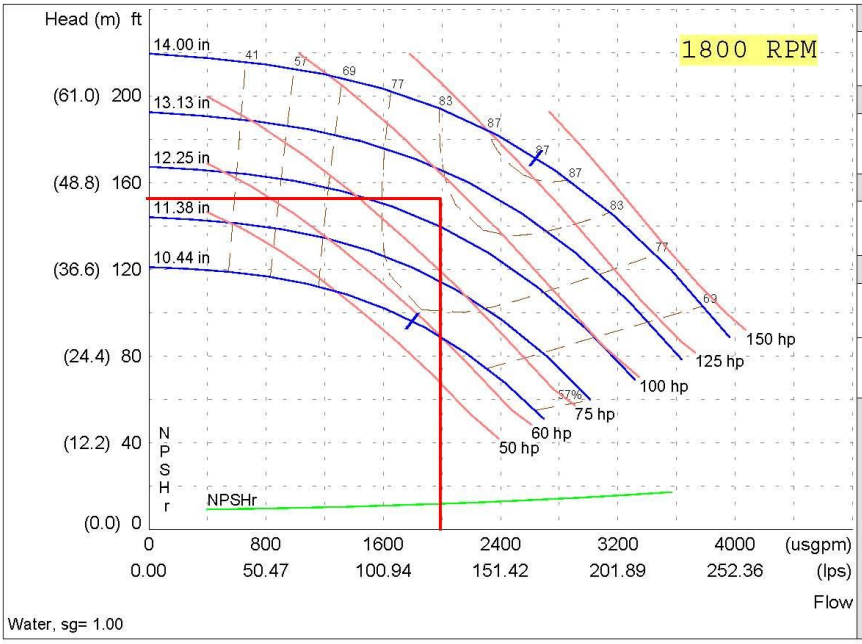
Legend	
No.	Suction x Discharge x Impeller
1	6x5x9.5M
2	5x4x10L
3	6x5x10H
4	8x6x10L
5	8x6x10H
6	10x8x11H
7	10x8x11M
8	5x4x12L
9	5x4x12H
10	6x5x12L
11	6x5x12H
12	6x5x12M
13	8x6x12.5L
14	8x6x12.5H
15	8x6x12.5M
16	12x10x12.5H
17	10x8x14L
18	10x8x14H
19	6x5x15L
20	6x5x15H
21	8x6x15L
22	8x6x15H
23	8x6x15M
24	12x10x15H
25	12x8x18

ARMSTRONG®

PERFORMANCE CURVES

Performance Guaranteed Only At Operating Point Indicated

File No:	
Date:	June 1,2000
Supersedes:	NEW
Date:	NEW



CURVE NO.
PT167-1-0-1800
SERIES
4600
SIZE
10x8x14L
RPM
1800
BHP based on shown Fluid's sp. gr.
4600 All Ratings

S.A. Armstrong Limited
23 Bertrand Ave.
Toronto, Ontario
Canada, M1L 2P3
Tel: (416) 755-2291
Fax: (416) 759-9101
Visit us at www.armstrongpumps.com

Armstrong Pumps Limited
Peartree Road, Stanway
Colchester, Essex
United Kingdom, C03 5JX
Tel: 01206-579491
Fax: 01206-760532

Armstrong Pumps Inc.
93 East Avenue
Buffalo, New York
USA, 14120-6594
Tel: (716) 693-8813
Fax: (716) 693-8970

Armstrong Darling Inc.
2200 Place Transcanadienne
Montreal, Quebec
Canada, H9P 2X5
Tel: (514) 421-2424
Fax: (514) 421-2436

NEW HW PUMP SELECTION

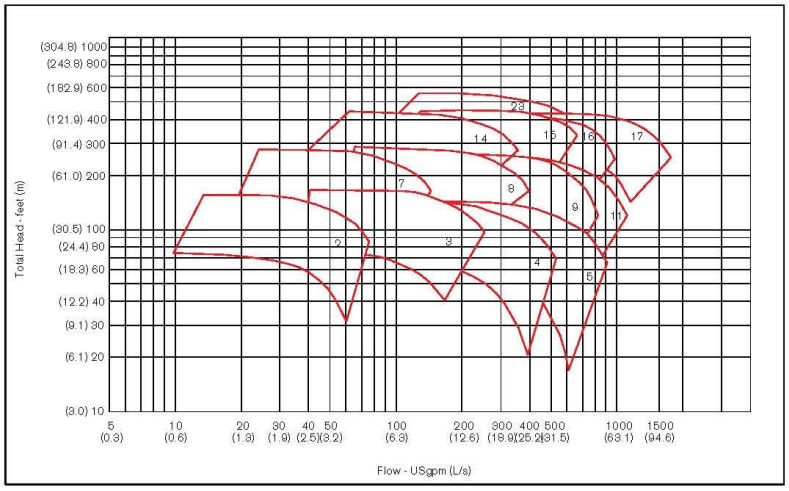
ARMSTRONG

FILE NO:	43.20
DATE:	Oct. 20, 2008
SUPERSEDES:	43.20
DATE:	Jan. 25, 2008

Series 4300

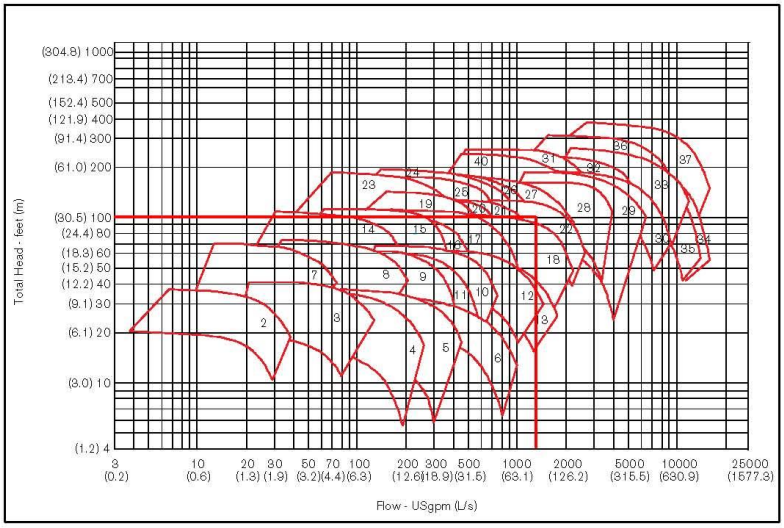
COMPOSITE CURVES

4300 - 3600 RPM



Legend	
No.	Suction x Discharge x Impeller
2	1.5x1.5x6
3	2x2x6
4	3x3x6
5	4x4x6
7	1.5x1.5x8
8	2x2x8
9	3x3x8
10	4x4x8
11	5x5x8
14	2x2x10
15	3x3x10
16	4x4x10
17	6x6x10
23	3x3x13

4300 - 1800 RPM



Legend	
No.	Suction x Discharge x Impeller
2	1.5x1.5x6
3	2x2x6
4	3x3x6
5	4x4x6
6	6x6x6
7	1.5x1.5x8
8	2x2x8
9	3x3x8
10	4x4x8
11	5x5x8
12	6x6x8
13	8x8x8
14	2x2x10
15	3x3x10
16	4x4x10
17	6x6x10
18	8x8x10
19	4x4x11.5
20	5x5x11.5
21	6x6x11.5
22	8x8x11.5
23	3x3x13
24	4x4x13
25	4x4x13L
26	6X6X13
27	8X8X13
28	10X10X13
29	12X12X13
30	14X14X14
31	8X8X15
32	10X10X15
33	14X14X15
34	16X16X15
35	16X16X15L
36	12X12X17
37	16X16X19

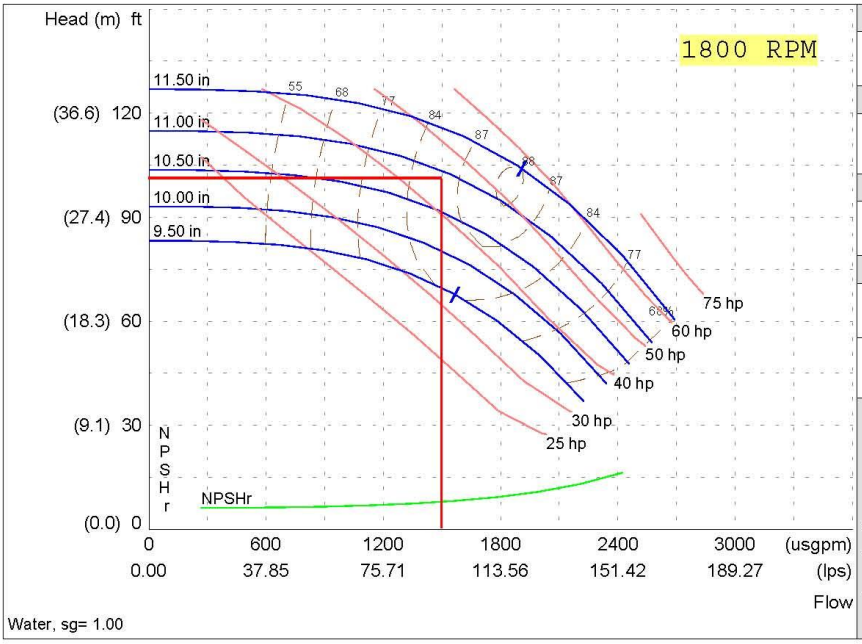
Page 1 of 2

ARMSTRONG®

PERFORMANCE CURVES

Performance Guaranteed Only At Operating Point Indicated

File No:	
Date:	June 1,2000
Supersedes:	NEW
Date:	NEW



CURVE NO.
PT113-1-0-1800
SERIES
4300 4380
SIZE
8x8x11.5
RPM
1800
BHP based on shown Fluid's sp. gr.

AVAILABILITY

4300 All Ratings
4380 All Ratings

S.A. Armstrong Limited
23 Bertrand Ave.
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Tel: (416) 755-2291
Fax: (416) 759-9101
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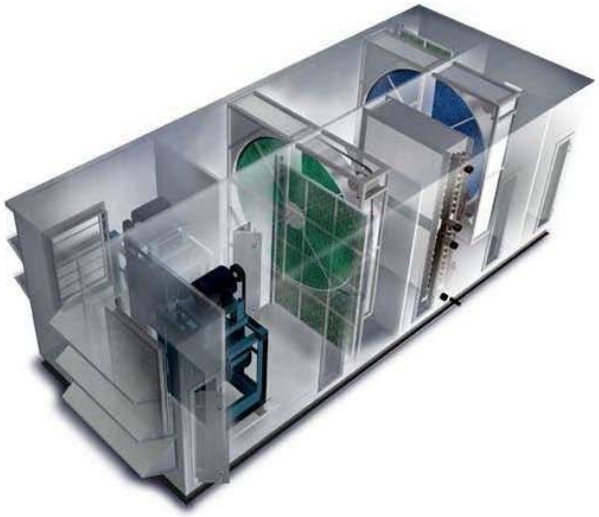
Armstrong Darling Inc.
2200 Place Transcanadienne
Montreal, Quebec
Canada, H9P 2X5
Tel: (514) 421-2424
Fax: (514) 421-2436

APPENDIX 4.D: NEW AIR HANDLER, EXHAUST FAN SELECTION

NEW AHU SELECTIONS

SEMCO
A FLÄKT WOODS COMPANY
Desiccant Wheel Products

EP Series
Packaged Energy Recovery Systems



Technical Guide

SIZE 35, 28X, 24XX

Maximum 50 hp Motor

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

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

SIZE 43, 35X, 28XX

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

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

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

SIZE 43X, 35XX

Maximum 50 hp Motor

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

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

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

NEW EXHAUST FAN SELECTIONS

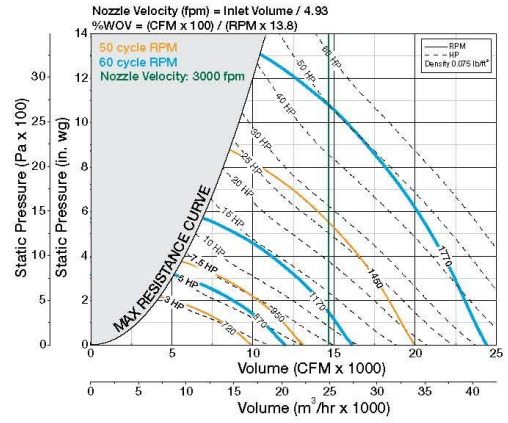
AIR DATA

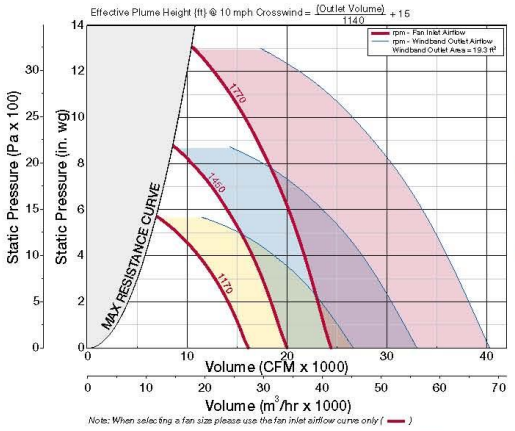
Vektor-MD Size 33

GREENHECK
Building Value in Air.

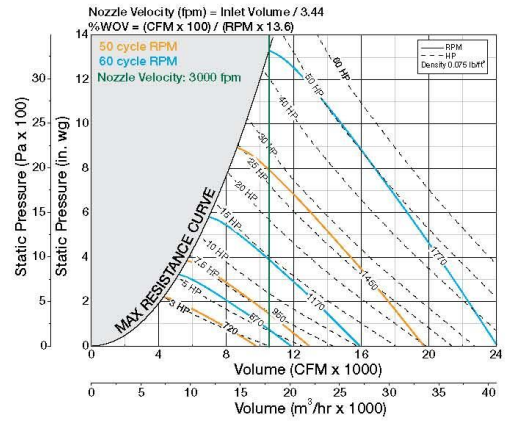
Inlet Airflow — 50% Wheel Width — **Outlet Airflow**

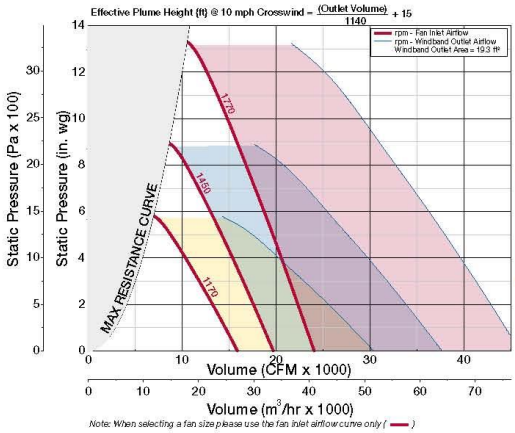
LV Low Velocity



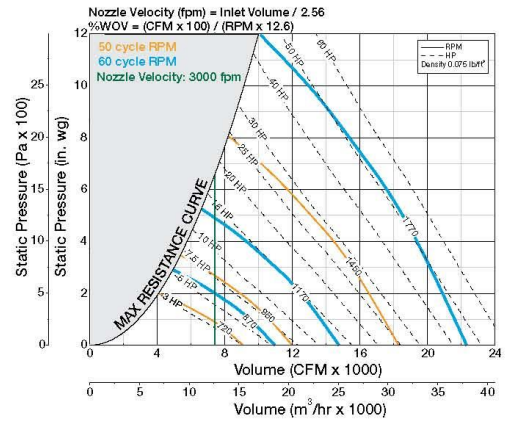


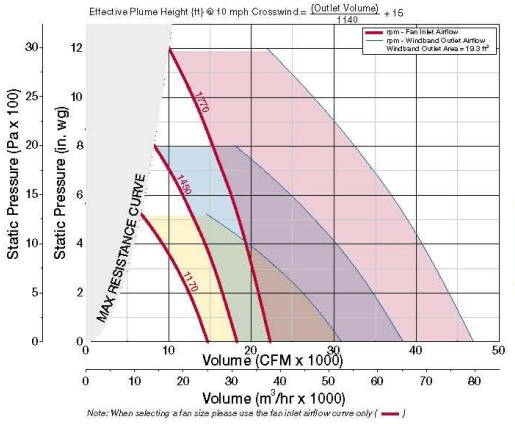
MV Medium Velocity





HV High Velocity



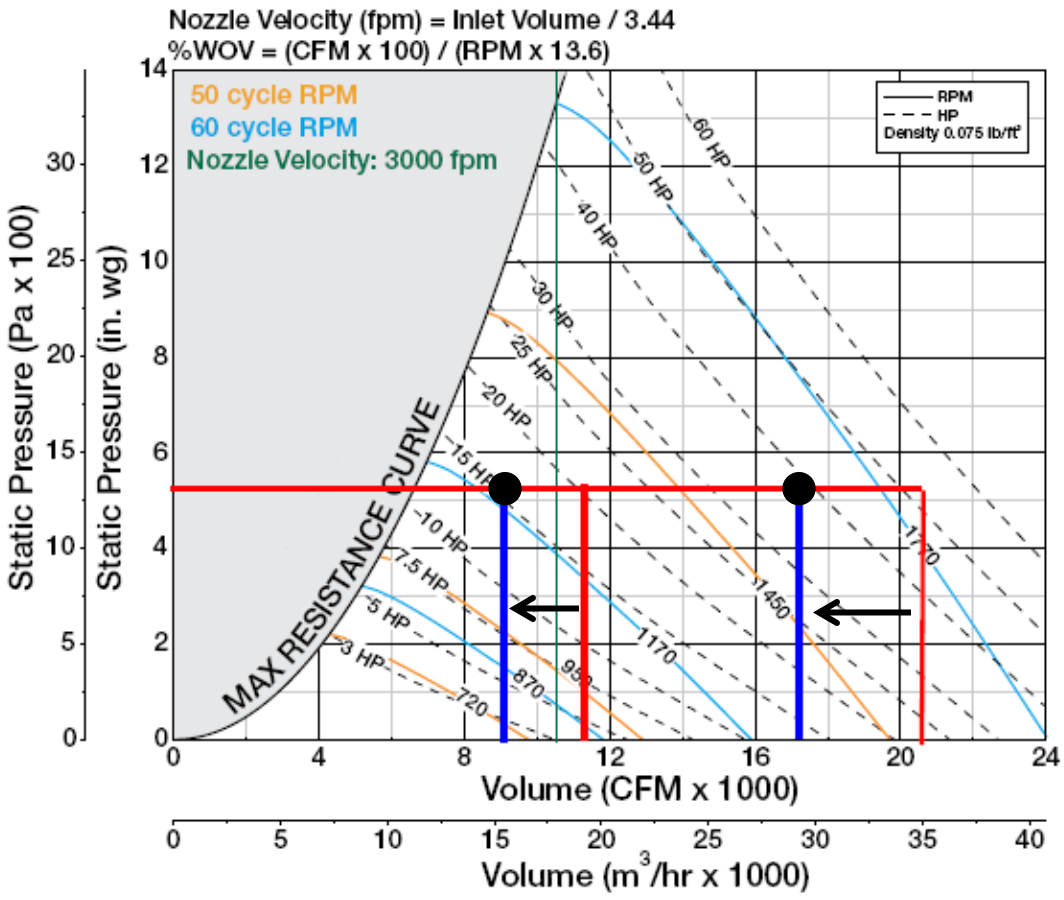


Performance certified is for installation Type A: Free inlet, Free outlet. Performance ratings do not include the effects of appurtenances (accessories). Power ratings (Bhp) do not include transmission losses. Performance ratings do not include the effects of cross winds.

Performance certified is for installation Type A: Free inlet, Free outlet. Performance ratings do not include the effects of appurtenances (accessories). Performance ratings do not include the effects of cross winds.

The AMCA Certified Ratings Seal applies to induced flow fan air performance and sound (AMCA Standard 260).

49


Nozzle Velocity (fpm) = Inlet Volume / 3.44
%WOV = (CFM x 100) / (RPM x 13.6)
50 cycle RPM
60 cycle RPM
Nozzle Velocity: 3000 fpm
RPM
HP
Density 0.075 lb/ft³
MAX RESISTANCE CURVE
60 HP
50 HP
40 HP
30 HP
25 HP
20 HP
15 HP
10 HP
7.5 HP
5 HP
3 HP
1750
1450
1170
950
870
720
Static Pressure (Pa x 100)
Static Pressure (in. wg)
Volume (CFM x 1000)
Volume (m³/hr x 1000)

APPENDIX 4.E: EXISTING AND UPDATED KEY EQUIPMENT SCHEDULES

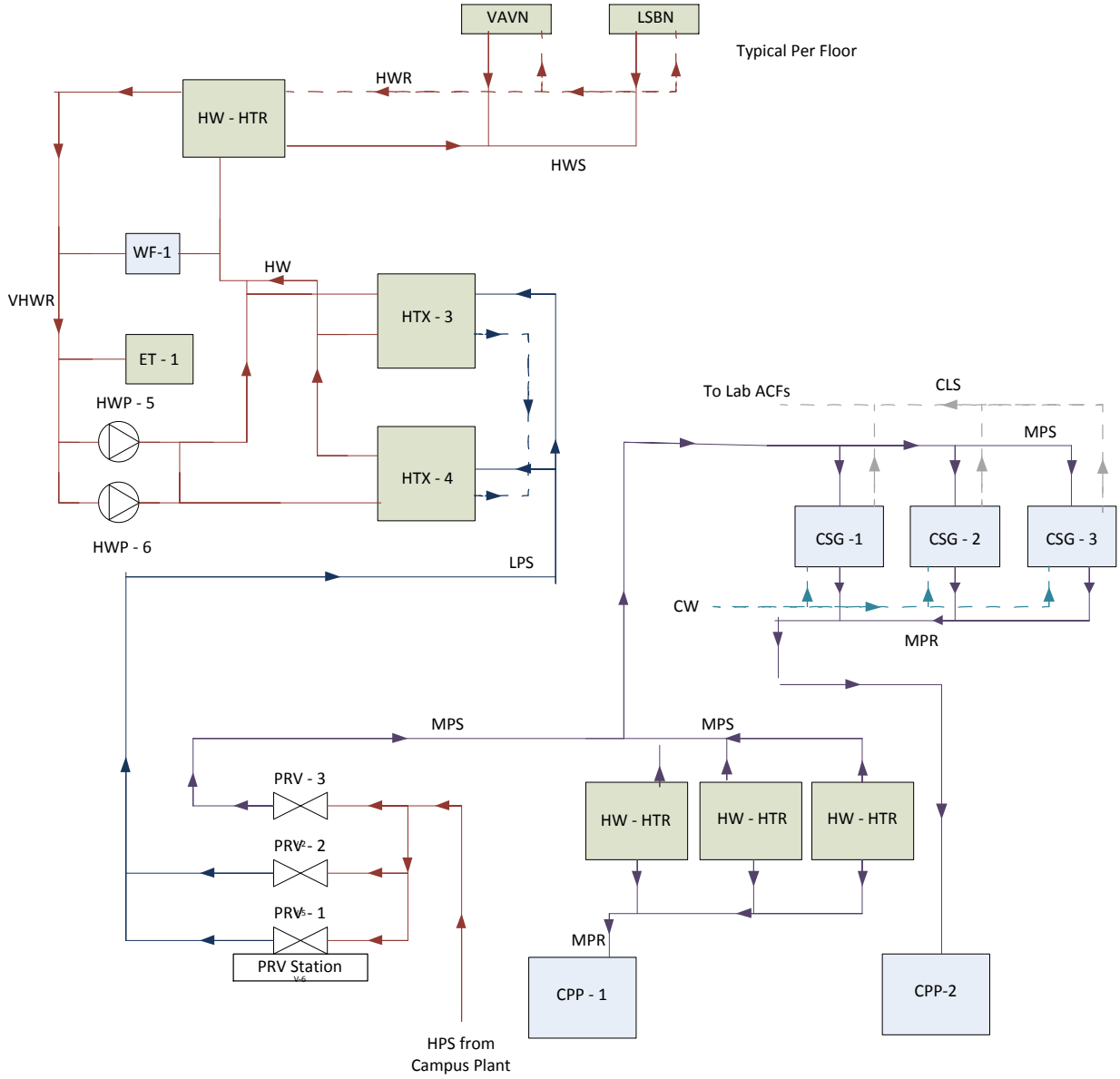
Existing Design - Pump Schedule for Ventilation Heating and AHU Chilled Water Coils								
Designation	Service	Location	GPM	Pump Head (ft. of H_2O)	Motor HP	Manufacturer	Model Number	RPM
CWP-1	Chilled Water	Basement Mezzanine	2780	150	150	Armstrong	SG-1010 Horizontal Spilt	1800
CWP-2	Chilled Water	Basement Mezzanine	2780	150	150	Armstrong	SG-1010 Horizontal Spilt	1800
CWP-3 Standby	Chilled Water	Basement Mezzanine	2780	150	150	Armstrong	SG-1010 Horizontal Spilt	1800
CWP-4	Chilled Water Low Flow	Basement Mezzanine	800	60	60	Armstrong	SG-88 Horizontal Spilt	1800
HWP-5	Ventilation Heating	First Floor	930	100	40	Armstrong	Series 4300 6x6x11.5 Vertical Inline	1800
HWP-6	Ventilation Heating	First Floor	930	100	40	Armstrong	Series 4300 6x6x11.5 Vertical Inline	1800

Existing Design – Basic Lab and Office AHU Schedule						
Designation	Service	Location	Capacity (cfm)	OA Capacity (cfm)	Heat Recovery Wheel	Supply Motor HP
ACF-1	Lab	Mech. Penthouse	50,000	50,000	Y	100
ACF-2	Lab	Mech. Penthouse	50,000	50,000	Y	100
ACF-3	Lab	Mech. Penthouse	50,000	50,000	Y	100
ACF-4	Lab	Mech. Penthouse	50,000	50,000	Y	100
ACF-5	Lab	Mech. Penthouse	50,000	50,000	Y	100
ACF-6	Offices	Mech. Penthouse	33,000	4,950	N	60
ACF-7	Offices	Mech. Penthouse	33,000	4,950	N	60
ACF-8	Offices	Mech. Penthouse	33,000	4,950	N	60

Proposed Design - Pump Schedule for Ventilation Heating and AHU Chilled Water Coils								
Designation	Service	Location	GPM	Pump Head (ft. of H_2O)	Motor HP	Manufacturer	Model Number	RPM
CWP-1	Active Chilled Beams CLG	Basement Mezzanine	2780	150	150	Armstrong	SG-1010 Horizontal Split	1800
CWP-2 Standby	Active Chilled Beams CLG	Basement Mezzanine	2780	150	150	Armstrong	SG-1010 Horizontal Split	1800
CWP-3	AHUs + Process CHW	Basement Mezzanine	2000	150	100	Armstrong	12x10x12.5H Horizontal Split	1800
CWP-4 Standby	AHUs + Process CHW	Basement Mezzanine	2000	150	100	Armstrong	12x10x12.5H Horizontal Split	1800
CWP-5	Chilled Water Low Flow	Basement Mezzanine	800	60	60	Armstrong	SG-88 Horizontal Split	1800
HWP-5	Active Chilled Beams HTG	First Floor	1400	100	50	Armstrong	8x8x11.5 Vertical Inline	1800
HWP-6 Standby	Active Chilled Beams HTG	First Floor	1400	100	50	Armstrong	8x8x11.5 Vertical Inline	1800

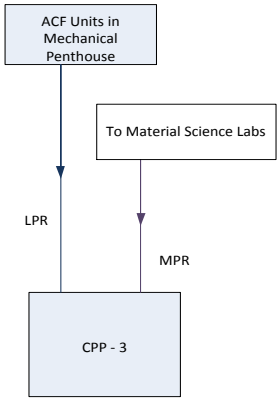
Proposed Design – Basic Lab and Office AHU Schedule						
Designation	Service	Location	Capacity (cfm)	OA Capacity (cfm)	Enthalpy/Sensible	Supply Motor HP
AHU-EXT-1	Lab/Office	Mech. Penthouse	36,000	36,000	Y/N	50
AHU-EXT-2	Lab/Office	Mech. Penthouse	36,000	36,000	Y/N	50
AHU-INT-LS1	Interior Lab Life Science	Mech. Penthouse	50,000	50,000	Y/Y	75
AHU-INT-LS2	Interior Lab Life Science	Mech. Penthouse	50,000	50,000	Y/Y	75
AHU-INT-MS1	Interior Lab Material Science	Mech. Penthouse	50,000	50,000	Y/Y	75
AHU-INT-MS2	Interior Lab Material Science	Mech. Penthouse	50,000	50,000	Y/Y	75

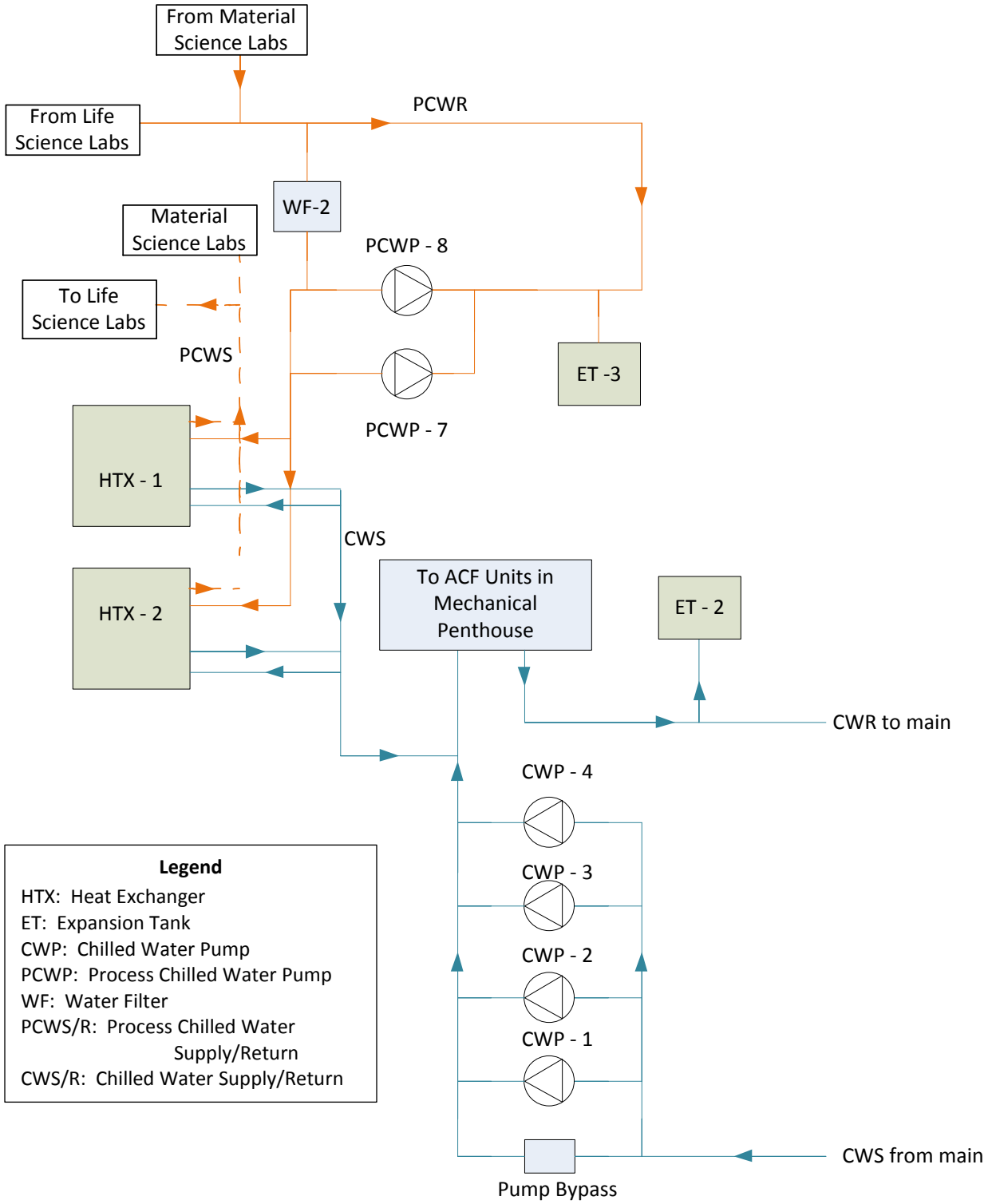
APPENDIX 4.F: EXISTING WATER FLOW DIAGRAMS



Legend

HW: Hot Water
HPS: High Pressure Steam
MPS: Medium Pressure Steam
LPS: Low Pressure Steam
CLS: Clean Steam
CW: Cold Water
CSG: Clean Steam Generator
PRV: Pressure Reducing Valve
ET: Expansion Tank
HTX: Heat Exchanger
CPP: Condensate Power Pump




From Material Science Labs
From Life Science Labs
PCWR
WF-2
Material Science Labs
PCWP - 8
To Life Science Labs
PCWS
ET -3
PCWP - 7
HTX - 1
CWS
HTX - 2
To ACF Units in Mechanical Penthouse
ET - 2
CWR to main
CWP - 4
CWP - 3
CWP - 2
CWP - 1
CWS from main
Pump Bypass
Legend
HTX: Heat Exchanger
ET: Expansion Tank
CWP: Chilled Water Pump
PCWP: Process Chilled Water Pump
WF: Water Filter
PCWS/R: Process Chilled Water Supply/Return
CWS/R: Chilled Water Supply/Return

APPENDIX 4.G: TRANE TRACE OUTPUTS

Energy Cost Budget / PRM Summary

By ACADEMIC

Project Name: Millennium Science Complex	Date: April 02, 2011
City: State College PA	Weather Data: Harrisburg, Pennsylvania

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

* Denotes the base alternative for the ECB-3 study

		* Alt-1 Existing Design			Alt-2 Proposed Design		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtu/hr	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtu/hr
Lighting - Conditioned	Electricity	594.4	4	177	596.6	100	178
Space Heating	Electricity	7.2	0	1	4.0	56	0
	Purchased Steam	7,019.9	43	2,859	5,604.3	80	1,514
Space Cooling	Purchased Chilled Water	4,952.8	30	2,930	3,756.9	76	2,751
Pumps	Electricity	1,331.3	8	152	1,495.5	112	181
Fans - Conditioned	Electricity	1,054.7	6	270	879.2	83	142
Receptacles - Conditioned	Electricity	1,518.3	9	451	1,576.3	104	464
Total Building Consumption		**16,478.5**			**13,912.8**		

		* Alt-1 Existing Design	Alt-2 Proposed Design
Total	**Number of hours heating load not met**	368	158
	Number of hours cooling load not met	2,670	0

	* Alt-1 Existing Design		Alt-2 Proposed Design	
	Energy 10^6 Btu/yr	Cost/yr $/yr	Energy 10^6 Btu/yr	Cost/yr $/yr
Electricity	4,505.8	102,089	4,551.6	100,277
Purchased Chilled Water	4,952.8	90,636	3,756.9	68,751
Purchased Steam	7,019.9	57,563	5,604.3	45,955
Total	**16,479**	**250,288**	**13,913**	**214,983**

Project Name: Millennium Science Complex
Dataset Name: 4-2 MSC FINAL.TRC

TRACE® 700 v6.2.6.5 calculated at 08:06 PM on 04/02/2011
Energy Cost Budget Report Page 1 of 1

MONTHLY UTILITY COSTS

By ACADEMIC

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
	------- Monthly Utility Costs -------												
Alternative 1													
Electric													
On-Pk Cons. ($)	6,093	5,550	6,378	5,257	5,208	5,163	5,371	5,336	4,965	5,331	5,289	6,069	66,010
On-Pk Demand ($)	2,988	2,988	2,996	2,997	2,999	3,030	3,063	3,047	2,978	3,004	2,997	2,991	36,079
Total ($):	9,081	8,539	9,374	8,254	8,207	8,194	8,435	8,383	7,943	8,335	8,287	9,059	102,089
Purchased Steam													
On-Pk Cons. ($)	10,655	9,525	10,798	4,085	890	723	713	768	882	3,383	4,154	10,988	57,563
Purchased Chilled Water													
On-Pk Cons. ($)	6,530	5,843	7,307	3,584	6,417	11,212	17,037	11,974	7,000	3,848	3,001	6,885	90,636
Monthly Total ($):	26,266	23,907	27,478	15,923	15,514	20,128	26,184	21,125	15,825	15,565	15,442	26,932	250,288

Building Area = 42,827 ft²

Utility Cost Per Area = 5.84 $/ft²

Project Name: Millennium Science Complex
Dataset Name: 4-2 MSC FINAL.TRC

TRACE® 700 v6.2.6.5 calculated at 08:06 PM on 04/02/2011
Monthly Utility Costs report Page 1 of 2

MONTHLY UTILITY COSTS

By ACADEMIC

Utility	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
	------- Monthly Utility Costs -------												
Alternative 2													
Electric													
On-Pk Cons. ($)	5,691	5,135	5,611	5,287	5,718	5,686	5,792	5,868	5,486	5,533	5,318	5,556	66,681
On-Pk Demand ($)	2,792	2,792	2,773	2,779	2,816	2,820	2,818	2,820	2,816	2,800	2,779	2,792	33,596
Total ($):	8,484	7,928	8,384	8,066	8,533	8,506	8,610	8,687	8,302	8,333	8,097	8,348	100,277
Purchased Steam													
On-Pk Cons. ($)	7,193	6,586	6,229	4,224	1,641	773	702	834	1,499	3,984	5,196	7,094	45,955
Purchased Chilled Water													
On-Pk Cons. ($)	2,540	2,168	3,234	3,314	5,704	9,891	16,067	10,508	5,991	3,673	3,117	2,546	68,751
Monthly Total ($):	18,216	16,682	17,847	15,604	15,878	19,170	25,379	20,029	15,792	15,990	16,409	17,987	214,983

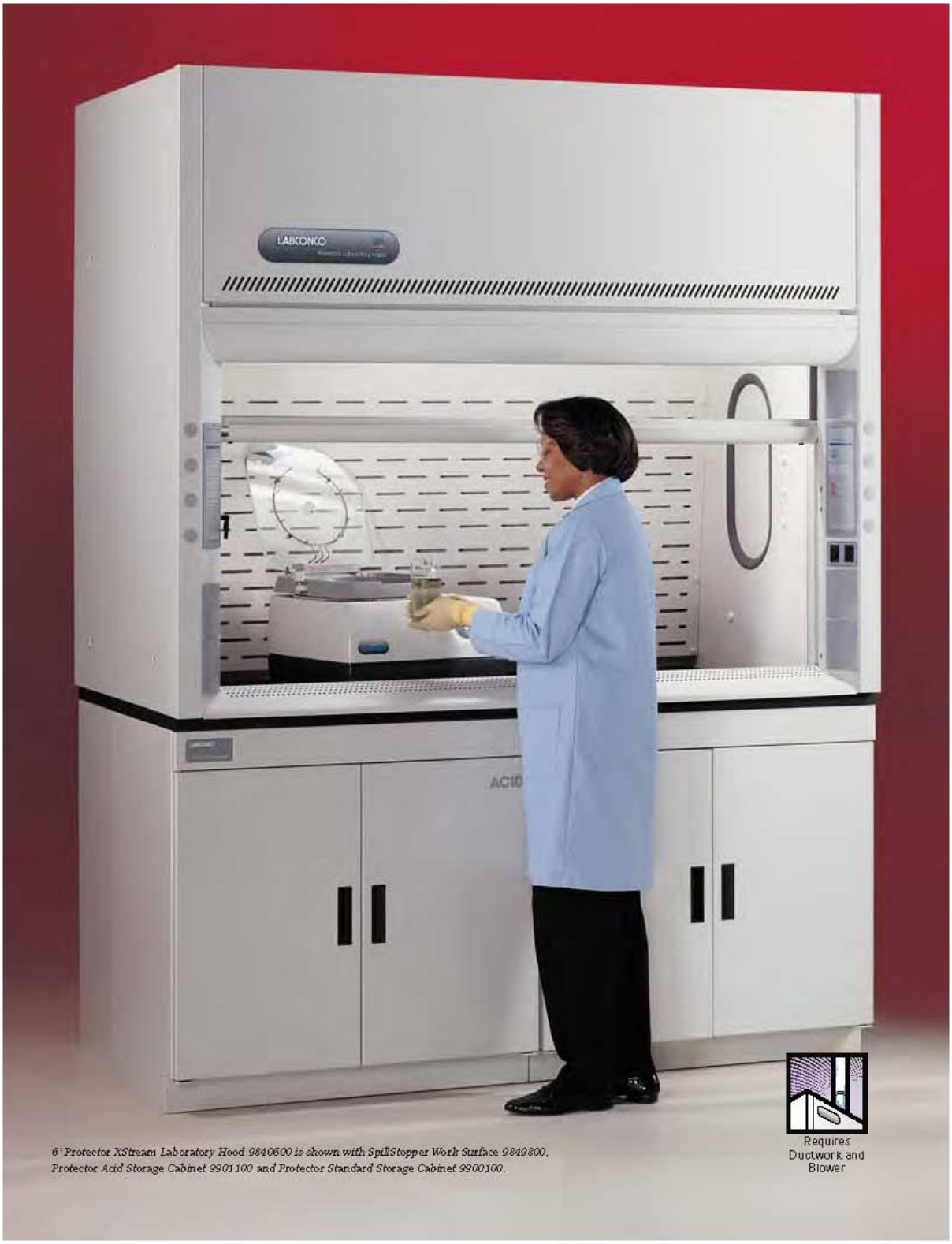
Building Area = 42,827 ft²

Utility Cost Per Area = 5.02 $/ft²

Project Name: Millennium Science Complex
Dataset Name: 4-2 MSC FINAL.TRC

TRACE® 700 v6.2.6.5 calculated at 08:06 PM on 04/02/2011
Monthly Utility Costs report Page 2 of 2

APPENDIX 4.H: LOW FLOW FUME HOOD CUTSHEETS



6' Protector XStream Laboratory Hood 9840600 is shown with SpillStopper Work Surface 9849800, Protector Acid Storage Cabinet 9901100 and Protector Standard Storage Cabinet 9900100.

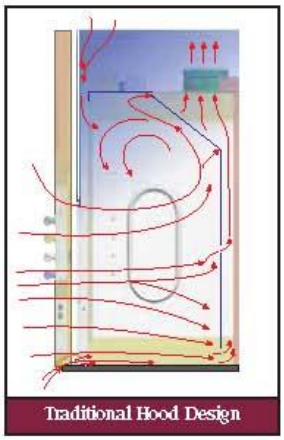
Protector® XStream® Laboratory Hoods

Patented High Performance and Low Flow Features & Benefits*

With its energy savings potential and unsurpassed containment, *regardless of sash position*, the patented Protector XStream is truly a high performance hood. Features, such as an upper dilution air supply, containment-enhancing sash handle, rear downflow dual baffle system and air foil, work together to decrease turbulence and enhance airflow. When operated at OSHA-approved 60 fpm face velocity, Protector XStream Laboratory Hoods provide an excellent economic payback when compared to traditional hoods running at 80 or 100 fpm.

These panel-lined hoods are available in 4', 5', 6' and 8' widths. They are designed to be used with a remotely-located blower or building exhaust system.

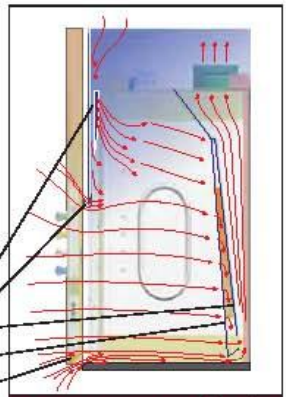
Using the concepts of fluid dynamics, Labconco researchers engineered the Protector XStream Laboratory Hood with **horizontal laminar airflow to reduce the tendencies for turbulence.** The innovative and aerodynamic designs of the sash handle, air foil, upper dilution air supply and rear downflow baffle work in concert to produce horizontal airflow patterns that significantly reduce concentrations of chemical contaminants throughout the work area, particularly near the face of the hood, the operator's breathing zone and at the work surface. Depending on sash position, tendencies for air turbulence, vortexing and **"the roll" frequently observed during traditional fume hood smoke tests are virtually eliminated.**



Traditional Hood Design

Smoke tests on traditional hoods show the tendency for contaminants generated in the interior to roll forward producing high concentrations of contaminants behind the sash in close proximity to the user's breathing zone.

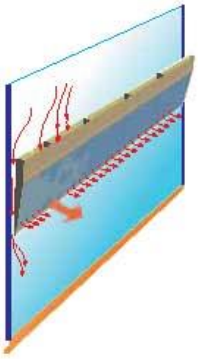
In contrast, smoke tests on Protector XStream Hoods show contaminants removed in a single pass and a remarkable lack of turbulence. Horizontal laminar air flowing toward the baffle forces contaminants to the rear interior, away from the user. The upper dilution air supply sweeps the upper interior to eliminate stagnant pockets of air and to prevent contaminants from concentrating in the area behind the sash.



Protector XStream Hood Design

Upper Dilution Air Supply

The **sash interior is constantly bathed with room air** from the dilution supply above the work area to eliminate chemical fumes along the sash plane, near the critical breathing zone. Five to ten percent of the required air volume is introduced through the dilution air supply to ensure maximum containment and greatest worker protection. **No additional blowers are required.**



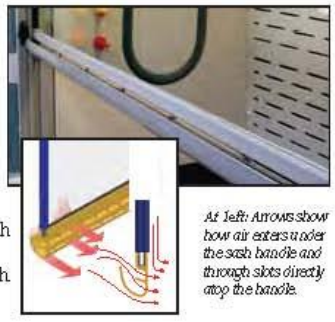
Rear Downflow Dual Baffle System

When the sash is open to the 18" working height or 28" loading height, the slots in the primary baffle **direct inflow air in non-turbulent streams** from the hood face into the baffle in a single pass. The secondary baffle, located between the primary baffle and the back wall, counteracts the upward air streams that create roll in traditional hoods by forcing the air movement downward before exhausting. **No moving mechanical components are used.**

Smoke released inside the hood moves in a horizontal stream to the primary baffle slots.

Containment-Enhancing Sash Handle

The revolutionary sash handle design includes a perforated air passage directly atop the handle to bleed air into the hood chamber and **direct chemical fume concentrations away from the user's breathing zone.** The large radiused sash handle sweeps airflow into the hood with minimal turbulence. Its ergonomic design is comfortable to the touch and easy to grasp to raise and lower the sash.



At left: Arrows show how air enters under the sash handle and through slots directly atop the handle.

Exclusive Feature

** US. Patent No. 6,461,233*

Protector® XStream® Laboratory Hoods

Additional Features & Benefits

Front and side panels may be easily removed for lamp replacement and access to electrical supply connections.

Fluorescent lighting illuminates the interior. The high efficiency, instant start, T8 fluorescent lights are located outside the hood interior for corrosion-resistance and easy replacement. Contact Labconco for ordering information on explosion-proof lighting.

Durable and attractive exterior is glacier white, dry powder epoxy-coated steel.

Large 28" sash opening offers superior viewing. When fully open, the sash does not extend above the hood.

Vertical-rising tempered safety glass sash is anti-jacking for smooth operation.

Chemical-resistant, fiberglass-reinforced composite panel liner surpasses all national codes for flame spread and has a bright white surface for excellent light reflectivity.

Service access panels allow accessibility to plumbing from the front and inside of the hood.

Color-coded service fixtures for gas, air, water, vacuum and other services have remote controls for use regardless of the sash position. Two service fixtures are pre-plumbed on fixtured models. Each hood is factory prepared for up to eight service fixtures (four on each side).

By-pass airflow design ensures stable face velocities that meet or exceed established standards.

ETL-listed. Hoods carry the ETL mark signifying that they are certified to UL 3101-1/61010-1, UL 1805 and CAN/CSA C22.2 No. 1010.1.

Performance tested to ASHRAE 110-1995.

CE mark. All 230 volt, 50 Hz models conform to the CE (European Community) requirements for electrical safety and electromagnetic compatability.

Sash stop located at 18" working height maximizes energy conservation by preventing the sash from being raised further unless manually released.

Ergonomic air foil allows air to sweep the work surface for maximum containment. Clean-Sweep* airflow openings pull inflow air from under the air foil so that clean air continually flows over the air foil creating a constant barrier of protection from contaminants.

Pre-wired electrical components. Fluorescent lights and switches are factory-wired to the hood's single point junction box. One electrical duplex receptacle is factory-wired on 115 volt, 60 Hz fixtured models. Each hood is factory-prepared for up to four electrical duplexes and an airflow monitor.

Exclusive Feature

**U.S. Patent No. 6,461,233*

Protector® XStream® Laboratory Hoods

6' Protector XStream Laboratory Hood 9340600 is shown with SpillStopper Work Surface 9949800, Protector Acid Storage Cabinet 9901100 and Protector Standard Storage Cabinet 9900100. Blower, ductwork, worksurface and base cabinets must be ordered separately.

All models feature:

- By-pass airflow design.
- Ergonomic air foil with aerodynamic Clean-Sweep® airflow openings.
- Upper Dilution Air Supply.®
- Glacier white, dry powder epoxy-coated steel exterior.
- Chemical-resistant, fiberglass-reinforced, composite panel liner and pre-set Rear Downflow Dual Baffle System® with flame spread less than 25 per ASTM E-84.
- 3/16" thick tempered safety glass vertical-rising sash with epoxy-coated aluminum sash handle with large radius and perforations.®
- Removable front and side panels and front and interior service access panels for access to plumbing and electrical wiring.
- Pre-wired T8 fluorescent lighting, ADA-compliant light and blower switches for 115 volt, 60 Hz operation.
- Sash stop located at 18" sash opening position.
- Epoxy-coated stainless steel, 12.81" ID exhaust connection(s).

*Contact Labconco at **800-821-5525** or **816-333-8811** for ordering information on explosion-proof lighting and other sash configurations and for blower sizing assistance.*

All models conform to the following regulations and standards:

- SEFA 1-2006
- NFPA 45-2004
- ASTM E84-09C
- ASHRAE 110-95
- ANSI Z9.5-2003
- UL 3101-1/61010-1
- CAN/CSA C22.2 No. 1010.1
- UL 1805
- CE Conformity Marking (230 volt models)

Fixtured models feature:

- Two pre-plumbed service fixtures with forged brass valves, lower right side with brass tubing for gas and lower left side with copper tubing for cold water. Components for converting either or both fixtures to air and vacuum are provided. **Inlet tubing is not provided.**
- One pre-wired 115 volt, 20 amp electrical duplex receptacle on lower right side.

All models require (not included):

- ***Remote Blower.*** See back pocket.
- ***Ductwork.*** See back pocket.
- ***Work Surface.*** See pages 100-104.
- ***Base Cabinet or Stand.*** See pages 106-116.

Optional accessories for on-site installation include:

- ***Service Fixture Kits.*** See page 117.
- ***Electrical Duplex Kits.*** See page 118.
- ***Guardian Airflow Monitor Kits.*** See page 118.
- ***Ceiling Enclosure and Rear Finish Panel Kits.*** See pages 119-120.
- ***Distillation Grid Kits.*** See page 120.
- ***Sash Stop Kits.*** See page 121.
- ***Snuffer Fire Extinguishers.*** See page 121.

® U.S. Patent No. 6,461,233

Heights of switches, electrical receptacle and service fixtures meet requirements of A.D.A.

Exclusive Feature

23

Ordering Information

Protector® XStream® Laboratory Hoods

ASHRAE 110-95 tests show less than 0.05 ppm leak rate when tested at 4.0 lpm; at OSHA-recognized 60, 80, and 100 fpm face velocity and sash positions of 18" and 28". To ensure performance at 60 fpm, Labconco engineers challenged the Protector XStream Hood under adverse conditions such as 30-75 fpm cross drafts, interior obstructions and average face velocities as low as 40 fpm. Contact Labconco for a technical paper with complete ASHRAE test data or visit our airflow test facility for hands-on testing.

Total Exhaust CFM and Static Pressure @ 18" Sash Opening (60% open)

Nominal Width	100 fpm	s.p.	80 fpm	s.p.	60 fpm	s.p.	CFM Savings at 60 fpm vs. 100 fpm	Total Average Annual Dollar Savings at 60 fpm vs. 100 fpm*
4 feet	470	0.11"	380	0.07"	280	0.04"	190	$1330
5 feet	610	0.13"	490	0.08"	370	0.05"	240	$1680
6 feet	750	0.15"	600	0.10"	450	0.06"	300	$2100
8 feet	1060	0.12"	850	0.08"	640	0.04"	420	$2940

Total Exhaust CFM and Static Pressure @ 28" Sash Opening (100% open)

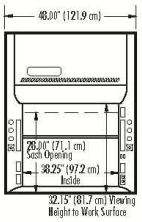
Nominal Width	100 fpm	s.p.	80 fpm	s.p.	60 fpm	s.p.	CFM Savings at 60 fpm vs. 100 fpm	Total Average Annual Dollar Savings at 60 fpm vs. 100 fpm*
4 feet	730	0.25"	590	0.13"	440	0.08"	290	$2030
5 feet	960	0.30"	770	0.19"	580	0.11"	380	$2660
6 feet	1180	0.36"	940	0.23"	710	0.13"	470	$3290
8 feet	1660	0.28"	1330	0.18"	1000	0.10"	660	$4620

**Based on average annual dollars per CFM usage of $7.00; fume hood operating 24 hours a day and 5 days per week (6240 hours per year). Average annual dollars per CFM usage can range from $5.00 – $12.00 depending on geographic location.*

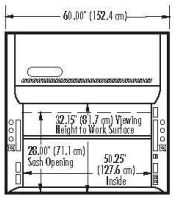
Catalog Number	Nominal Width	Electrical Requirements	Exterior Depth	Interior Working Depth	Fluorescent Lamps	Service Fixtures	Electrical Duplex	Exhaust Collar(s)	Shipping Wt. lbs./kg
9840400	4 feet	115 volts, 60 Hz	39.20"	27.3"	(2) 25 watt	None	None	12.81" ID	440/200
9840401	4 feet	115 volts, 60 Hz	39.20"	27.3"	(2) 25 watt	2	1	12.81" ID	450/204
9840402**	4 feet	230 volts, 50 Hz	39.20"	27.3"	(2) 25 watt	None	None	12.81" ID	440/200
9840403**	4 feet	230 volts, 50 Hz	39.20"	27.3"	(2) 25 watt	2	None	12.81" ID	450/204
9840500	5 feet	115 volts, 60 Hz	39.20"	27.3"	(2) 32 watt	None	None	12.81" ID	525/238
9840501	5 feet	115 volts, 60 Hz	39.20"	27.3"	(2) 32 watt	2	1	12.81" ID	525/243
9840502**	5 feet	230 volts, 50 Hz	39.20"	27.3"	(2) 32 watt	None	None	12.81" ID	525/238
9840503**	5 feet	230 volts, 50 Hz	39.20"	27.3"	(2) 32 watt	2	None	12.81" ID	535/243
9840600	6 feet	115 volts, 60 Hz	39.20"	27.3"	(2) 32 watt	None	None	12.81" ID	600/272
9840601	6 feet	115 volts, 60 Hz	39.20"	27.3"	(2) 32 watt	2	1	12.81" ID	610/277
9840602**	6 feet	230 volts, 50 Hz	39.20"	27.3"	(2) 32 watt	None	None	12.81" ID	600/272
9840603**	6 feet	230 volts, 50 Hz	39.20"	27.3"	(2) 32 watt	2	None	12.81" ID	610/277
9840800	8 feet	115 volts, 60 Hz	39.20"	27.3"	(4) 25 watt	None	None	(2) 12.81" ID	770/349
9840801	8 feet	115 volts, 60 Hz	39.20"	27.3"	(4) 25 watt	2	1	(2) 12.81" ID	780/354
9840802**	8 feet	230 volts, 50 Hz	39.20"	27.3"	(4) 25 watt	None	None	(2) 12.81" ID	770/349
9840803**	8 feet	230 volts, 50 Hz	39.20"	27.3"	(4) 25 watt	2	None	(2) 12.81" ID	780/354

***International electrical configuration*

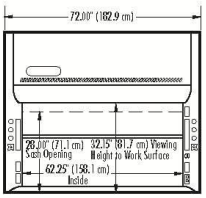
4 Feet
98404 Series



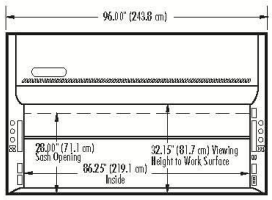
5 Feet
98405 Series



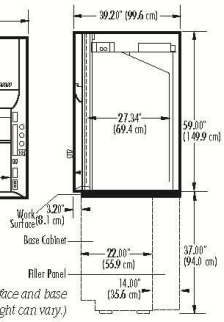
6 Feet
98406 Series



8 Feet
98408 Series



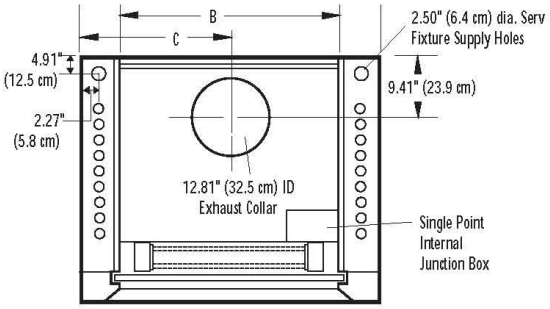
Side View /
All Models



(Side view shown with accessory work surface and base cabinet available for all hood widths. Height can vary.)

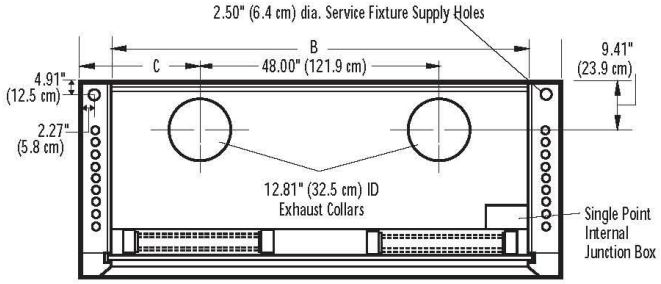
Dimensional Data

Protector® XStream® Laboratory Hoods

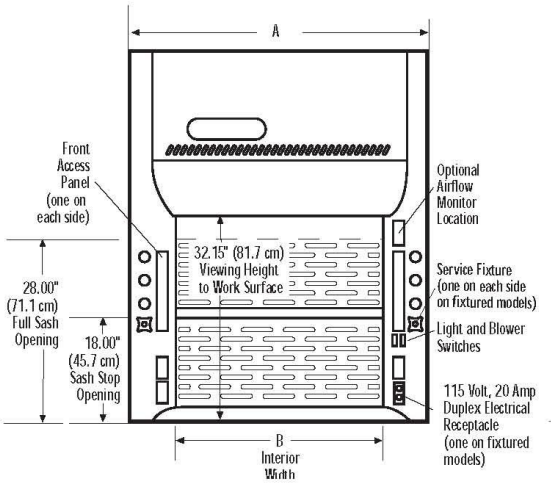


TOP 4', 5', 6'

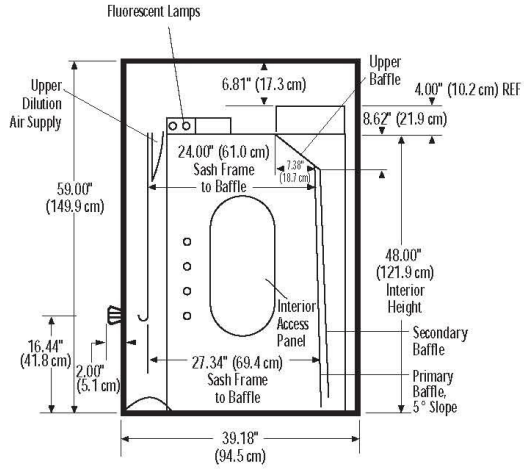
	A	B	C
4' Hood	48.00" (121.9 cm	38.25" (97.2 cm)	24.00" (61.0 cm)
5' Hood	60.00" (152.4 cm)	50.25" (127.6 cm)	30.00" (76.2 cm)
6' Hood	72.00" (182.9 cm)	62.25" (158.1 cm)	36.00" (91.4 cm)
8' Hood	96.00" (243.8 cm)	86.25" (219.1 cm)	24.00" (61.0 cm)



TOP 8'



FRONT



SIDE

*Contact Labconco at **800-821-5525** or **816-333-8811** or visit **www.labconco.com** for detailed AutoCAD drawings.*

APPENDIX 4.I: ADDITIONAL CFD DATA

Detailed Geometries						
Element	Length	Width	Height	Location		
	Δx (m)	Δy (m)	Δz (m)	x (m)	y (m)	z (m)
Room	3.3528	3.218	3.3528	-	-	-
Human	0.5	0.5	1.89	2.48	1.21	0.0
Table	1.0668	0.853	1.0668	0.579997	0.0	0.0
Fume Hood Base	1.4	0.853	1.0668	1.9528	0.0	0.0
Fume Hood Wall1	0.0	0.853	2.0	1.9528	0.0	0.0
Fume Hood Wall2	0.0	0.853	2	3.3528	0.0	0.0
Fume Hood Sash	1.4	0.0	0.48	1.9528	0.853	1.52
Fume Hood Top	1.4	0.853	0.1	1.9528	0.0	2.00
Table (2)	3.3528	0.609759	1.0668	0.0	2.608241	0
Cabinet	0.914630	0.304800	0.914630	2.0	2.9132	1.6
Wallboard	1.544630	0.075	1.15	0.0	3.143	1.429996
General Exhaust	0.609	0.609	0.0	2.0	2.0	3.3528
Ceiling Diffuser (16, locations vary)	0.15225	0.15225	0.15225	Varies		
Contaminant Inlet C=1000	0.335280	0.3048	0.0	2.557516	0.49	1.06685
Fume Hood Outlet	1.4	0.853	0.0	1.952800	0.0	2

Surface Temperatures of applicable elements were set at 25°C

Model Parameters	
Turbulence Model	KECHEN
Differencing Scheme	Hybrid
Energy Equation	Temperature
Iterations	4,000
Ambient Temperature	25°C
Grid Size	55 x 45 x 42

Inlet Conditions			
Scenario	Desired Exhaust Flow	Total Inlet Diffuser Flow	Inlet Velocity/ Cell
	CFM	CFM	m/s
80 FPM, 18" Sash	540	500	0.629
80 FPM, 30" Sash	900	800	1.006
100 FPM, 18" Sash	675	600	0.787
100 FPM, 30" Sash	1125	1000	1.258

CFD File Results: Residuals					
Scenario	Mass Residual	Temperature Residual	KE Residual	EP Residual	Simulation Length (hr:min)
100 fpm, 18" Sash	1.01%	0.01%	11.6%	0.6%	1:59
80 fpm, 18" Sash	0.63%	0.009%	12.5%	0.1%	2:05
100 fpm, 30" Sash	1.60%	0.01%	12.5%	0.9%	2:04
80 fpm, 30" Sash	1.11%	0.01%	9.8%	0.45%	2:06

APPENDIX 4.J: LIFE CYCLE COST BREAKDOWN

Table Ca-1. Projected fuel price indices (excluding general inflation), by end-use sector and fuel type.

Census Region 1 (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont)

Projected April 1 Fuel Price Indices (April 1, 2010 = 1.00)

Sector and Fuel	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Residential															
Electricity	0.94	0.98	1.01	1.01	1.01	1.02	1.03	1.03	1.03	1.04	1.05	1.05	1.06	1.06	1.05
Distillate Oil	1.00	1.05	1.11	1.15	1.18	1.23	1.27	1.31	1.34	1.36	1.37	1.38	1.39	1.41	1.42
LPG	0.99	1.02	1.06	1.10	1.13	1.15	1.17	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26
Natural Gas	1.05	1.07	1.06	1.04	1.04	1.05	1.05	1.05	1.05	1.06	1.07	1.08	1.09	1.09	1.10
Commercial															
Electricity	0.90	0.92	0.94	0.93	0.92	0.93	0.95	0.95	0.96	0.97	0.98	0.99	1.00	1.01	1.01
Distillate Oil	1.01	1.07	1.14	1.19	1.23	1.29	1.33	1.37	1.40	1.43	1.44	1.46	1.48	1.49	1.50
Residual Oil	1.00	1.10	1.23	1.32	1.37	1.43	1.49	1.54	1.60	1.64	1.66	1.68	1.71	1.73	1.75
Natural Gas	1.07	1.13	1.13	1.11	1.11	1.12	1.12	1.12	1.12	1.13	1.14	1.16	1.17	1.17	1.18
Coal	0.98	0.98	0.98	0.98	0.98	0.97	0.97	0.96	0.95	0.95	0.94	0.95	0.95	0.95	0.95
Industrial															
Electricity	0.85	0.88	0.90	0.87	0.87	0.88	0.90	0.91	0.91	0.92	0.93	0.94	0.96	0.97	0.97
Distillate Oil	1.03	1.10	1.16	1.22	1.26	1.32	1.36	1.41	1.44	1.47	1.48	1.50	1.52	1.53	1.54
Residual Oil	1.01	1.10	1.22	1.31	1.36	1.41	1.46	1.51	1.57	1.60	1.62	1.64	1.66	1.69	1.71
Natural Gas	1.16	1.27	1.28	1.26	1.26	1.26	1.26	1.26	1.26	1.27	1.29	1.31	1.33	1.33	1.34
Coal	0.99	0.99	0.98	0.98	0.97	0.97	0.97	0.96	0.96	0.95	0.95	0.95	0.95	0.95	0.95
Transportation															
Motor Gasoline	1.04	1.09	1.17	1.23	1.25	1.28	1.31	1.33	1.35	1.37	1.38	1.40	1.41	1.42	1.43

Table Ca-1, continued. Projected fuel price indices (excluding general inflation), by end-use sector and fuel type.

Census Region 1 (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont)

Projected April 1 Fuel Price Indices (April 1, 2010 = 1.00)

Sector and Fuel	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Residential															
Electricity	1.06	1.06	1.07	1.09	1.10	1.11	1.12	1.12	1.13	1.13	1.14	1.15	1.15	1.16	1.17
Distillate Oil	1.44	1.45	1.46	1.49	1.50	1.52	1.54	1.56	1.59	1.61	1.63	1.65	1.66	1.68	1.70
LPG	1.26	1.27	1.28	1.29	1.30	1.31	1.33	1.34	1.35	1.37	1.38	1.39	1.40	1.41	1.43
Natural Gas	1.11	1.12	1.14	1.16	1.19	1.21	1.23	1.24	1.25	1.26	1.27	1.29	1.30	1.31	1.32
Commercial															
Electricity	1.01	1.02	1.03	1.05	1.06	1.08	1.10	1.12	1.13	1.14	1.15	1.15	1.16	1.17	1.17
Distillate Oil	1.52	1.54	1.56	1.58	1.59	1.62	1.64	1.67	1.69	1.72	1.74	1.76	1.79	1.81	1.83
Residual Oil	1.77	1.78	1.81	1.83	1.86	1.89	1.92	1.94	1.98	2.00	2.03	2.06	2.10	2.14	2.17
Natural Gas	1.19	1.20	1.22	1.25	1.28	1.31	1.33	1.33	1.35	1.36	1.38	1.39	1.41	1.43	1.44
Coal	0.95	0.95	0.95	0.96	0.97	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.99	0.99
Industrial															
Electricity	0.97	0.98	1.00	1.02	1.04	1.06	1.09	1.10	1.11	1.13	1.13	1.14	1.15	1.15	1.16
Distillate Oil	1.56	1.58	1.60	1.62	1.64	1.66	1.69	1.71	1.74	1.77	1.79	1.81	1.83	1.85	1.87
Residual Oil	1.72	1.73	1.76	1.78	1.80	1.84	1.86	1.88	1.91	1.93	1.96	1.99	2.03	2.06	2.10
Natural Gas	1.36	1.38	1.41	1.45	1.48	1.53	1.56	1.58	1.60	1.62	1.64	1.66	1.69	1.72	1.75
Coal	0.95	0.95	0.95	0.96	0.96	0.96	0.96	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98
Transportation															
Motor Gasoline	1.45	1.46	1.48	1.50	1.51	1.52	1.54	1.56	1.58	1.60	1.62	1.63	1.65	1.66	1.68

Table S-1, continued. Projected fuel price indices with assumed general price inflation rates of 2 %, 3 %, 4 %, and 5 %, by end-use sector and fuel type.

Census Region 1 (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont)

Projected April 1 Fuel Price Indices (April 1, 2010 = 1.00)

COMMERCIAL

	Electricity				Distillate Oil				Residual Oil				Natural Gas				Coal			
	Inflation Rate				Inflation Rate				Inflation Rate				Inflation Rate				Inflation Rate			
Year	2 %	3 %	4 %	5 %	2 %	3 %	4 %	5 %	2 %	3 %	4 %	5 %	2 %	3 %	4 %	5 %	2 %	3 %	4 %	5 %
2011	0.92	0.92	0.93	0.94	1.03	1.04	1.05	1.06	1.02	1.03	1.04	1.05	1.09	1.10	1.11	1.12	1.00	1.01	1.02	1.03
2012	0.96	0.98	0.99	1.01	1.11	1.14	1.16	1.18	1.15	1.17	1.19	1.21	1.17	1.20	1.22	1.24	1.02	1.04	1.06	1.08
2013	1.00	1.03	1.06	1.09	1.21	1.24	1.28	1.32	1.30	1.34	1.38	1.42	1.20	1.23	1.27	1.31	1.04	1.07	1.10	1.13
2014	1.00	1.04	1.08	1.12	1.29	1.34	1.39	1.45	1.43	1.49	1.55	1.61	1.20	1.25	1.30	1.35	1.06	1.10	1.15	1.19
2015	1.02	1.07	1.12	1.18	1.36	1.43	1.50	1.57	1.52	1.59	1.67	1.75	1.23	1.29	1.35	1.42	1.08	1.13	1.19	1.25
2016	1.05	1.11	1.18	1.25	1.45	1.53	1.63	1.72	1.61	1.71	1.81	1.92	1.26	1.34	1.42	1.50	1.09	1.16	1.23	1.30
2017	1.09	1.16	1.24	1.33	1.53	1.64	1.75	1.87	1.71	1.83	1.96	2.09	1.28	1.37	1.47	1.57	1.11	1.19	1.27	1.36
2018	1.12	1.21	1.31	1.41	1.61	1.74	1.88	2.03	1.81	1.95	2.11	2.28	1.31	1.42	1.53	1.65	1.13	1.22	1.32	1.42
2019	1.14	1.25	1.36	1.49	1.68	1.83	2.00	2.18	1.92	2.09	2.28	2.49	1.34	1.47	1.60	1.74	1.14	1.24	1.36	1.48
2020	1.18	1.30	1.43	1.58	1.74	1.92	2.12	2.33	2.00	2.20	2.42	2.67	1.38	1.52	1.67	1.84	1.16	1.28	1.41	1.55
2021	1.22	1.36	1.51	1.67	1.79	2.00	2.22	2.47	2.06	2.30	2.56	2.84	1.42	1.58	1.76	1.95	1.17	1.30	1.45	1.61
2022	1.25	1.41	1.58	1.77	1.85	2.08	2.34	2.62	2.13	2.40	2.70	3.02	1.47	1.65	1.85	2.08	1.20	1.35	1.51	1.70
2023	1.30	1.47	1.67	1.89	1.91	2.17	2.46	2.78	2.21	2.51	2.84	3.22	1.51	1.72	1.95	2.21	1.23	1.39	1.58	1.79
2024	1.33	1.53	1.75	2.00	1.96	2.25	2.57	2.94	2.28	2.62	3.00	3.43	1.55	1.77	2.03	2.32	1.26	1.44	1.65	1.89
2025	1.35	1.57	1.81	2.09	2.02	2.34	2.71	3.13	2.36	2.73	3.16	3.65	1.58	1.83	2.12	2.45	1.28	1.48	1.71	1.97
2026	1.39	1.62	1.89	2.20	2.09	2.44	2.85	3.32	2.42	2.83	3.31	3.85	1.63	1.91	2.23	2.60	1.31	1.53	1.79	2.08
2027	1.42	1.68	1.98	2.33	2.15	2.54	2.99	3.52	2.50	2.95	3.48	4.09	1.69	1.99	2.34	2.76	1.33	1.57	1.85	2.18
2028	1.47	1.75	2.08	2.47	2.22	2.65	3.15	3.74	2.58	3.08	3.66	4.35	1.75	2.08	2.48	2.95	1.36	1.62	1.93	2.30
2029	1.53	1.84	2.21	2.65	2.30	2.77	3.33	3.99	2.67	3.21	3.86	4.63	1.82	2.19	2.63	3.16	1.39	1.68	2.02	2.42
2030	1.58	1.92	2.33	2.82	2.37	2.88	3.49	4.23	2.76	3.36	4.07	4.93	1.90	2.30	2.80	3.39	1.43	1.74	2.11	2.56
2031	1.64	2.02	2.47	3.02	2.45	3.01	3.69	4.51	2.87	3.52	4.32	5.28	1.98	2.43	2.98	3.64	1.46	1.80	2.20	2.69
2032	1.71	2.11	2.61	3.23	2.54	3.15	3.90	4.81	2.97	3.68	4.55	5.62	2.05	2.54	3.14	3.88	1.49	1.85	2.29	2.82
2033	1.76	2.20	2.75	3.43	2.63	3.29	4.11	5.13	3.05	3.82	4.77	5.95	2.10	2.63	3.29	4.10	1.53	1.91	2.39	2.98
2034	1.81	2.29	2.89	3.64	2.73	3.44	4.34	5.46	3.18	4.02	5.07	6.37	2.17	2.75	3.46	4.36	1.56	1.98	2.49	3.14
2035	1.87	2.38	3.04	3.86	2.82	3.60	4.59	5.83	3.28	4.19	5.33	6.77	2.24	2.86	3.64	4.62	1.60	2.05	2.60	3.31
2036	1.92	2.47	3.18	4.08	2.92	3.76	4.83	6.20	3.40	4.38	5.63	7.22	2.31	2.97	3.82	4.90	1.64	2.11	2.72	3.49
2037	1.97	2.56	3.33	4.31	3.01	3.92	5.09	6.59	3.52	4.58	5.95	7.71	2.38	3.10	4.02	5.21	1.68	2.19	2.84	3.68
2038	2.02	2.65	3.48	4.55	3.11	4.09	5.35	7.00	3.66	4.80	6.30	8.23	2.46	3.23	4.23	5.53	1.71	2.25	2.95	3.86
2039	2.07	2.75	3.64	4.80	3.21	4.26	5.64	7.44	3.79	5.03	6.66	8.79	2.54	3.37	4.45	5.88	1.76	2.33	3.08	4.07
2040	2.13	2.85	3.81	5.07	3.31	4.44	5.93	7.91	3.94	5.27	7.05	9.39	2.62	3.51	4.69	6.24	1.80	2.41	3.22	4.29

51