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Charting a Course to Energy Independence

Providence, RI
August 9-12, 2009

Cleanroom Efficiency Made Simple

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Clean Room Energy Use

- Basics of Clean Room Energy Use are to Reduce:
  - Operating Hours
  - Flow
  - Static Pressure
  - Heating and Cooling Requirements

New Cleanroom Case Study

- Genentech, Vacaville, CA

- 180,000 SF of Class 10K and 100K
- Annual Energy Cost Savings $552,800
- Increased First Cost $1,783,360
- Utility Incentive $842,400
- Simple Payback 1.7 years
- From California Institute of Energy Efficiency (CIEE) Publication

New Cleanroom Case Study

- Variable Speed on Fans, $23,000/yr.
- High Efficiency Boiler saves $48,700/yr.
- Cooling Tower Water for Process Cooling saves $62,700/yr.
- Makeup Air Units discharge 55F up to 60F saves $155,000 per year.
- Efficient Chillers sized (1) 600 ton, (2) 1400 ton saves $113,250/yr.

Retrofit Cleanroom Case Study 1

- Western Digital, Kuala Lumpur, Malaysia

- Increase from 80,000 to 90,000 SF
- Cleanliness from 10,000 to 10
- Energy Use Decreases 44%

Retrofit Cleanroom Case Study 1

- Full Load Flow 550 air changes per hour
- Unoccupied Flow 100-200 ach
- Old Peak Elec. Demand = 16.9 W/SF
- New Peak Elec. Demand = 9.4 W/SF

- From California Institute of Energy Efficiency (CIEE) Publication

Retrofit Cleanroom Case Study 2

- Hine Design, Sunnyvale, CA

- Increase from 80,000 to 90,000 SF
- Cleanliness from 10,000 to 10
- Energy Use Decreases 44%

Retrofit Cleanroom Case Study 2

- 45,000 SF, 4,000 SF of Class 100 and 6,000 SF of Class 10,000 and chase space
- Former Flow reduced to 60% during occupied
- Unoccupied 15% of former full flow
- Saved $36,000 per year, Costs $55,000
- Simple Payback 1.5 years

- From California Institute of Energy Efficiency (CIEE) Publication

Clean Room Energy Use

- Reduce Static Pressure:
  - Use Lower Pressure Drop Filters
  - Redo Ductwork to lower pressure drop

Clean Room Energy Use

- Reduce Heating and Cooling Requirements:
  - Reduce exhaust and outside air requirements.
  - Establish unoccupied deadband for temperature and humidity. This must be carefully accomplished so that room is in specified limits during occupancy.

Clean Room Energy Use

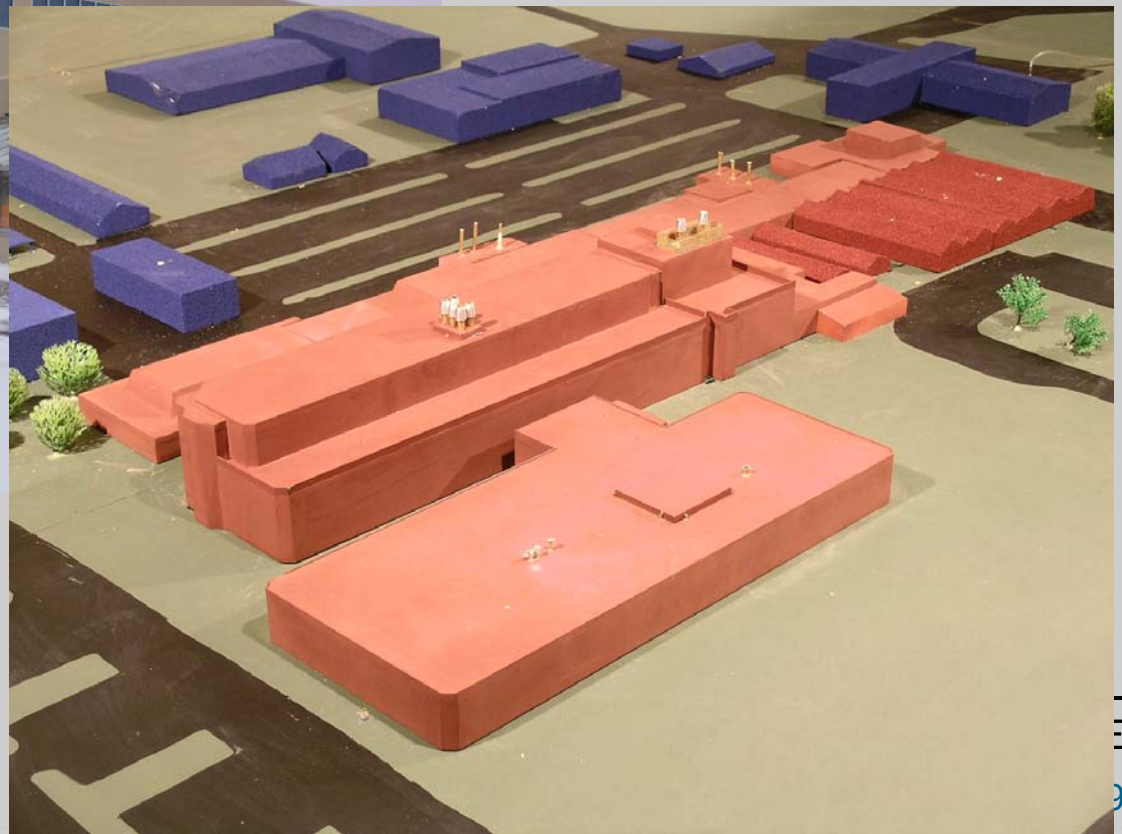
- Reduce Exhaust Air Flow:
  - Reduce exhaust air flow to laminar flow benches, hoods or equipment when not in use possibly only during unoccupied period.
  - Must be coupled with a sophisticated flow control system on both supply and exhaust.

Patent Pending Technology

- The technology to achieve Active VAV is patent pending, proprietary, but is now available in the marketplace.

- Data presented in the rest of the study is mainly courtesy of Brad Cochran of www.cppwind.com in Ft. Collins, CO.

Lethbridge Research Centre, Alberta



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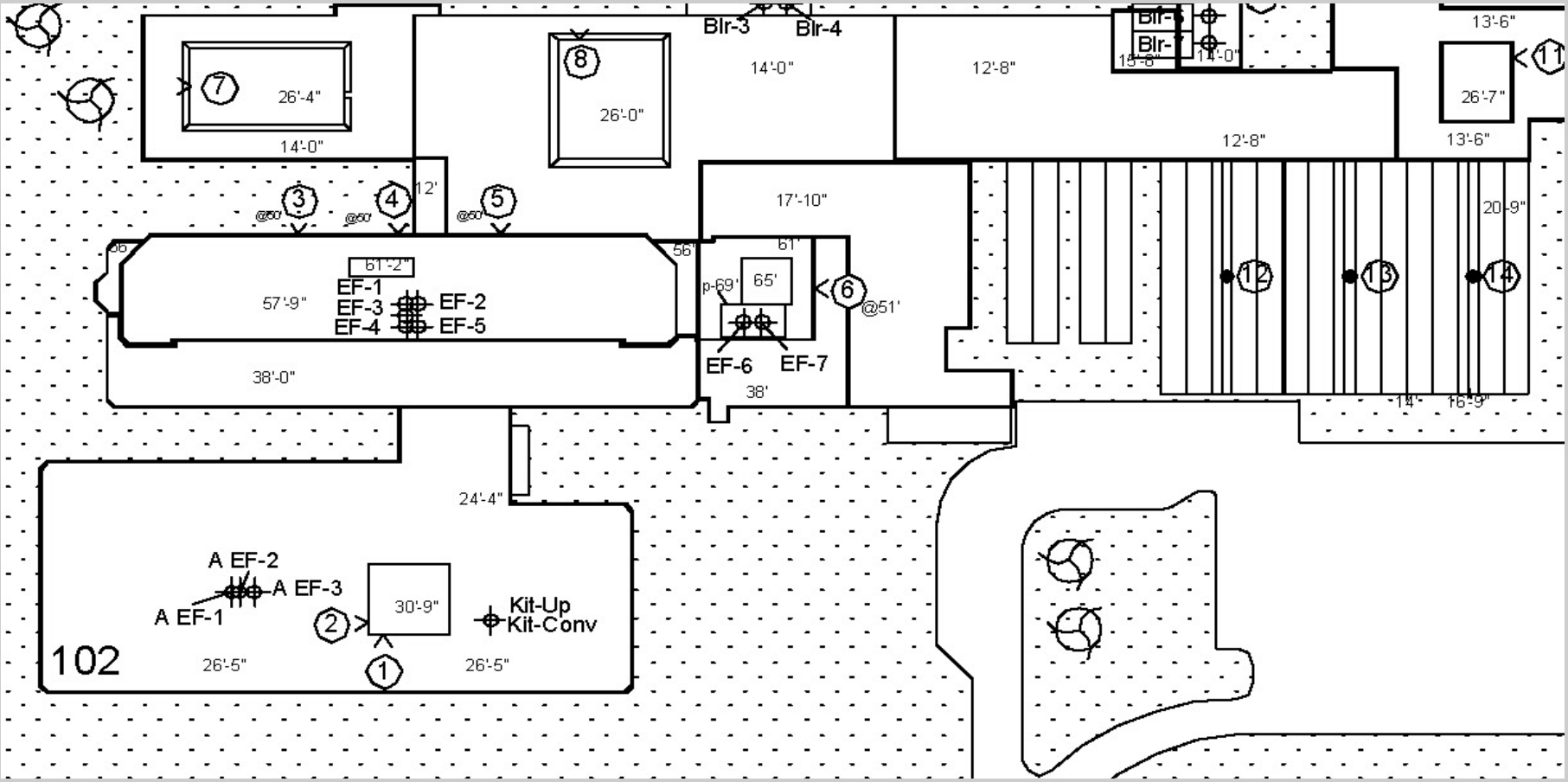
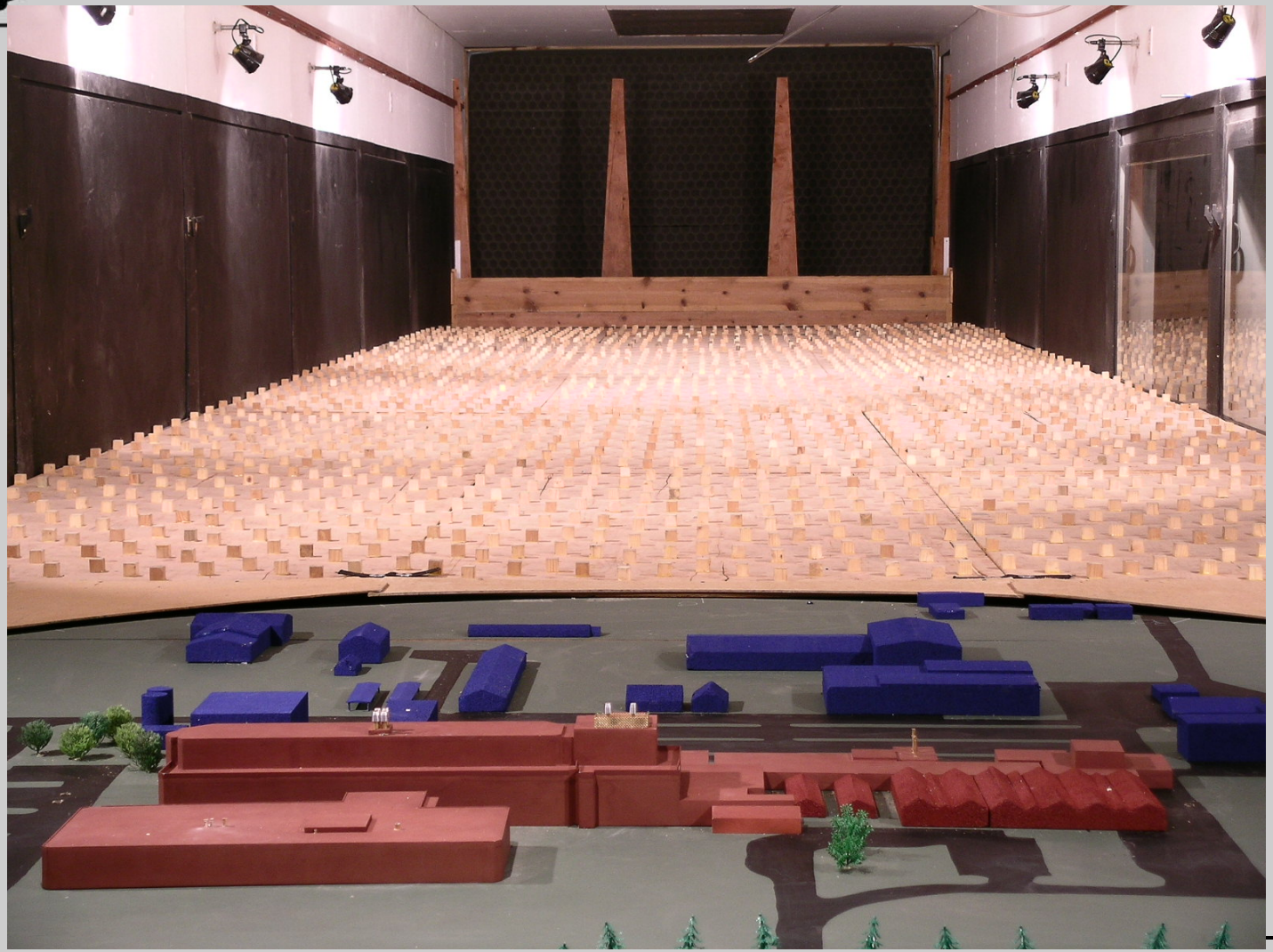
EF-1 to 5 @ 27,000 cfm
EF-6 and –7 @ 10,300 cfm



Setup in Wind Tunnel



Result for EF-3; Full Load
$(C/m)_{max}$ = 109; U_{crit} = 13.1 m/s

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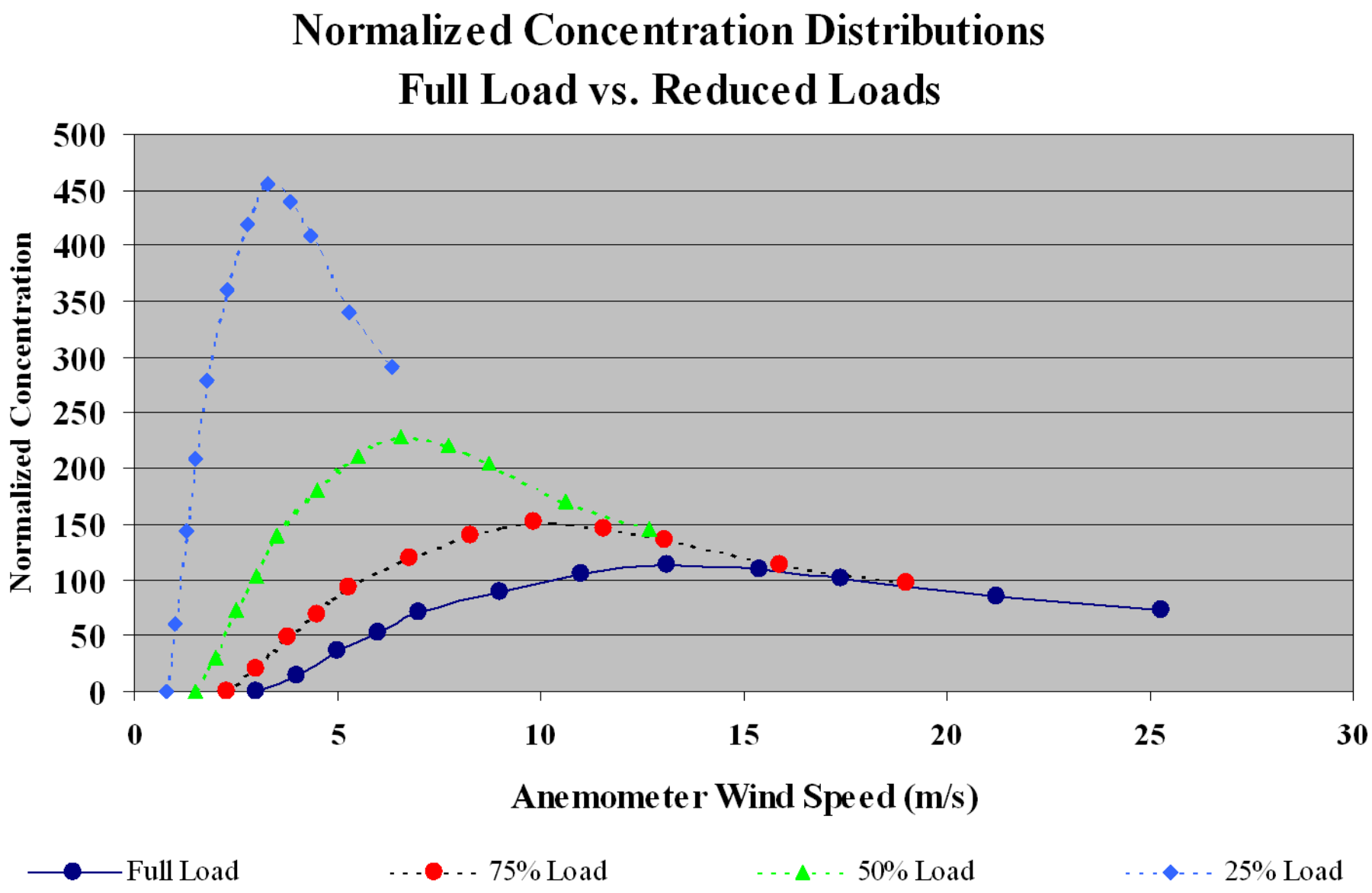
Result for EF-6; Full Load
$(C/m)_{max}$ = 208; U_{crit} = 9 m/s

Results/Analysis: EF-3



EF-1 and 5 Minimum Fan Load vs. Speed and Direction

Full Load Parameters

Volume Flow:	12.75	m^3/s	27,000	cfm
Exit Velocity:	25.41	m/s	5000	fpm

Wind Direction	Anemometer Wind Speed (m/s) 0 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	10 - 11	11 - 12	12 - 13	13 - 14	> 14
0	23.4%	25.5%	21.2%	16.5%	14.2%	12.9%	12.1%	11.5%	11.1%	10.8%	10.6%	10.4%	10.3%	10.3%
5	24.9%	28.7%	26.6%	[illegible]	20.3%	19.8%	19.4%	19.1%	18.8%	18.6%	18.4%	18.2%	18.1%	18.0%
165	16.8%	-	-	[illegible]	-	-	-	-	-	-	-	-	-	-
170	23.9%	22.7%	14.5%	13.5%	12.8%	12.3%	12.0%	11.7%	11.5%	11.4%	11.2%	11.1%	11.0%	11.0%
175	30.2%	35.1%	32.2%	23.9%	20.6%	19.6%	18.9%	18.3%	17.8%	17.5%	17.2%	16.9%	16.7%	16.6%
180	31.9%	38.8%	39.4%	32.7%	25.2%	23.1%	[illegible]	[illegible]	[illegible]	20.3%	19.9%	19.6%	19.3%	19.1%
185	30.2%	35.1%	32.2%	23.9%	20.6%	19.6%	[illegible]	[illegible]	[illegible]	17.5%	17.2%	16.9%	16.7%	16.6%
190	23.9%	19.8%	14.5%	13.5%	12.8%	12.3%	12.0%	11.7%	11.5%	11.4%	11.2%	11.1%	11.0%	11.0%
195	12.5%	-	-	-	-	-	-	-	-	-	-	-	-	-

39.4%

Worst Case

Minimum Flow Rate : 39.4% x 27,000 cfm = 10,600 cfm

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EF-6 and 7 Minimum Fan Load vs. Speed and Direction

Full Load Parameters

Volume Flow:	4.86	m3/s	10,300	cfm
Exit Velocity:	18.69	m/s	3679	fpm

Wind Direction	Anemometer Wind Speed (m/s)												
	0 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	11 - 12	12 - 13	13 - 14	>10
0	-	-	-	-	-	-	-	-	-	-	-	-	-
10	13.0%	-	-	-	-	-	-	-	-	-	-	-	-
20	28.0%	29.3%	25.2%	21.4%	19.1%	17.7%	16.8%	16.2%	15.7%	15.3%	14.8%	14.6%	14.4%
30	35.4%	43.9%	47.7%	46.9%	43.0%	38.4%	34.8%	32.2%	30.4%	29.0%	27.1%	26.4%	25.9%
40	37.5%	47.8%	54.0%	56.2%	54.7%	50.6%	46.0%	42.1%	39.1%	36.9%	33.9%	32.9%	32.0%
50	35.4%	43.9%	47.7%	46.9%	43.0%	38.4%	34.8%	32.2%	30.4%	29.0%	27.1%	26.4%	25.9%
60	28.0%	29.3%	25.2%	21.4%	19.1%	17.7%	16.8%	16.2%	15.7%	15.3%	14.8%	14.6%	14.4%
70	13.0%	-	-	-	-	-	-	-	-	-	-	-	-
80	12.2%	-	-	-	-	-	-	-	-	-	-	-	-
90	22.6%	23.3%	19.8%	16.7%	15.0%	13.9%	13.2%	12.7%	12.4%	12.1%	11.7%	11.5%	11.4%

56.2%

Worst Case

Minimum Flow Rate : 56.2% x 10,300 cfm = 5800 cfm

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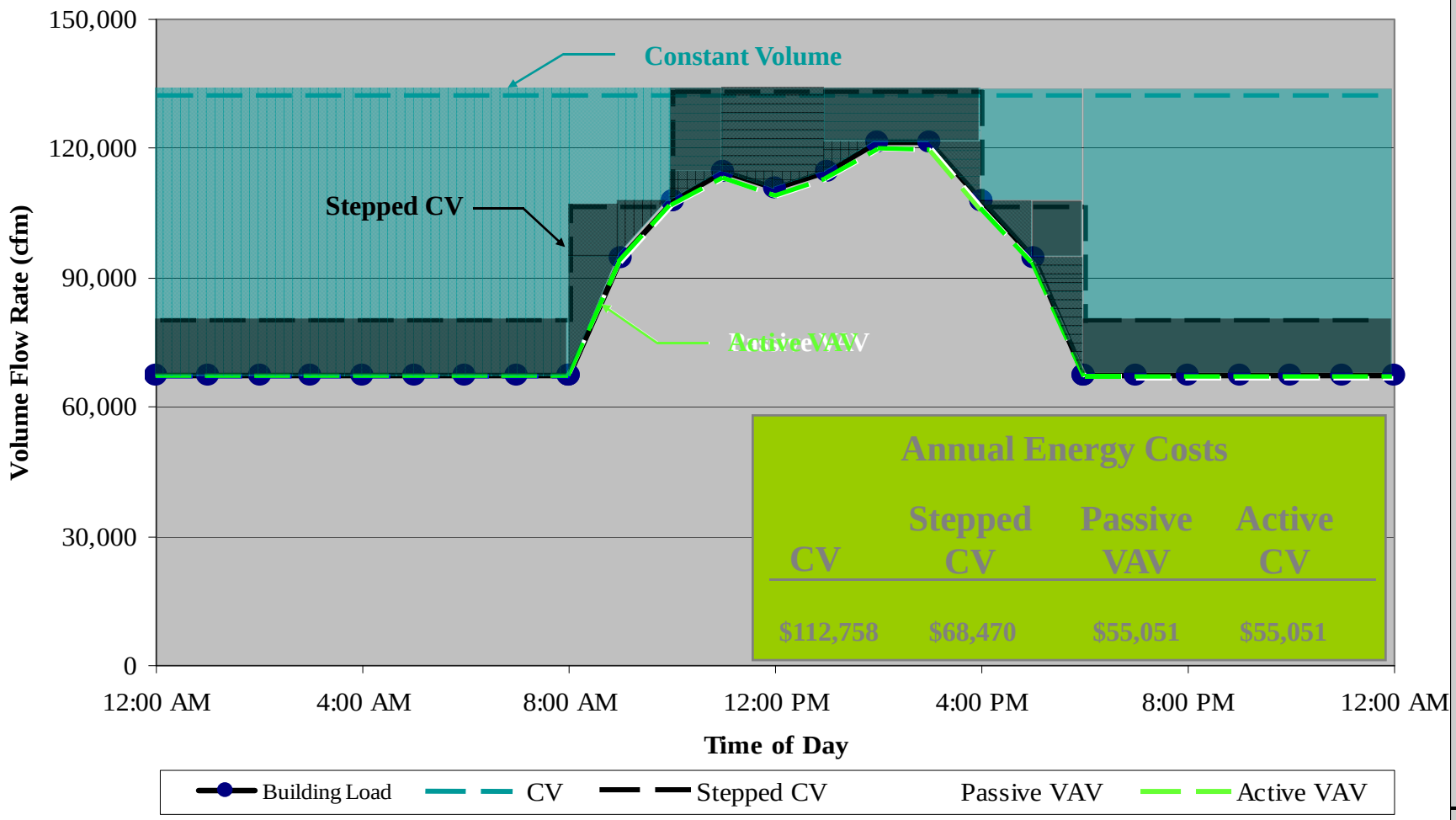
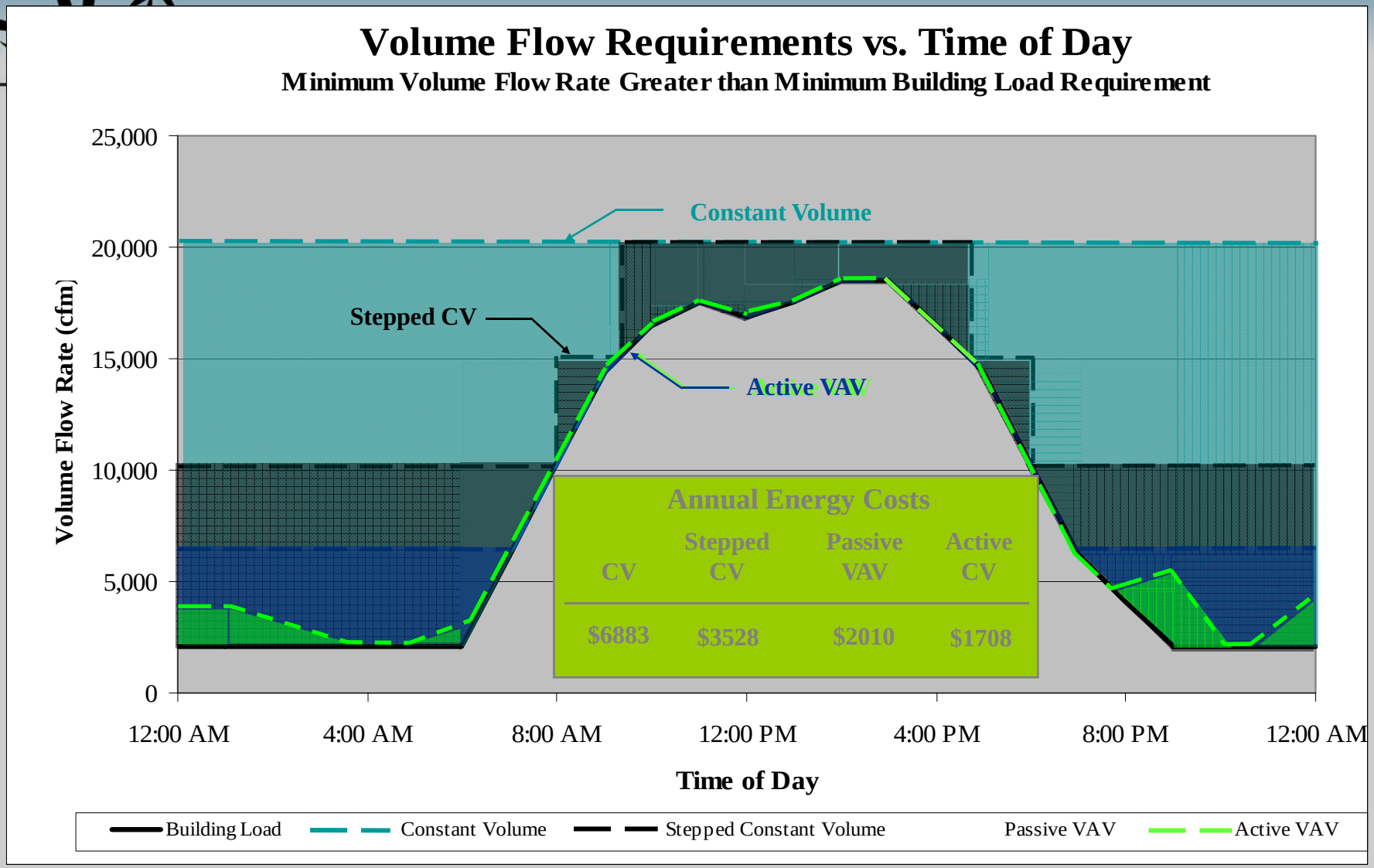
Inputs to Energy Calculations

- kW - hr = 0.7457 x bhp – hr
- Unit cost = $0.10 per kW-hr
- Fan CFM versus kw-hr

EF-1 through 5



EF-6 and 7


Volume Flow Requirements vs. Time of Day
Minimum Volume Flow Rate Greater than Minimum Building Load Requirement
Volume Flow Rate (cfm)
25,000
20,000
15,000
10,000
5,000
0
Constant Volume
Stepped CV
Active VAV
Annual Energy Costs
CV
Stepped CV
Passive VAV
Active CV
$6883
$3528
$2010
$1708
12:00 AM
4:00 AM
8:00 AM
12:00 PM
4:00 PM
8:00 PM
12:00 AM
Time of Day
Building Load
Constant Volume
Stepped Constant Volume
Passive VAV
Active VAV

Summary

- Exhaust Savings of over 80% are possible.
- Current Technology Allows Exhaust Flows To Be Operated as a VAV System as Well
- Significant Energy Savings Can Be Realized By Tailoring Exhaust Flow Rates To Current Building Loads.

Summary

- The idea of clean room energy efficiency can be made simple.
- The doing of cleanroom energy efficiency is anything but simple.
- THANK YOU!